

# Rebarino



The stainless steel reinforcement

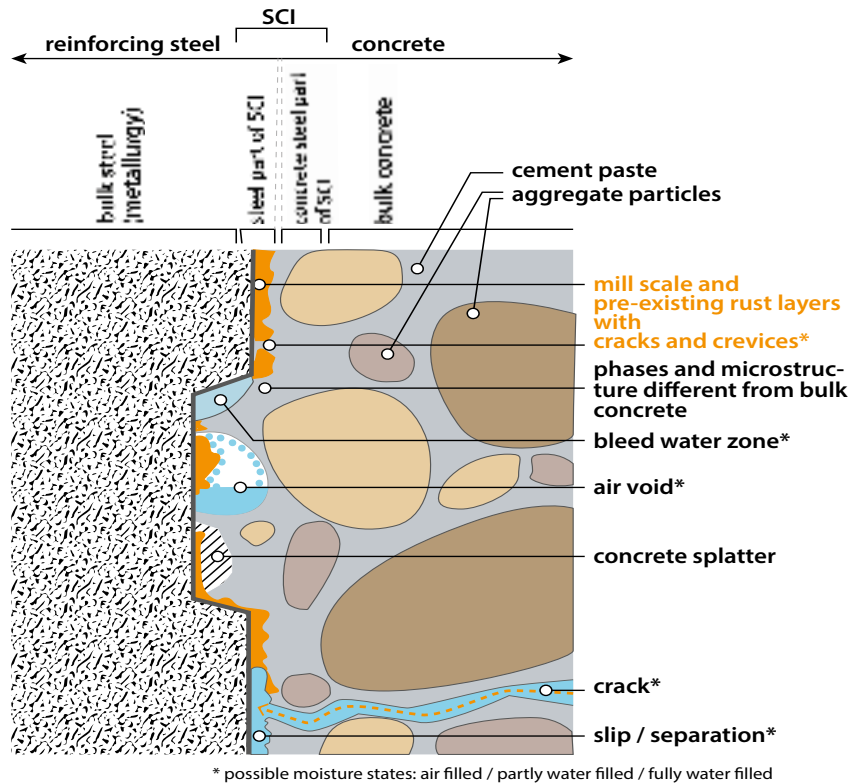


# Reinforcement corrosion: a real problem

Steel reinforcement in concrete can be affected by external agents and as a result of this interaction, corrosion process can be initiated damaging and loosing reinforcement section.

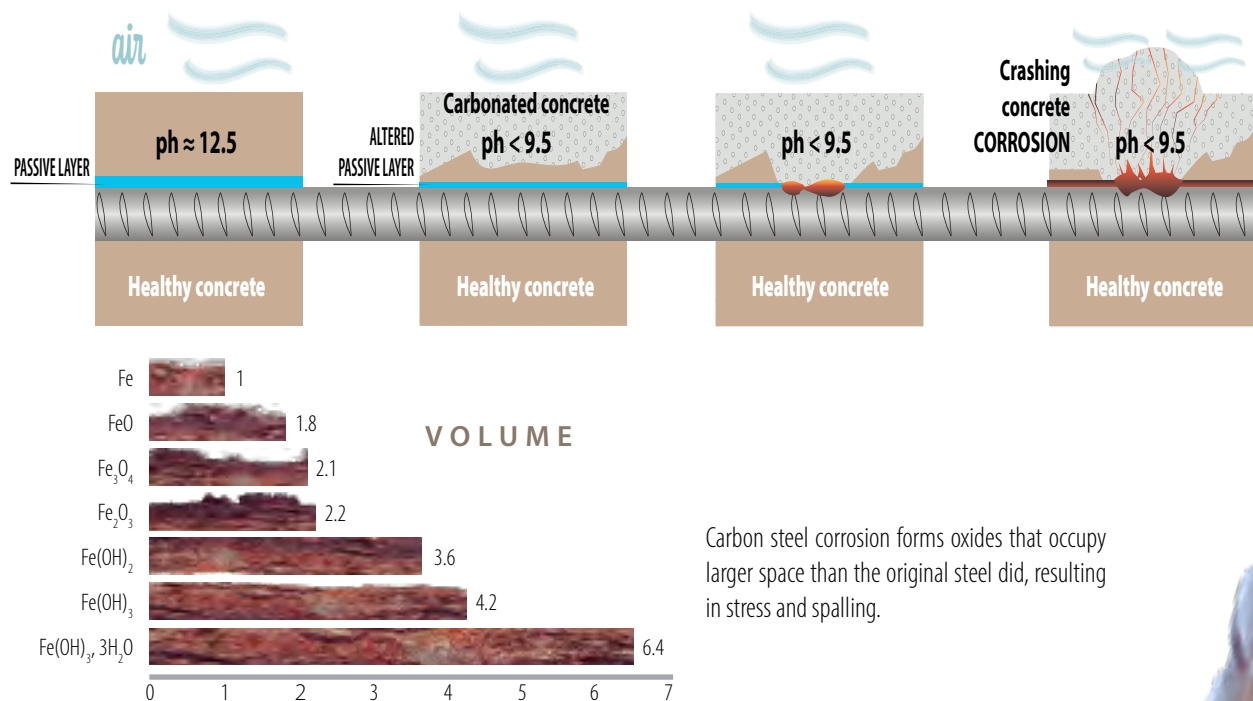
There are several ways for the aggressive agent to attack steel reinforcement:

- Diffusion
- Permeability
- Capillarity absorption



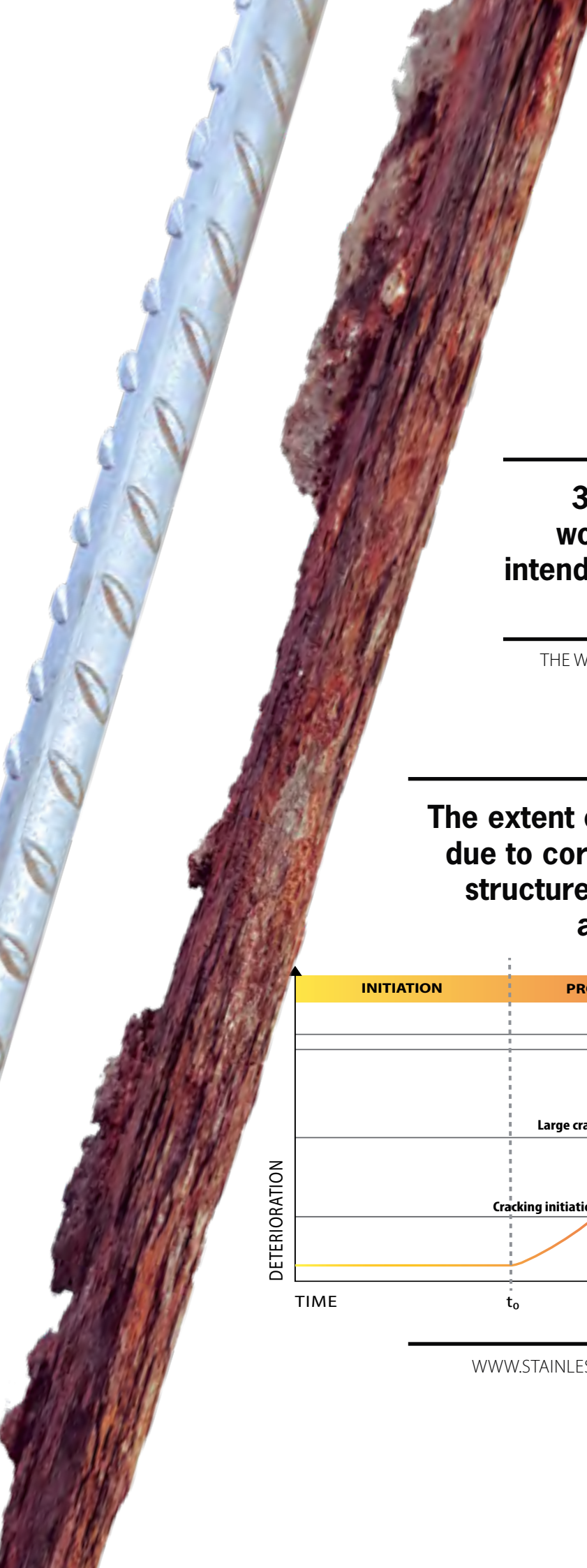
Source: Figure from *The Steel Concrete Interface*  
 Publication: *Materials and Structures*  
 Author: Ueli M. Angst et al  
 Publisher: Springer Nature  
 Feb 27, 2017

Nevertheless, sometimes it is not necessary the presence of an aggressive agent to attack the steel reinforcement, which is the case of concrete carbonation.



Carbon steel corrosion forms oxides that occupy larger space than the original steel did, resulting in stress and spalling.

Data obtained "Guía de reparación y protección del hormigón e impermeabilización" by Lanko



---

**3.2% of the world GDP is intended to fight corrosion.**

---

THE WORLD CORROSION ORGANIZATION

---

**50% of the assigned budget by EU was invested to repair corrode structures.**

---

NACE 2018

---

**The extent of damage due to corrosion in a structure increases along time.**

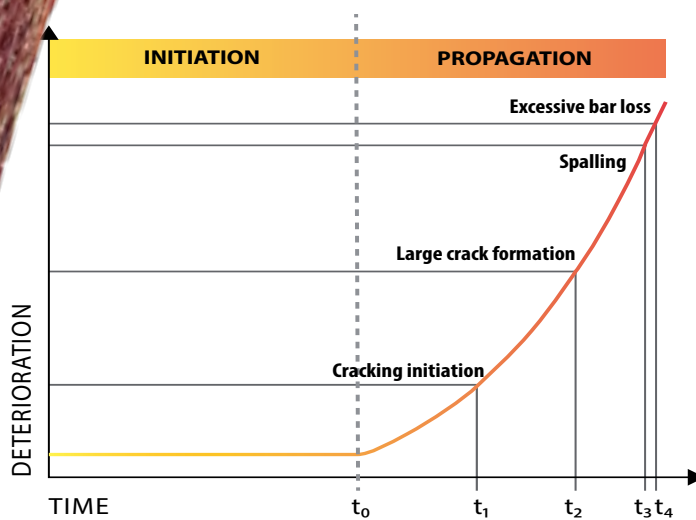
---

---

**Maintenance and repair costs follow the same pattern.**

---

ARUP



---

**60% of corrosion repairs by traditional methods fail before 10 years.**

---

CONREPNET

WWW.STAINLESSSTEELREBAR.ORG

# The solution to corrosion

ACERINOX 50 years of experience and technical knowledge in the production of stainless steel, is at the service of the construction sector with REBARINOX®, the new trademark of the stainless steel reinforcement bar.

REBARINOX® is manufactured following the most demanding standards in ROLDAN, the Acerinox' long products factory in Ponferrada (León, Spain). It is an excellent constructive solution due to its outstanding properties in terms of profitability, sustainability, resistance, durability and its mechanic and physic properties.



**REDUCCI N**  
**DEL COSTE DE MANTENIMIENTO**  
**COST MAINTENANCE REDUCTION**



**REDUCCIÓN DEL  
IMPACTO AMBIENTAL**

**ENVIRONMENTAL  
IMPACT REDUCTION**



**BUENAS  
PROPIEDADES MECÁNICAS**  
**GOOD MECHANICAL  
PROPERTIES**



**ACERO INOXIDABLE**

**STAINLESS STEEL**



## Profitability

Stainless steel is often associated with high initial costs. However, when used as reinforcement in critic areas of reinforced concrete structures, it increases only between 1 to 3% the total project cost, ensuring more than 100 years durability. It means that the final life cycle cost of the work will be reduced more than 15%.

## Sustainability

Stainless steel is 90% recyclable. More than 60% of the material used to new production comes from scrap. It is considered green material, reusable as long as is needed keeping its original properties.

## Strength

Stainless steel is a ferritic alloy with 10.5% minimum chromium content, and no more than 1.2% carbon. This chromium content is essential to guarantee the formation of a stable passive layer that provides protection against corrosion and regenerates in case of breakage. Its resistance requires the correct selection of the stainless steel type which mostly depends on the environment.

## Durability

Durability associated to suitable stainless steel concrete embedded is 100 years maintenance free.

## Mechanical properties

REBARINOX® combines high mechanical resistance so as good ductility and tenacity.



# Rebarino

**Rebarinox® is in compliance with the established lifespan values by the Structural Code, in various types of projects.**

# REBARINOX® supply

ACERINOX supplies the following range of Rebarinox® sizes, with available stock of the most common ones:

	Ø (mm)	Length (mm)
Bar	4 - 50	3000 - 12000
Coil	6 - 32	
Other sizes on request		

Average coil weight (Kg)	Coil diameter		Coil height (mm)
	Inside Ø (mm)	Outside Ø (mm)	
1400-1900	900-1000	1200-1400	1700-2200

Rebarinox® austenoferritic (duplex) alloys combine excellent corrosion resistance and interesting mechanical properties.

And many alloys to meet any requirement:

Rebarinox®	According to UNE EN 10088-1	Ø (mm)	PREN - Pitting resistance equivalent number(*)
702(1)	1.4003	6 - 25	10 < PREN ≤ 16
903	1.4482	5 - 50	17 < PREN ≤ 22
915	1.4362	5 - 50	23 < PREN ≤ 30
917	1.4462	5 - 50	PREN ≥ 31
216(1)	1.4307/1.4301	4 - 40	18 < PREN ≤ 22
217(1)	1.4311	4 - 40	20 < PREN ≤ 25
332(1)	1.4404	4 - 40	24 < PREN ≤ 26
359(1)	1.4436	4 - 40	25 < PREN ≤ 30
331(1)	1.4429	4 - 40	25 < PREN ≤ 30

PREN(\*)=Cr+3.3Mo+16N

(\*) It measures the stability of the passive layer facing external agents, specially chloride. There are alterations depending on the type of stainless steel, the higher the value the most stable the passive layer will be.

Regarding duplex stainless steel, the last addend is usually 30N.

(1) MINIMUM ORDER QUANTITY

## Duplex Rebarinox®. Chemical composition

	C	Mn	P	S	Si	Cr	Ni	Mo	N	Cu
EN 1.4482	≤0.030	4.0 - 6.0	≤0.035	≤0.030	≤1.0	19.5 - 21.5	1.5 - 3.5	0.1 - 0.6	0.05 - 0.20	≤1
UNS S32001	≤0.030	4.0 - 6.0	≤0.040	≤0.030	≤1.0	19.5 - 21.5	1.0 - 3.0	≤0.60	0.05 - 0.17	≤1
STANDARD ACX903	0.019	4.166	0.023	0.001	0.608	20.220	1.820	0.398	0.145	0.120

Lean duplex. Its lower alloy content maintaining similar behaviour, ensures price stability. Due to this feature, it is a very attractive grade for long-term execution times civil works.

EN 1.4362	≤0.030	≤2.00	≤0.035	≤0.015	≤1.00	22.0 - 24.0	3.5 - 5.5	0.1 - 0.6	0.05 - 0.20	0.1 - 0.6
UNS S32304	≤0.030	≤2.50	≤0.040	≤0.030	≤1.00	21.5 - 24.5	3.0 - 5.5	0.05 - 0.6	0.05 - 0.20	0.05 - 0.6
STANDARD ACX915	0.020	1.590	0.024	0.001	0.570	22.790	4.125	0.199	0.137	0.292

Lower alloys content. Very attractive grade for long-term civil works.

EN 1.4462	≤0.030	≤2.00	≤0.035	≤0.015	≤1.00	21.0 - 23.0	4.5 - 6.5	2.5 - 3.5	0.10 - 2.22	
UNS S32205	≤0.030	≤2.50	≤0.030	≤0.020	≤1.00	22.0 - 23.0	4.5 - 6.5	3.0 - 3.5	0.14 - 0.20	
STANDARD ACX917	0.020	1.685	0.024	0.001	0.390	22.381	4.764	3.164	0.165	

Molybdenum increases its pitting corrosion resistance. This grade is the perfect solution where durability is a must.



[www.cedinox.es](http://www.cedinox.es)  
for technical  
data sheets



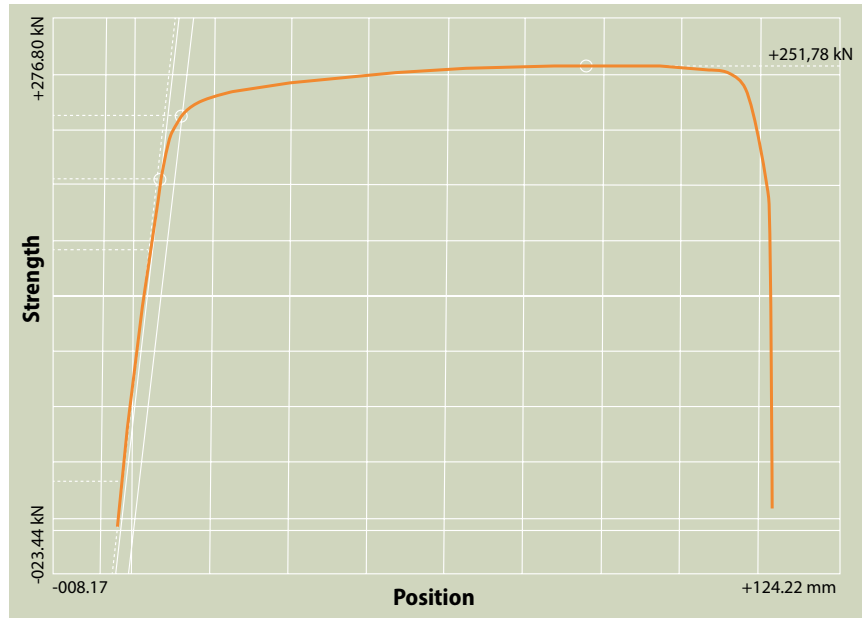
# REBARINOX<sup>®</sup> properties

Thanks to the available large amount of stainless steel alloys it is possible to obtain many different mechanical properties offering unique versatility and adaptability.

This is why adequate characterisation should be done to choose the suitable material for each application.

Tensile test results  
Material: REBARINOX 915 (1.4362), Ø20 mm

Maximum strength: 251.78 kN  
Tensile strength (Rm): 801 MPa  
Yield stress (Rp0.2%): 604 MPa  
Yield stress (Rp1%): 713 MPa  
Rm/Rp0.2%: 1.3267



Next chart is a guideline and shows principal Rebarinox<sup>®</sup> mechanical properties:

REBARINOX <sup>®</sup>	Rp0.2% (MPa)	Rm (MPa)	A5 (%)	Agt (%)	Rm/Rp0.2%
Cold rolled bar	>600	>700	>12		>1.03
Hot rolled bar and coil	>500	>540	>14	>5	>1.08

ILLUSTRATIVE MECHANICAL PROPERTIES OF SOME REBARINOX<sup>®</sup> SELECTED GRADES:

		Yield stress Rp0.2% (MPa)	Tensile strength (MPa)	Elongation (%)
<b>REBARINOX 903 (1.4482)</b>		500-650	700-850	40-50
<b>REBARINOX 915 (1.4362)</b>		530-650	720-860	14-50
<b>REBARINOX 917 (1.4462)</b>		650	820	35
Comparative stainless steel round bar mechanical properties according to EN 10088-3:				
EN 1.4003	3CR12	260	450	20
EN 1.4301	AISI 304	195	500	40
EN 1.4404 EN 1.4571	AISI 316L	215	500	40
EN 1.4482	UNS 32001	400	650	25
EN 1.4362	S32304	400	600	25
EN 1.4462	2205	450	650	25





1486

Zwick / Manufacturing

Zwick /

Zwick / ZHP

**Automated tensile  
and hardness  
test system in  
Acerinox Europa.**

# Seismic resistance

Rebarinox® can dissipate 56% more energy than carbon steel.



**Carbon steel  
CS-C (Cyclic)**

**Stainless steel  
SS-C (Cyclic)**

**Stainless steel  
SS-M (Monotonic)**

“Higher ductility and energy dissipation capability of stainless steel reinforced columns, joined to the excellent properties of corrosion resistance, benefit the future use of stainless steel reinforcement bars in reinforced concrete structures in aggressive environments and under seismic loads action”.\*

*\* Experimental investigation about cyclic response of stainless steel reinforced concrete columns carried out by experts from Oporto, University College London and University of Southampton.*

# Magnetic properties

Different Rebarinox® alloys are available to adapt to the magnetic permeability in every specific requirement.

There are special low permeability alloys to be used whenever necessary, as hospitals, research centres and airports, for instance.





**Rebarinox® excellent fatigue behaviour enables to manage large amount of cyclic loads. It is ideal for railway pergolas.**

FATIGUE TEST	
CARBON STEEL	2,000,000 CYCLES
STAINLESS STEEL	6,000,000 CYCLES

# Rebarinox® at sub-zero temperatures

Rebarinox® shows excellent resistance as well as ductility and tenacity properties at low temperature conditions, even sub-zero temperatures.

Additionally, under those conditions, its energy absorption capacity is extremely significant, eliminating the risk of structural weakening. Rebarinox® is highly recommended in any application at low temperatures, as roads exposed to frost/thaw cycles, or when cryogenic temperatures are required, for example liquefied natural gas storage.

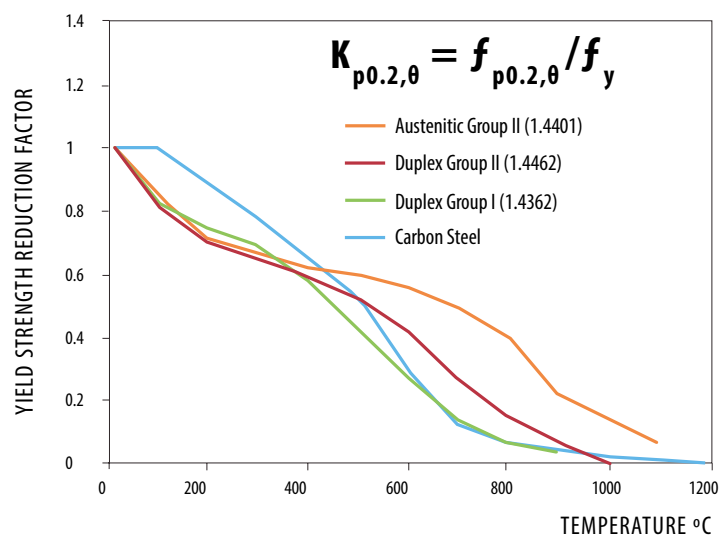
When reinforced bars are subjected to temperatures below -50°C, austenitic stainless steels should be used.

A good example is shown on the right picture, the Hastings bridge over Mississippi river in Minnesota, USA, where the use of ice-melting salts is required due to the low temperatures reached during their long winters.

# Fire resistance

Fire resistance in stainless steel structural elements can be determined according to EN 1993-1-2. Simplified design guidelines for carbon steel can be safely used for stainless steel, in combination with specific coefficient of resistance and stiffness reduction according to each type of stainless steel.

Ratio between resistance, stiffness or stress at high design temperature and the same values at room temperature, are the reduction coefficients. These values(\*) for stainless steel differ widely from carbon steel, due to the difference of microstructures and alloy elements.



Rebarinox® far longer resistance at high temperature adds extra safety in case of fire.

(\*)EN 1993-1-2 Annex C

(\*) Appendix C, Annex 23 Structural Code



**The correct selection of the material is an essential part for the project success.**

## Together with carbon steel

There is concern about galvanic couple as a result of mixing carbon steel and stainless steel. This galvanic couple exists as two different metals are being connected, however it can be considered insignificant when both materials are embedded in a concrete matrix.

Therefore, stainless steel is perfectly valid to be connected to carbon steel. Moreover, the galvanic potential difference between corroded and non-corroded carbon steels is quite higher than that between stainless steel and carbon steel. The Structural Code so provides.

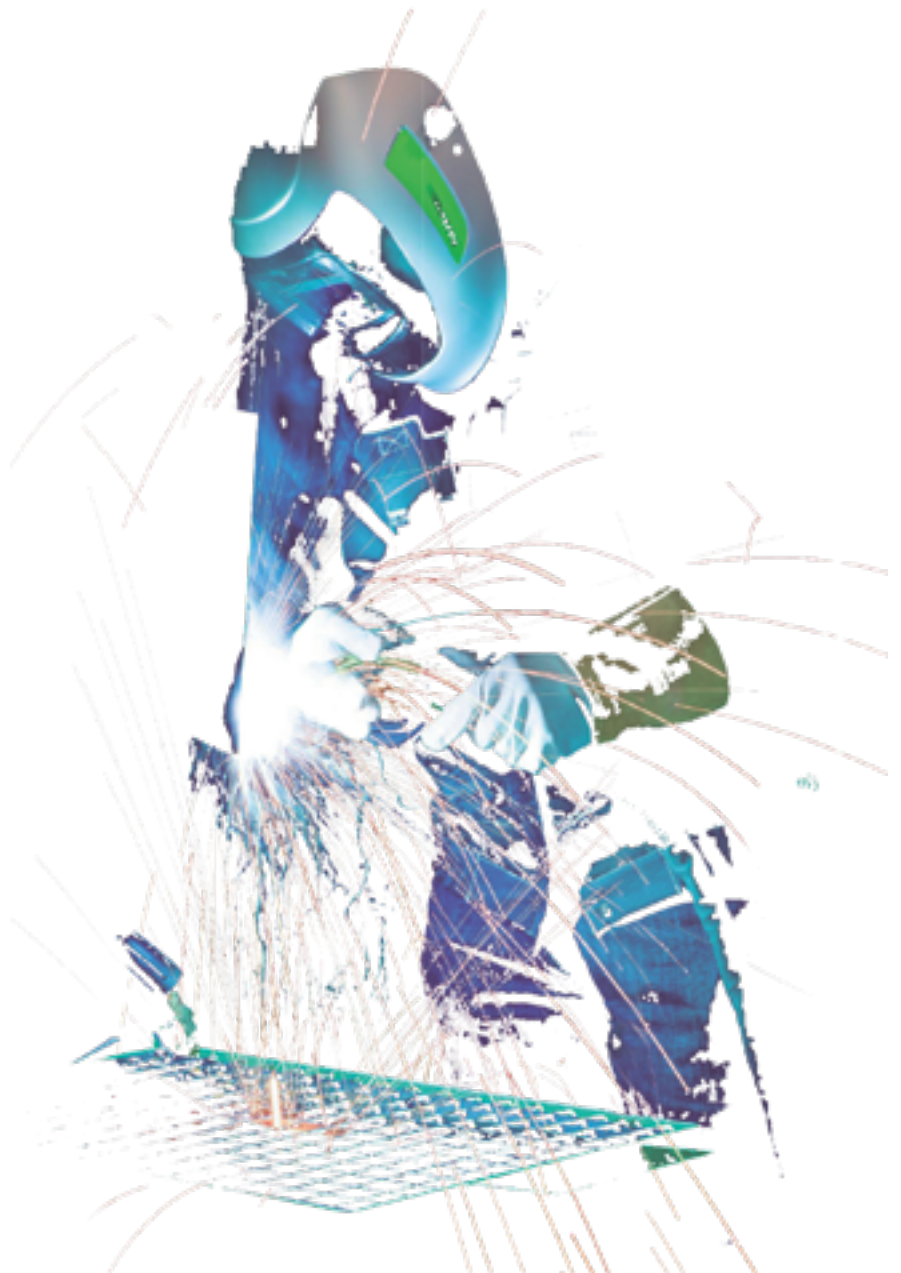
Regarding joining methods, the same used for carbon steel are effective, such as stainless steel wire, metallic connectors and welding with the accurate metal filler selection.

Rebarinox® counts on a verified protocol on welding with carbon steel, according to UNE-EN-ISO 15614-1:2018 standard (1).

In addition, welding austenoferritic stainless steel rebar to carbon steel rebar or duplex stainless steel rebar technical instruction is available at [www.cedinox.es](http://www.cedinox.es).



(1)





**The use of stainless steel reinforcement bars in combination with carbon steel bars in concrete structures, is a common practice included in the Structural Code.**



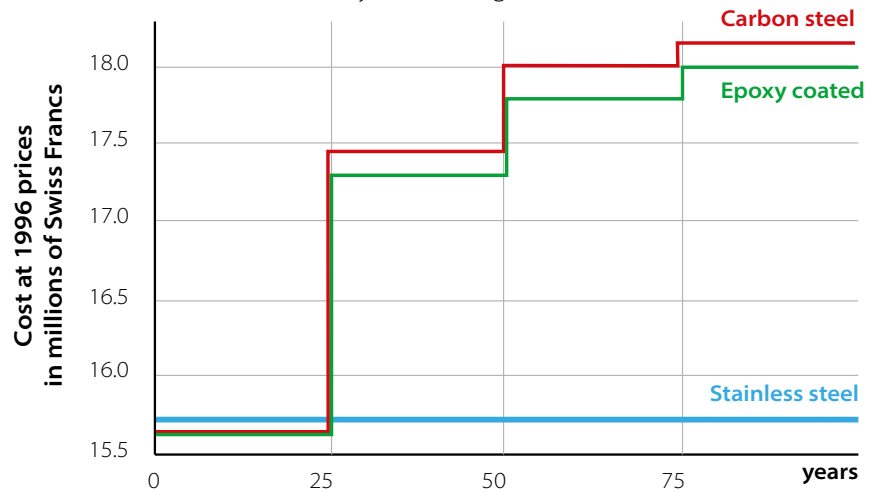
# Where should we use Rebarinox®?

Rebarinox® is specially recommended in long lifespan projects, located in aggressive environments, specially with chlorides from melting-ice salts, or because its presence in different processes like desalination, water treatment, and others. Repairs, inspections or rehabilitations of these projects are very expensive and often impossible to execute.

It should be reminded that the highest stainless steel initial cost in concrete structures, increases less than 3% of total costs ensuring more than 100 years of life. This initial investment will bring 15% saving along the whole project life.

## SCHAFFHAUSEN BRIDGE

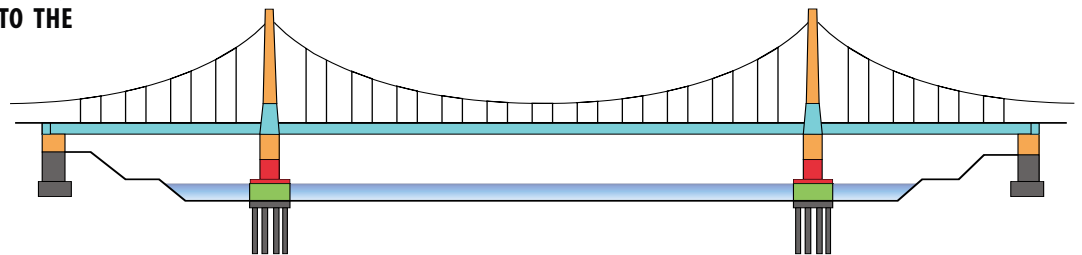
Analysis for Design Life (LCC)



Data from TR51 Guidance on the use of stainless steel reinforcement. Concrete Society

Rebarinox® installation in critical parts of the project will guarantee higher durability, eliminating the **RELATED COSTS TO THE PROJECT LIFE:**

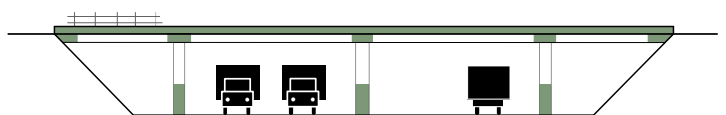
- Maintenance.
- Losses resulting from future income.
- Periodic inspections costs.
- Replacement material costs.
- Bureaucratic and administrative expenses.



Atmospheric zone    Deck and De-icing Salt Spray zone    Submerged zone    Splash zone    Embedded zone



Bridge cross section



Bridge longitudinal section

Source: Arminox





**The use of stainless steel reinforcement enables to reduce coatings in certain categories of exposure, according to current Structural Code. Rebarinox® guarantees higher durability.**

# Which Rebarinox® grade should be used?

The installation of Rebarinox® will allow:

- Reducing required wall thickness.
- Increasing maximum acceptable crack width, according to every country standardization.

Stainless steel grades with less alloy content such as ferritic Rebarinox® ACX 702 would not be affected by carbonation while duplex Rebarinox® ACX 915 and ACX 917 would withstand carbonation and aggressive environment attacks, mainly chlorides.

Some Rebarinox® use recommendations, depending on the exposure conditions according to EUROCODE are:

CLASS (environment)	SUBCLASS	EUROCODE	TYPE OF PROCESS		RECOMMENDED STAINLESS STEEL	
					EN	REBARINOX®
Non-aggressive		X <sub>0</sub>	None	Inside areas with low humidity.	Not necessary	
NORMAL	High humidity	X <sub>C1</sub> /X <sub>C2</sub>	Corrosion due to carbonation	Inside areas with humidity > 65%	1.4003	702**
	Medium humidity	X <sub>C3</sub> /X <sub>C4</sub>	Different cause from chlorides	Outside areas with frequent/moderate rain	1.4482	903
MARINE	Aerial	X <sub>S1</sub>	Corrosion due to chlorides	Near the coast structures	1.4362	915
	Submerged	X <sub>S2</sub>		Submerged structures		
	Tidal and splash zones	X <sub>S3</sub>		Elements in marine structures	1.4462	917
With CHLORIDES DIFFERENT FROM SEA ONES		X <sub>D1</sub> /X <sub>D3</sub>		Indoor swimming pools Water treatment		
FROST	NO DE-ICING SALTS	X <sub>F1</sub> /X <sub>F3</sub>	Exposed to icing and de-icing attacks areas		1.4482 1.4301/1.4307*	903 217
	DE-ICING SALTS	X <sub>D1</sub> /X <sub>D3</sub>	De-icing salts attacks		1.4362 1.4462 1.401/1.4404*	915 917 359

The following situations can occur independently or in combination with the previous ones

CHEMICALLY AGGRESSIVE	LOW	X <sub>A1</sub>	Chemical attack	1.4003 / 1.4482	702** / 903
	MEDIUM	X <sub>A2</sub>		1.4362	915
	HIGH	X <sub>A3</sub>		1.4462	917

\* Recommended grades below -50°C, on request

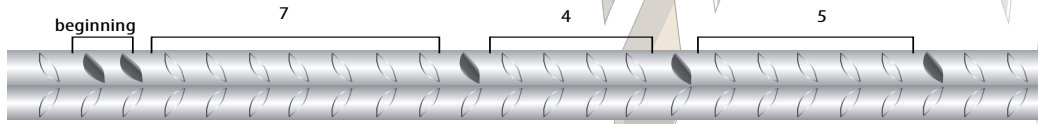
\*\* On request



**The Structural Code enables the limitation of maximum crack width, less restrictive in case of using stainless steel in the transverse reinforcement, as in the outer lengthwise part.**

# Rebarinox® identification

## Manufacturer identification



## CANADA [G30.18-09]

Ø mm	Designation	Identification
11.3	10	R 10 S S ..
16	15	R 15 S S ..
19.5	20	R 20 S S ..
25.2	25	R 25 S S ..
29.9	30	R 30 S S ..
35.7	35	R 35 S S ..

## Certificates

Rebarinox® meets the following international standards:

XP A 35-014	ASTM A 955	PNE 36067
BS 6744	TC 104WI EC104031:2016	



Available with the CARES Cloud App

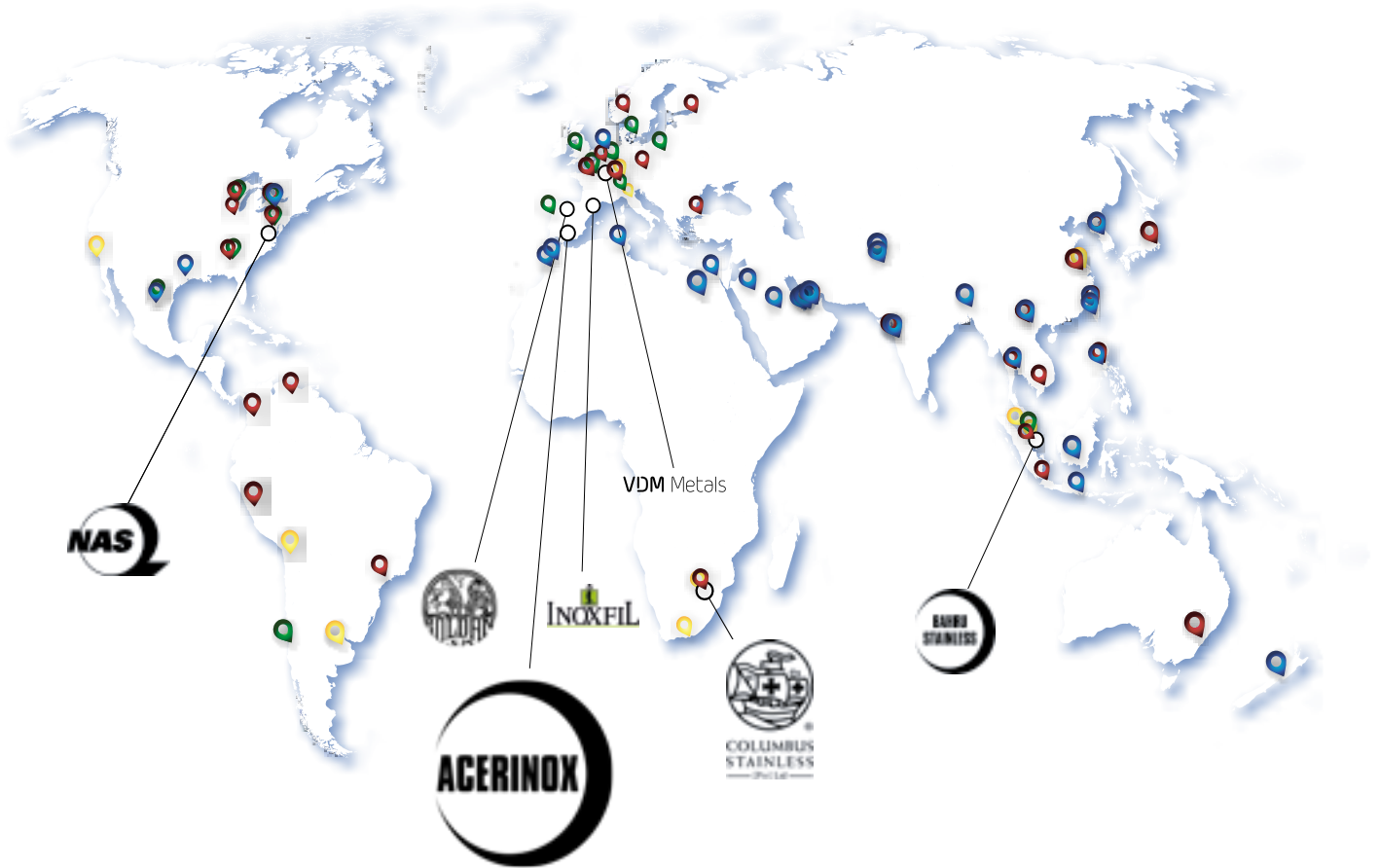


Industrie Service



**Rebarinox®**, a  
necessary ally in  
The Sagrada Familia  
culmination

# Acerinox: the confidence of a strong group



Acerinox is the Spanish multinational global leader in stainless steel manufacturing. With a total production capability of 3.5 million tonnes per year. Acerinox owns factories in five continents confirming its global presence, stainless steel flat products manufacturing at Acerinox Europa, North American Stainless, Columbus and Bahru Stainless; and Roldan, Inoxfil and North American Stainless for long products manufacture. In March 2020, VDM Metals, worldwide leader in high performance alloys manufacture and design, also takes part of the group.

Every Acerinox facility satisfies the quality and environmental controls required by each country legislation, apart from the application of the Environmental Management System according to ISO 14001.

Furthermore, subsidiaries assume higher standards than legal requirements in areas such as quality, safety and sustainability.

Scrap plays a key role in all Acerinox fabrication processes. Thus, a great value is added bringing it back to the material life cycle, reducing the environmental impact with the use of the same material for centuries.

Acerinox is one of the major scrap recyclers wherever is located. The production in the factories of Acerinox is transformed into final products which return to the factories as scrap to be melted again. This is a cycle that could be infinite due to the material properties.



**The Acerinox commitment to new production systems with the most advanced and efficient energy consumption technology, is a good example of the Group concern with the emissions reduction.**

# Rebarinox® recommendations

## Transport & handling

Before shipping, make sure every chain and steel element is not in contact with stainless steel rebar. Raffia or wooden elements must be used at possible contact places.



When stainless steel and carbon steel bars must be overlapped, stainless steel must be on top and a spacer element should be used between both materials to avoid any stainless steel contamination from carbon steel.



When outside storage is required, material should be covered by a waterproof canvas.



Avoid contact with the ground using wooden blocks and store stainless steel and carbon steel separately. This way we avoid problems with contamination by oils, dirt or by contact among different materials.



When rebar has to be moved with lift trucks, the forks should be protected with nylon.



Avoid carbon steel slings, use nylon or polypropylene ones wherever possible.

## Manufacturing & installation

Make sure stainless steel rebar is contamination free before starting to work. If there is any, it will be removed by pickling or mechanical means (\*).



If cleaning is required, do it with pressurized water. Do not use sea or brackish water.



All tools employed in the installation must be made of stainless steel and these should have been never used with carbon steel. If this is not possible, tools must be carefully cleaned before use.



Stainless steel should be processed in machines exclusively dedicated to this material, in order to avoid contamination by projections or oxide traces from other materials.



Excessive temperature oxidation or *blueing* due to abrasive cutting, should be removed with pickling paste. Good refrigerated cutting tools help to avoid the problem.



It must be considered that stainless steel bending process involves higher effort than carbon steel does, and it also has "memory" or spring effect.

Rebarinox® can be welded using many welding techniques. Edges should always be cleaned from dirt, oil or grease and use the right electrodes and filler material (\*).



After welding, slag and oxidation must be removed by mechanical or pickling methods.



Bars should be joined with stainless steel wire or specific connectors.



Stainless steel connectors do exist to join bars along the length.



In order to avoid any galvanic corrosion, wire must have the same corrosion level than stainless steel reinforcement bar. Mostly used are 316L or duplex.

(\*). Contact your supplier



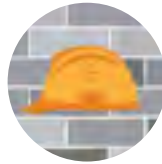


**The right handling and processing of the product is the key to the project success.**

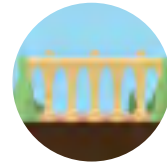
# Some Rebarinox® projects



Blackpool, Ireland  
 Monaco extension to the sea  
 (Photo in page 17)  
 Sohar Harbour, Sultanate of Oman  
 Jebel Ali Free extension, United Arab Emirates  
 Ras Laffan Gas Loading Piers, Qatar  
 Pearl Island, Doha, Qatar



Modern Art Museum, Vitoria, Spain  
 Santa Catalina Church, Seville, Spain  
 Church of Santiago, Spain  
 Jerez de los Caballeros Wall, Spain  
 Segovia Cathedral, Spain  
 Eiffel bridge rehabilitation, Portugal








Queensferry Crossing, Scotland  
 Champlain Bridge, Montreal, Canada  
 (Photo page 27)  
 Sheikh Zayed Bridge, Abu Dhabi, United Arab Emirates  
 Sitra Bridge, Bahrain  
 Shenzhen Western Corridor Bridge, Hong Kong  
 Hastings Bridge, Hastings MN, USA  
 (Photo in page 13)  
 Hong Kong – Macao Bridge  
 (Photo in page 15)



Parking in Boston airport, USA  
 Copenhagen Metro, Denmark  
 La Sagrada Familia, Barcelona, Spain (Photos in page 21)  
 Qasr al Alam Guest Palace, Muscat, Sultanate of Oman  
 Museum of Islamic Art, Doha, Qatar



AVE Leon – Palencia, Spain  
 (Photo in page 11)  
 Mediterranean Highway, Spain  
 Connection between Garden State- I80. New Jersey, USA  
 Glacier National Park, Flathead River. Southeast Essex, Montana, USA

-  Harbours, piers, maritime works
-  Rehabilitation
-  Bridges
-  Roads, transport
-  New construction

Technical enquiries to our specialists at [www.cedinox.es](http://www.cedinox.es)



Commercial network at [www.acerinox.com](http://www.acerinox.com)





quality  
effective  
sustainable  
corrosion resistance  
**REBARINOX®**  
the solution  
profitable  
durable  
innovative  
ally  
suitable  
proven  
weldable  
efficient

We thank customers, suppliers and colleagues for their loyalty, recognition and cooperation. Without them our work would not be possible. We would also like to thank companies such as IDOM, ARMINOX, TRYCSA, SENDIN and many others, for welcoming us to make some of the pictures shown in this publication, and to many others for providing their own.

# ACERINOX



VDM Metals

