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The durability and service life benefits of Stainless Steel Rebar and the underpinning properties and features – A stainless industry primer for owner's, planners, specifiers, and designers on the technical and market realities

2018

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STAINLESS STEEL REBAR

Corroding Infrastructure

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Some Abbreviations

- SSR >> Stainless Steel Reinforcement
- CRR >> Corrosion Resistant Reinforcement
- DOT >> Department of Transportation
- FHWA >> Federal Highways Administration (U.S.)
- LCC >> Life Cycle Cost

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ASTM A955 Overview

- SSR – deformed and smooth
- Various chemical compositions
- 2304, 2205, XM-28, 2101, 316LN and others
- Weldable material
- Bend diameters, dimensional profiles – same as conventional bars
- The steel is mill-pickled in acid to provide optimal corrosion resistance
- Yield (min) of 60 & 75 ksi (0.2% offset) (420, 520) – moving to 80 ksi
- Elongation min of 20% in 8” (actual >30%)
- Mandatory corrosion tests, e.g. macrocell test

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Unique Mechanical and Other Properties

Mechanical	Other
High strength rebar at 520 Mpa moving to 550 Mpa	Excellent low temperature properties
Modulus of Elasticity is within 3% of mild steel	Fire and heat resistant
Yield is calculated by the 0.2% offset method	Low magnetic permeability (austenitic)
Exceptional ductility >> 20%	Excellent bond with concrete
	Easily machined and welded

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Leveraging Mechanical / Other Properties

- The structural design concepts follow those of mild steel
- The development lengths and splice lengths follow conventional steel
- High strength steel >> a potential to reduce steel
- Ideal for seismic and shock applications
- Suitable for low and high temperature environments
- Used in applications where reduced magnetic interference is specified
- Bars can be easily connected/welded to extend lengths or form complex shapes

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Chemical Composition Commonly used Alloys (%)

UNS # Type	32304 "2304"	24100 "XM-28"	31803 "2205"	31653 "316ln"
Nickel	3 - 5.5	0.5 - 2.5	4.5 - 6.5	10 - 14
Chromium	21.5 - 24.5	16.5 - 19	21 - 23	16 - 18
Molybdenum	.05 - 0.6	--	2.5 - 3.5	2 - 3
Manganese	2.5	11 - 14	2	2
Carbon	0.03	0.15	.03	.03max
Total Alloys (incl other)	28-34	29-37	31-36	31-38

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Corrosion Resistance (CR)

- The science shows that SSR has far superior corrosion resistant properties
- Chemistry matters, alloyed bars are the future
- Coatings are fragile, costly to field repair and are prone to degradation
- Low alloy products provide poor corrosion resistance
- There are substantial differences in the CR of the various types of steel rebar
- Composite rebar has limited track record, and is a degradable material

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Representative Corrosion Research

- The 2009 FHWA study concluded that only SSR can confidently provide a service life of 75 to 100 years
- In an ACI journal simulating bridge decks, the average time to corrosion of black and galvanized steel was 2.3 and 5 years. SSR did not corrode during the test period
- In macrocell testing, XM-28 out performs a low alloy non-stainless bar by 80 times
- In salt spray testing, SSR is a minimum of 600 times more resistant (see graph)

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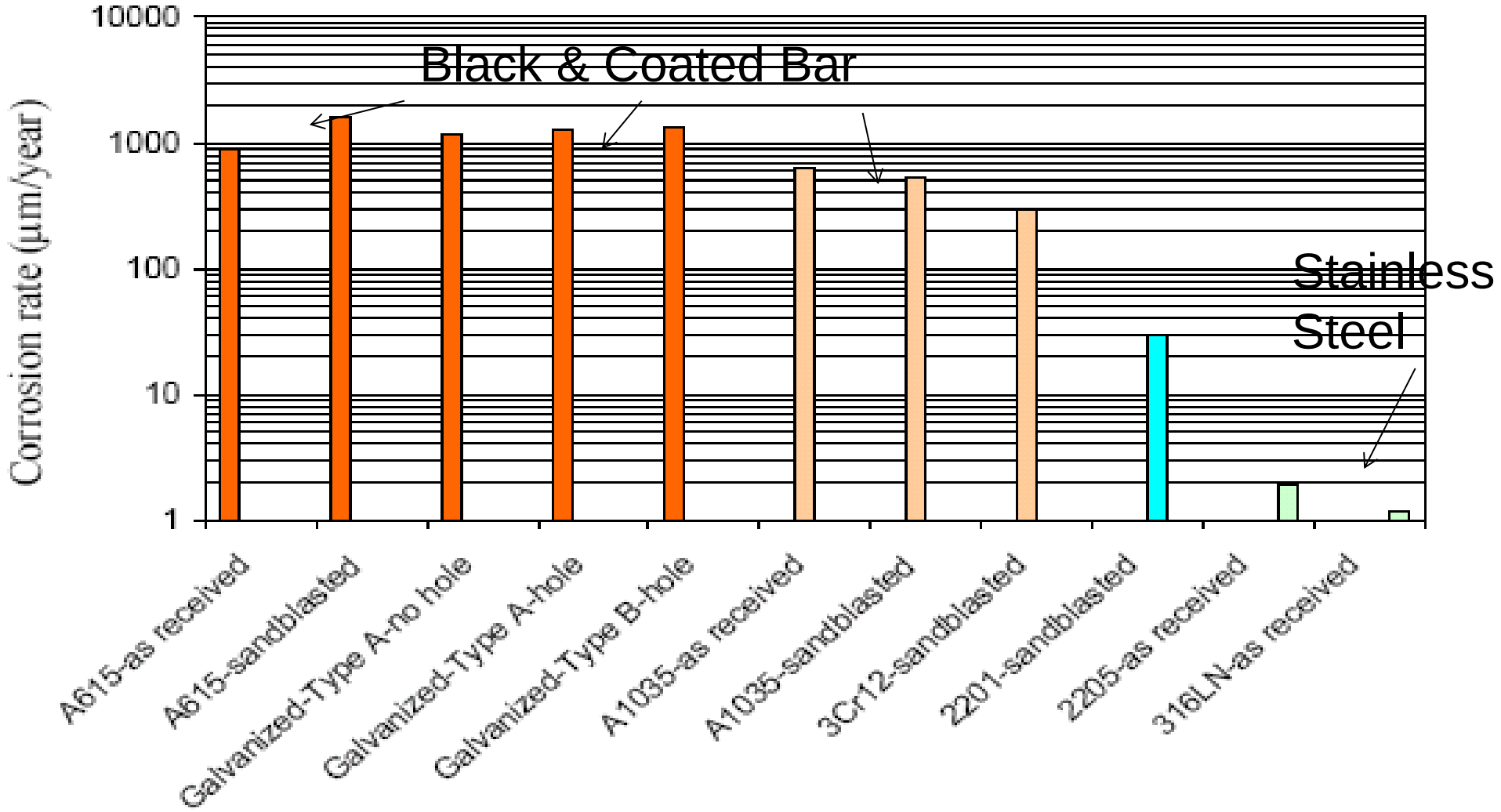
Corrosion Rate Comparison



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Initial Cost Reduction Benefits due to Chemistry

- Reduction in concrete cover initially meant to protect black steel
- Less cover = less concrete cost, and more “live load” capacity
- New York and Michigan DOT’s specify reduced cover with stainless
- Less cover is associated with smaller crack widths
- Lighter structures are more seismically efficient
- Stainless is unaffected by deck cracking >> hence, membranes, deck sealants, concrete additives are “belts and suspenders”
- Reduces field QA burden associated with coated rebar

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Long Term Cost Reduction due to Chemistry

- Dramatic service life extension
- Reductions in repairs and maintenance
- Reduction in Owners' need for future capital
- Reduction in traffic congestion, hence user costs
- More effective infrastructure utilization = Economic spinoffs

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LCC : New York State DOT case study

- LCC measures long term cost effectiveness
- NYSDOT concluded that with SSR the LCC for a bridge deck rehabilitation was 20% less
- For a new bridge structure it was almost 10% less
- The lower LCC is due to better rebar chemistry, better concrete durability which reduces future structure repair costs
- The initial cost to use SSR is **< 1%** for new structures
- These results are substantial and compelling

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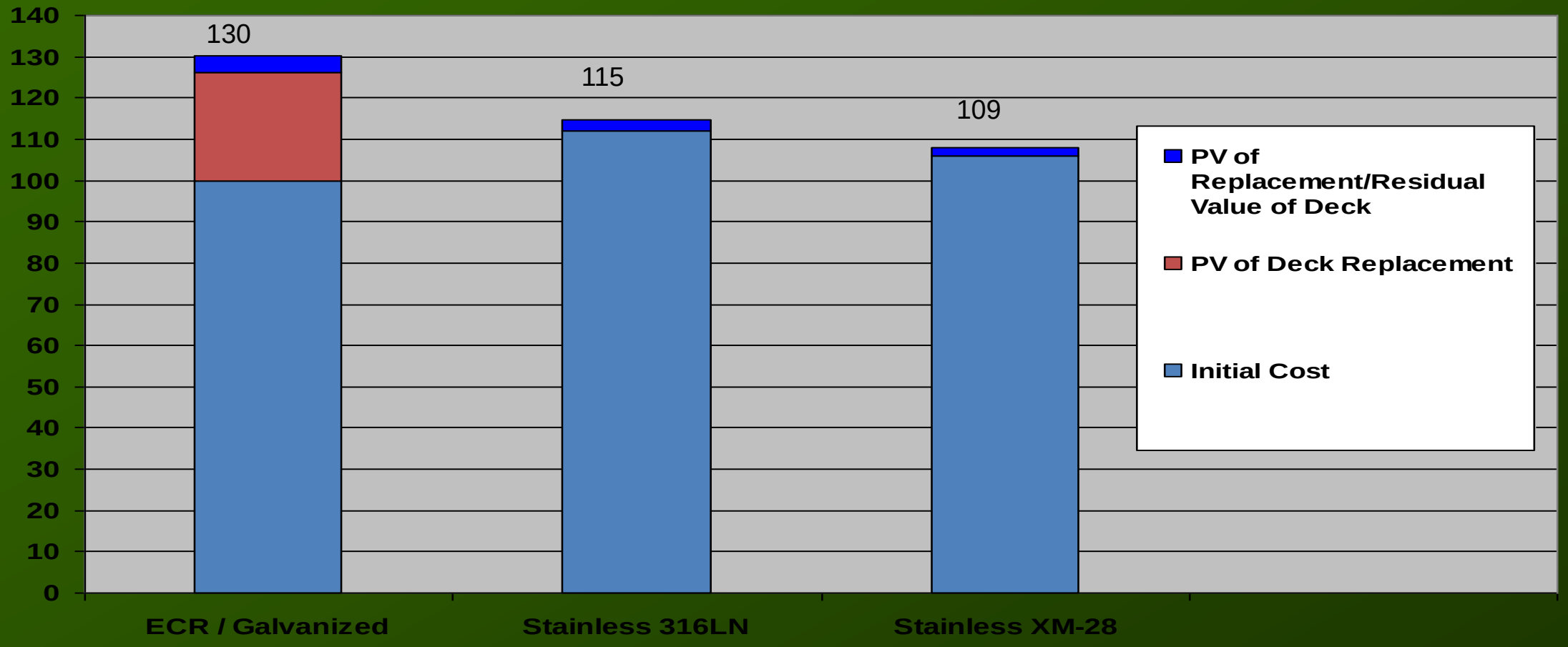
Total Deck Cost After 100 Years

Index : Initial Cost of ECR / Galvanized = 100



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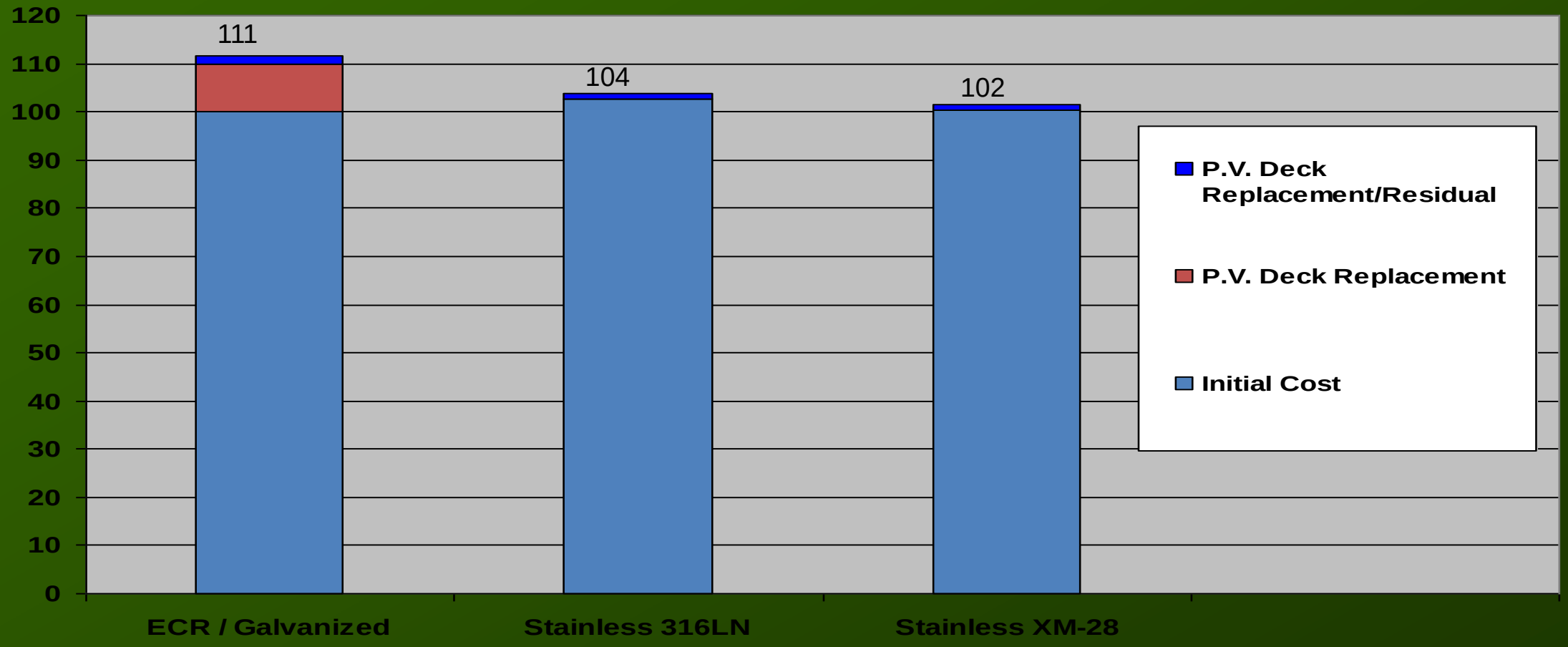
Total Interchange Cost After 100 years

Index : Initial Cost of ECR / Galvanized = 100



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Track record of field success

- Functioning pier built 75+ years ago (1937) with stainless steel in Progreso, Mexico
- The Gulf of Mexico is a very
  harsh environment
- Still has an additional
  25 year life expectancy

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Pricing/Quality Realities

- SSR prices have declined dramatically
- Product Price and Quality are directly related … ↑ Price ↑ Quality
- Cheaper rebar = less quality, less durability, reduced service life, higher repair costs and bridge downtime with higher user costs
- Owners' overall costs decline with more effective rebar
- SSR may cost more but it WORKS!

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Owners' use of SSR
Strategic Highways / Heavy traffic

- Owners are allocating better performing CRR to their more strategic and busiest roadways
- There are many examples of this practice – two are the Virginia and Vermont DOT's
- Virginia mandates SSR on all roadway classes giving an option only for "Rural and Collector Local Roads"
- Vermont mandates SSR everywhere but allows coated bar for "Unpaved Roads" with limited traffic volume and a 30 year life

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Where is SSR used

- Highway Infrastructure
  - Decks and deck panels
  - Barrier walls, curbs, sidewalks, medians, expansion joints
  - Approach slabs and wing walls
  - Dowels
- Marine/Coastal Infrastructure and Structures
- Hospitals (MRI's)
- Naval

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Snapshot of Major Projects

- The increase in interest by Owners and engineers is evidenced by the increasing scale in project size across North America

Project	Owner	SSR [tonnes]	SSR Type
Champlain	Canada	15,000	2304
Stillwater	MN DOT	5,400	2304
Hoan	Wis DOT	4,500	2304
Bonner	NC DOT	2,700	XM-28
Pulaski	PANYNJ	2,100	XM-28
Gardiner	Toronto	5,000+	2205
Calgary RR	AB DOT	5,000	2304

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Material Availability

- There is ample product supply
- Three mills are producing SSR in the U.S.
- There are also various international producers of SSR
- The current capacity to produce SSR vastly exceeds current demand

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Summary

- Owners need cost effective durability solutions for infrastructure exposed to chlorides
- SSR is the primary bar used in moderate to high risk zones of chloride attack for structures that are strategically important and/or with high traffic volumes
- It is designed to provide superior chloride resistance extending service life
- Ensures the least LCC by substantially reducing future repairs and maintenance – the benefits of using SSR substantially exceed the costs
- Traffic congestion is reduced increasing roadway throughput = economic benefits
- There are cost reductions associated with cover, deck protection, concrete design, high yield strength
- Track record of Progreso, i.e. 75+ yr. service life in a very high chloride application
- The usage of SSR has gone “mainstream”

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Thank You

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