Design and evaluation of new and existing stainless steel structures in Europe

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“Surely, there is a better way?”

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"There is a better way – find it"

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EN1993-1-4 Annex A

Selection of materials and durability

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Steel Knowledge

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knowledge for a brighter future

ACERINOX

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Bundesanstalt für
Materialforschung
und -prüfung

euro inox
The European
Stainless Steel
Development Association

Annex A 2015 - Significant changes

- The Annex is "**Normative**"

- Introduces concepts of Corrosion Resistance Factor – **CRF** and Corrosion Resistance Class - **CRC**

Table A.1: Determination of Corrosion Resistance Factor CRF = $F_1 + F_2 + F_3$

F_1 Risk of exposure to chlorides from salt water or deicing salts		
NOTE M is distance from the sea and S is distance from roads with deicing salts.		
1	Internally controlled environment	
0	Low risk of exposure	M > 10 km or S > 0,1 km
-3	Medium risk of exposure	1 km < M ≤ 10 km or 0,01 km < S ≤ 0,1 km
-7	High risk of exposure	0,25 km < M ≤ 1 km or S ≤ 0,01 km
-10	Very high risk of exposure	Road tunnels where deicing salt is used or where vehicles might carry deicing salts into the tunnel
-10	Very high risk of exposure	M ≤ 0,25 km North Sea coast of Germany and all Baltic coastal areas
-15	Very high risk of exposure	M ≤ 0,25 km Atlantic coast line of Portugal, Spain and France. English Channel and North Sea Coastline of UK, France, Belgium, Netherlands and Southern Sweden All other coastal areas of UK, Norway, Denmark and Ireland Mediterranean Coast
F_2 Risk of exposure to sulfur dioxide		
For European coastal environments the sulfur dioxide concentration is usually low. For inland environments the sulfur dioxide concentration is either low or medium. The high classification is unusual and associated with particularly heavy industrial locations or specific environments such as road tunnels. Sulfur dioxide concentration may be evaluated according to the method in ISO 9225.		
0	Low risk of exposure	< 10 μg/m³ average gas concentration
-5	Medium risk of exposure	10 - 90 μg/m³ average gas concentration
-10	High risk of exposure	90 - 250 μg/m³ average gas concentration
F_3 Cleaning regime or exposure to washing by rain (if $F_1+F_2 \geq 0$, then $F_3 = 0$)		
0	Fully exposed to washing by rain	
-2	Specified cleaning regime	
-7	No washing by rain or No specified cleaning	
If the component is to be regularly inspected for any signs of corrosion and cleaned, this should be made clear to the user in written form. The inspection, cleaning method and frequency should be specified. The more frequently cleaning is carried out, the greater the benefit. The frequency should not be less than every 3 months. Where cleaning is specified it should apply to all parts of the structure, and not just those easily accessible and visible.		

EN 1993-1-4 Annex A [normative] Selection of materials and durability

Table A.2: Determination of Corrosion Resistance Class CRC

Corrosion Resistance Factor (CRF)	Corrosion Resistance Class (CRC)
CRF = 1	I
0 ≥ CRF > −7	II
-7 ≥ CRF > −15	III
-15 ≥ CRF ≥ −20	IV
CRF < −20	V

Table A.3: Grades in each Corrosion Resistance Class CRC

Corrosion resistance class CRC				
I	II	III	IV	V
1.4003	1.4301	1.4401	1.4439	1.4565
1.4016	1.4307	1.4404	1.4462	1.4529
1.4512	1.4311	1.4435	1.4539	1.4547
	1.4541	1.4571		1.4410
	1.4318	1.4429		1.4501
	1.4306	1.4432		1.4507
	1.4567	1.4162		
	1.4482	1.4662		
		1.4362		
		1.4062		
		1.4578		
A grade from a higher class may be used in place of the class indicated by the CRF.				
NOTE: The corrosion resistant classes are only intended for use with this grade selection procedure and are only applicable to structural applications.				

A.3 Swimming pool environments

(1) To address the risk of stress corrosion cracking (SCC) in pool atmospheres, only the steel grades given in Table A.4 shall be used for load bearing parts exposed to atmospheres above indoor swimming pools.

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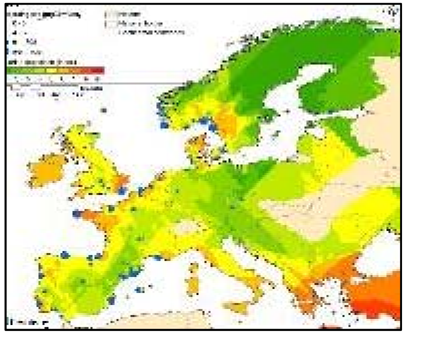
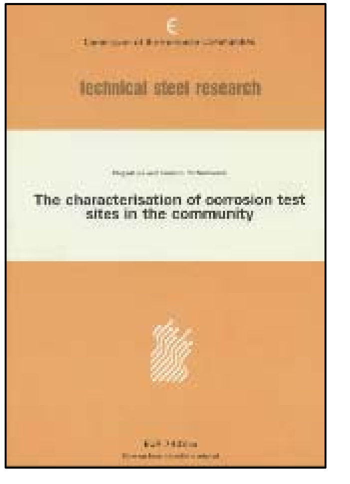
CRF and CRC Evaluation

Chloride exposure **F1**

- Direct operating experience
- Exposure test site data in Europe
- Chloride mapping data
- Chloride deposition data





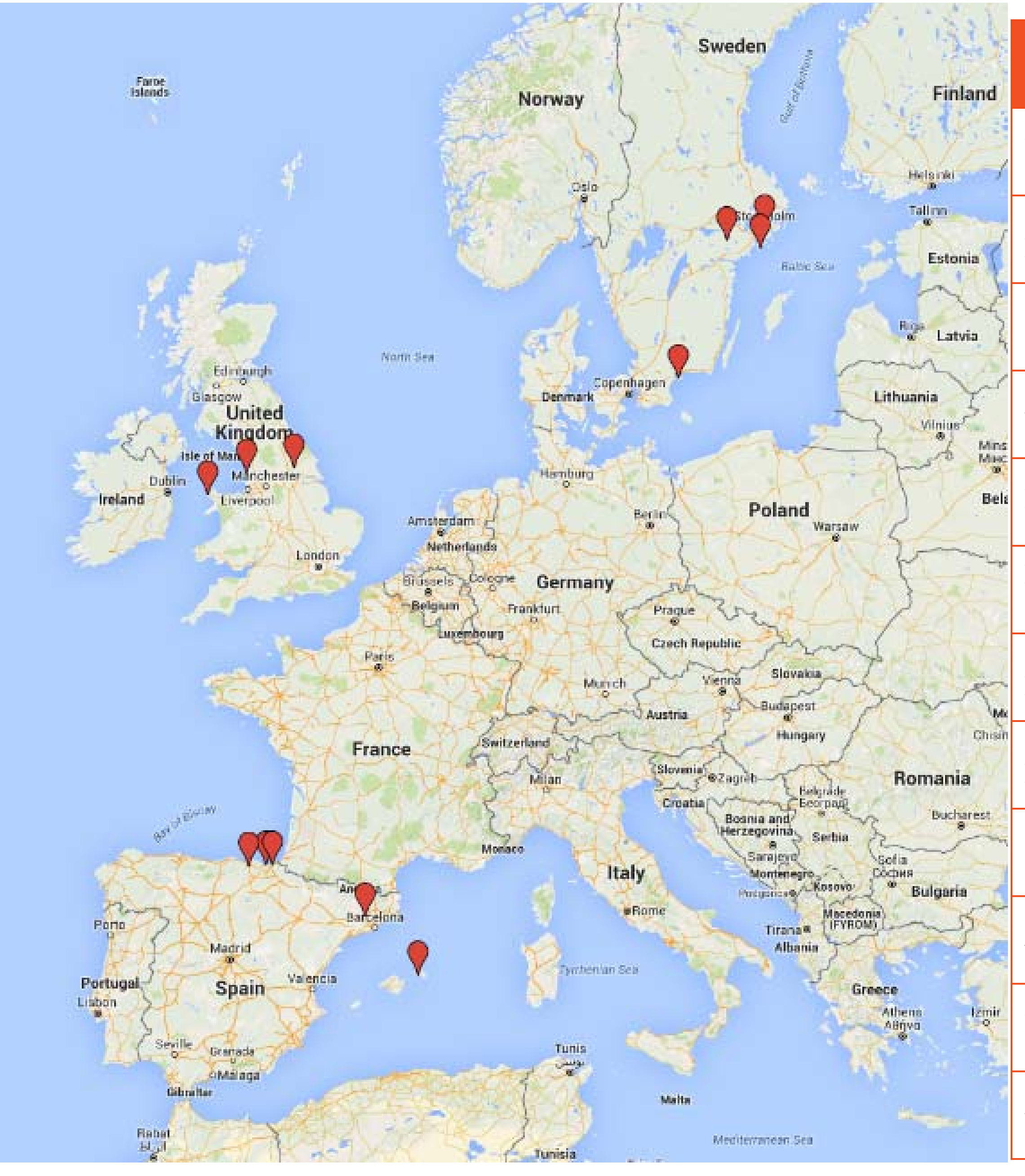
Example Specification

f_y = 200 N/mm^{-2} CRC II (Austenitic with no Mo)

f_y = 450 N/mm^{-2} CRC III (Lean duplex)

The final choice of alloy is for the supplier

Annex A – real structures



Structure name	Location	Year of construction
Sölvesborg Pedestrian and Cycle Bridge	Solvesborg, Sweden	2013
Orrhammarvägen Bridge	Flen, Sweden	2009
Sicklauddsbron	Stockholm, Sweden	2002
Nynashamn road bridge	Nynashamn, Sweden	2011
Millennium Bridge	York, United Kingdom	2000
Blackpool seafront (various elements)	Blackpool, United Kingdom	Circa 2000-2010
Celtic Gateway Bridge	Holyhead, United Kingdom	2006
Sant Fruitós Bridge	Manresa, Spain	2009
Zumaia footbridge	Zumaia, Spain	2008
Anorga bridge	San Sebastian, Spain	2011
Puerto Arrupe	Bilbao, Spain	2003
Cala Galdana bridge	Menorca, Spain	2005

Various foreshore elements, Blackpool, England
Various architects, 2002—

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Various architects, 2002—

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Various architects, 2002—

Celtic Gateway Bridge, Holyhead, Wales
2006. Alloy 1.4362 for the structure

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2006. Alloy 1.4362 for the structure

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Nynashamn road bridge, Nynashhamn, Sweden
2011. Alloy 1.4162

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Nynashamn road bridge, Nynashhamn, Sweden
2011. Alloy 1.4162

Nynashamn road bridge, Nynashhamn, Sweden
2011. Alloy 1.4162

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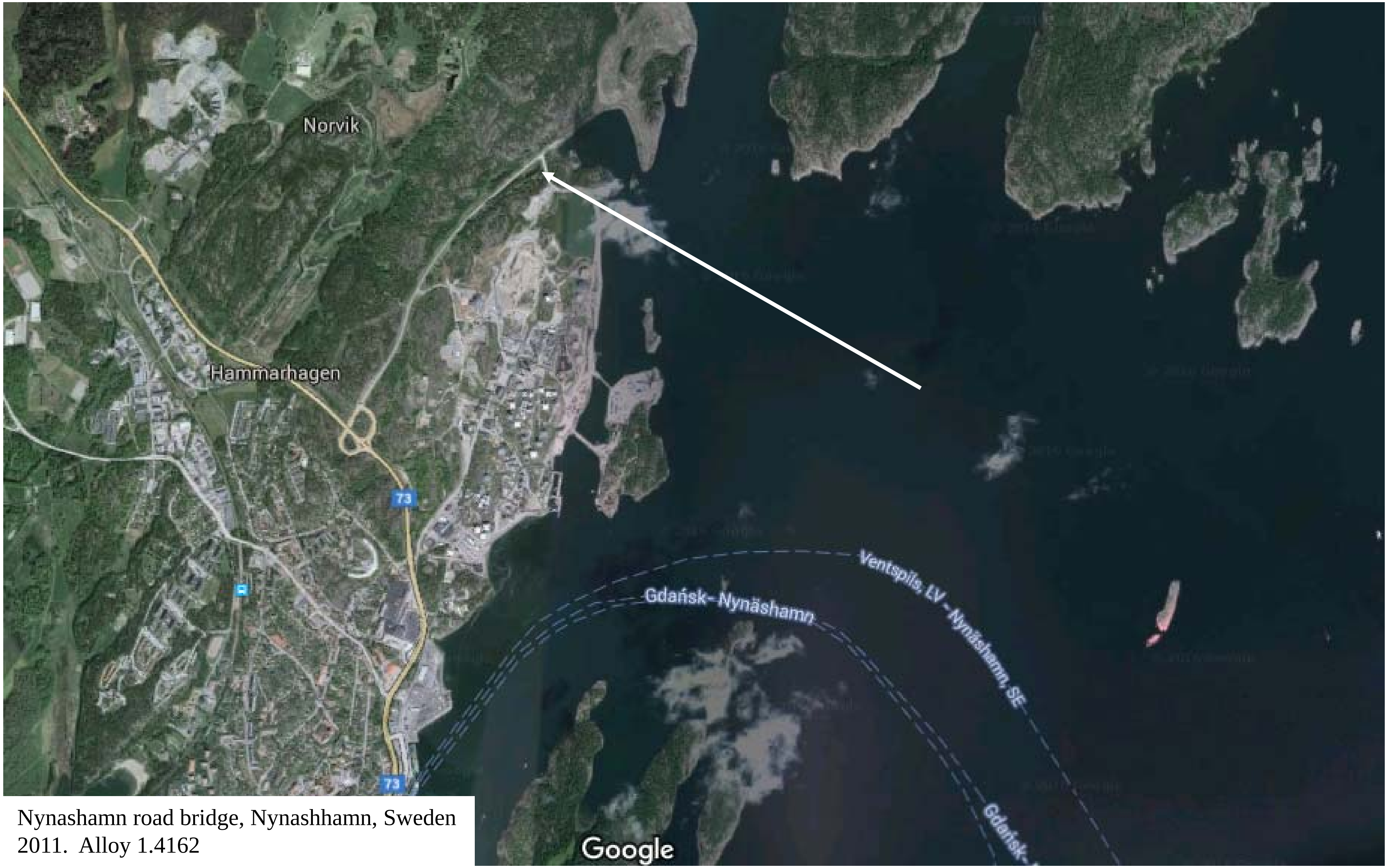
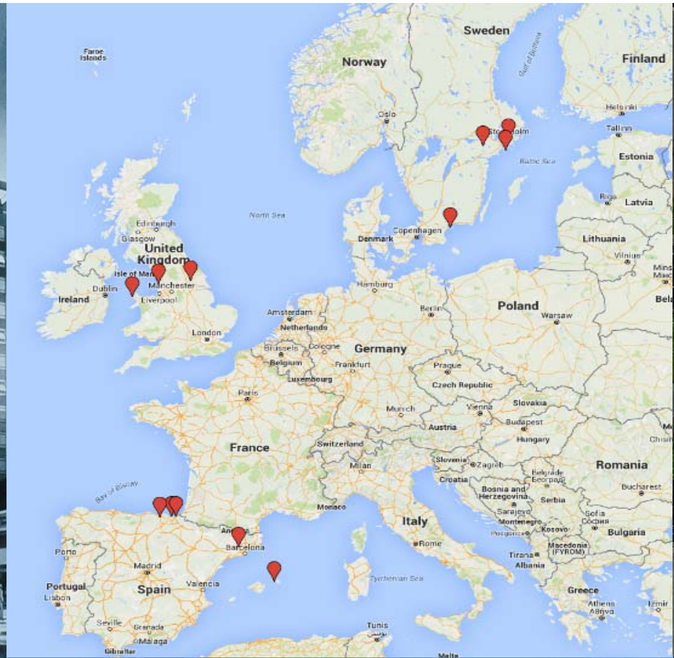
Nynashamn road bridge, Nynashhamn, Sweden
2011. Alloy 1.4162



Nynashamn road bridge, Nynashhamn, Sweden
2011. Alloy 1.4162

Lessons learned?

- Annex A is consistent with performance
- Lean duplex outperform assumptions
- Requires better guidance on assessing the environment



Sweden
Norway
Finland
Faroe Islands
Oslo
Helsinki
Tallinn
Estonia
Latvia
Lithuania
Copenhagen
Denmark
North Sea
Edinburgh
Glasgow
United Kingdom
Isle of Man
Dublin
Ireland
Manchester
Liverpool
London
Hamburg
Amsterdam
Netherlands
Berlin
Poland
Warsaw
Brussels
Belgium
Cologne
Germany
Frankfurt
Luxembourg
Prague
Czech Republic
Paris
Munich
Vienna
Slovakia
Austria
Budapest
Hungary
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Italy
Bulgaria
Rome
Albania
Tyrrhenian Sea
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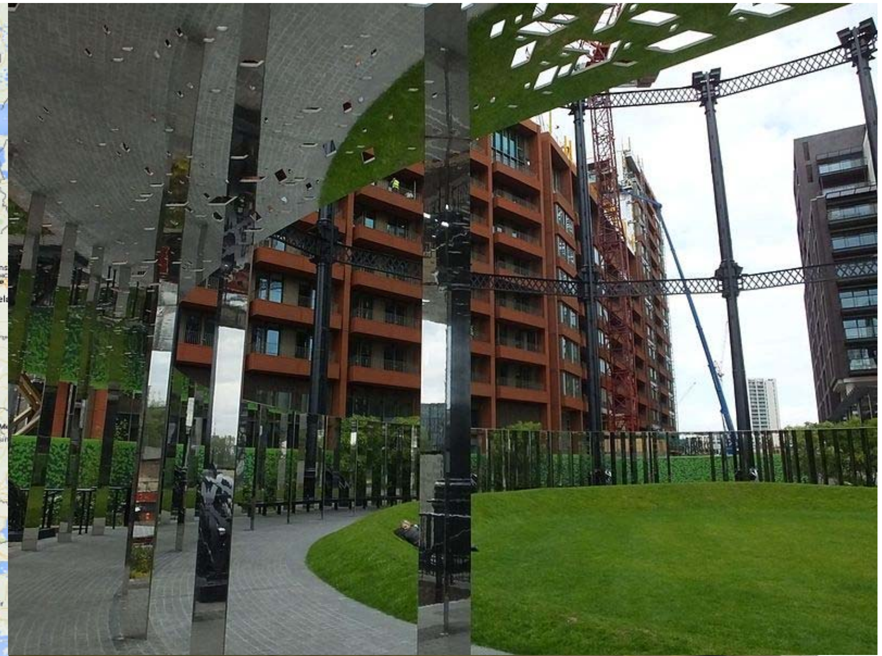
Malta



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