

Connecting weathering steel with other materials

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SSAB

Agenda

PATINA FORMATION

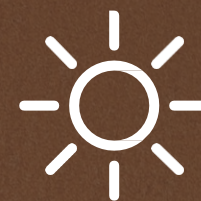
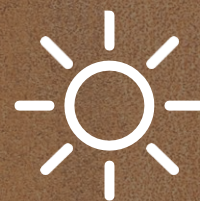
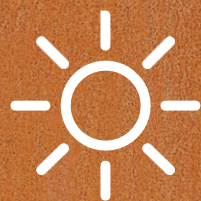
FACTORS TO CONSIDER & WHICH MATERIALS CAN BE CONNECTED WITH WEATHERING STEEL

TYPICAL CONNECTIONS IN A WEATHERING STEEL STRUCTURE

EXAMPLES OF WEATHERING STEEL CONSTRUCTIONS

SUSTAINABLE CONSTRUCTION USING WEATHERING STEEL

Patina formation process



- Frequent cycles of wet and dry weather conditions will speed up the patina formation process
- To maintain an even patina, it's recommended that water can run off freely and not stay on the surface. In a sheltered location with damp conditions, COR-TEN® may not adopt the intended color
- The color changes from fresh, newly developed orange-brown, to light and eventually dark brown

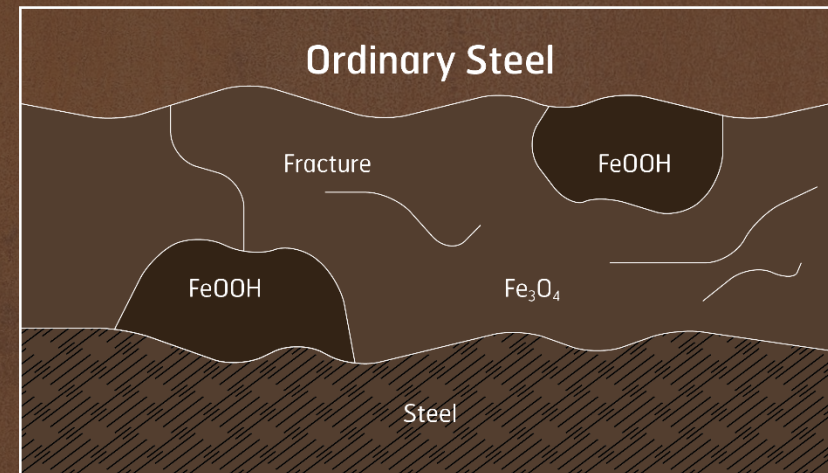
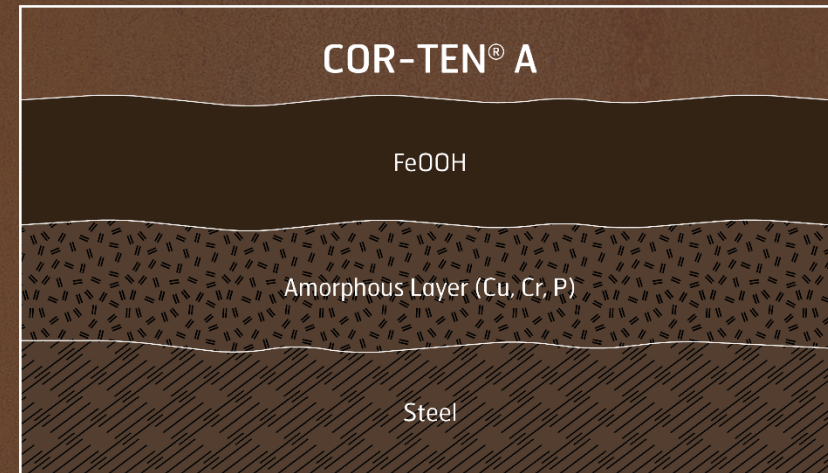
FAQ

How long does it take the patina to fully develop?

The speed of change and the final color of the steel depend on the atmospheric conditions of a site and the surrounding air quality. Expect 2-6 years for the patina to fully develop.

Corrosion aspects of Weathering & steel

- The corrosion resistance of weathering steels is based on preventing the penetration of water and oxygen to the steel surface.
- A more uniform and dense oxide layer, FeOOH, is formed. Enrichment of alloying elements are beneficial for oxide layer formation.
- The pores in the rust patina are plugged by the formation of insoluble sulphates originating from atmospheric pollutants [SO₂].
- In ordinary steel the oxide layer is inhomogeneous. Fractures and pores enable rust to proceed gradually.
- Based on a 32-year long study by VTT Technical Research Centre of Finland,² COR-TEN[®] material loss has been only 70µm (meaning 0.07mm).



² VTT report: VTT-CR-05247-14, Säämkestävien teräslevyjen korroosiotutkimus v. 2014, Leena Carpen

Factors to be considered before connecting weathering steel with other materials

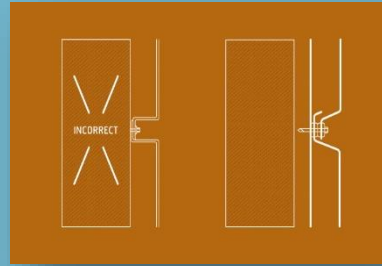
Compatible materials to avoid galvanic corrosion



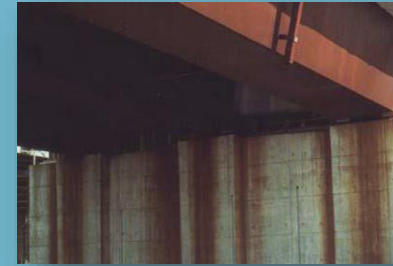
Surface area of connection



Avoid crevice corrosion



Avoid rust water stain



**Type of connection
Bolts, welding**




Which materials can be combined with weathering steel?

Most susceptible for corrosive attack
Less noble
Anodic



Less susceptible for corrosive attack
More noble
Cathodic

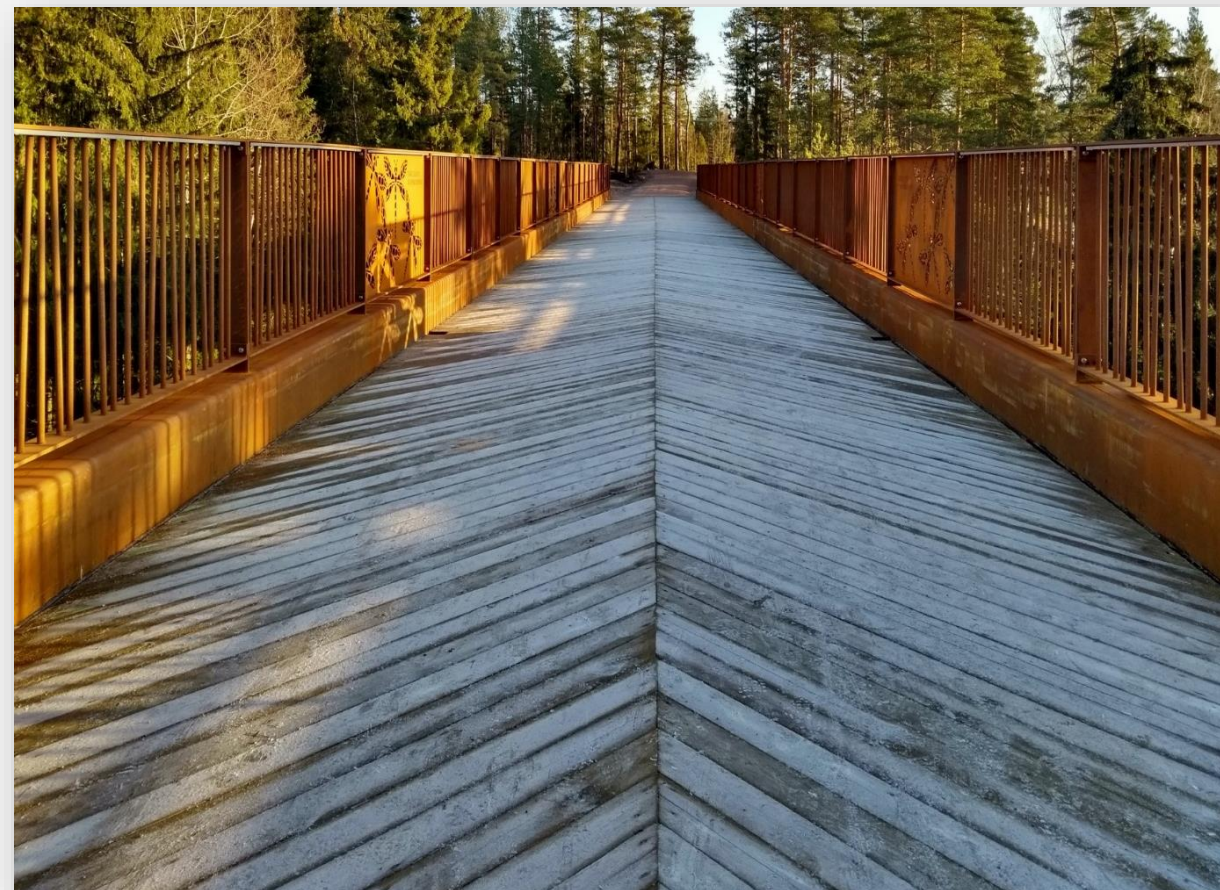
Materials in ascending order of electro potential	Recommendation for connection with weathering steel – Bolts, Screws
Magnesium	
Zinc / Hot –dipped galvanized steel	✓
Aluminum	✓
Patinated weathering steel	✓
New weathering steel / carbon steel	✓
Brass	
Copper	
Bronze	
Stainless steel	✓


 Most common

Which materials can be combined with weathering steel?

Materials	Recommendation for connection with weathering steel
Concrete	<input checked="" type="checkbox"/>
Glass	<input checked="" type="checkbox"/>
Wood*	<input type="checkbox"/>
Painted carbon steel	<input checked="" type="checkbox"/>
Plastic	<input checked="" type="checkbox"/>
Brick	<input checked="" type="checkbox"/>

- * Impregnated wood has some copper and can cause galvanic corrosion
- * When wood & weathering steel are connected, it is good to insulate with sealants (rubber)
- * Appropriate corrosion allowance to be added when connecting with wood
 - Sealants recommended to be used with all materials to avoid crevice corrosion
 - Rust water run-off before stabilization of patina to be ensured to avoid rust stain



 Most common

Relative Surface area of connecting materials

More noble than weathering steel

- ▶ E.g; Stainless steel
- ▶ Surface area of weathering steel >>> surface area of connecting Stainless steel
- ▶ Stainless steel & weathering steel sheets cannot be connected together!

Less noble than weathering steel

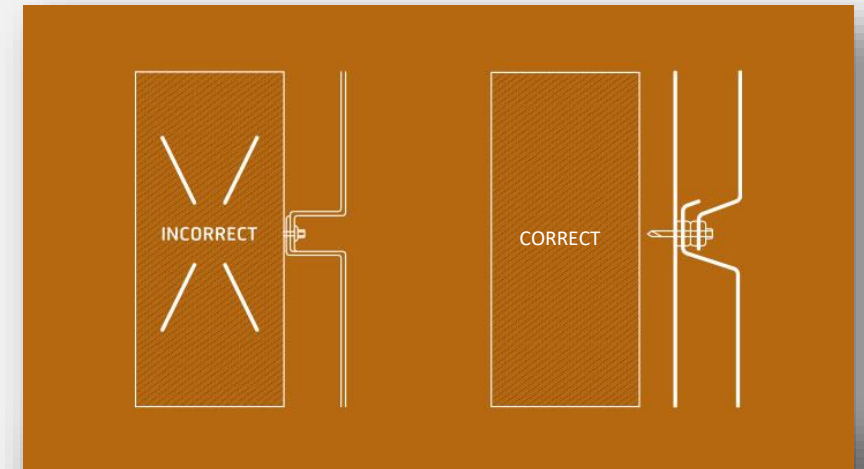
- ▶ E.g; Galvanized steel
- ▶ Galvanized steel works with weathering steel
- ▶ Galvanized bolts – have enough coating to withstand the years of rust patina development with only a minimal loss in coating life
- ▶ With Galvanized bolts, there is a risk for zinc hydroxide runoff



- Vähäkangas Bridge, Ylivieska, Finland
- Galvanized corrugated bridge deck connected to weathering steel girder
- Bridge constructed in 1981; 41 years old

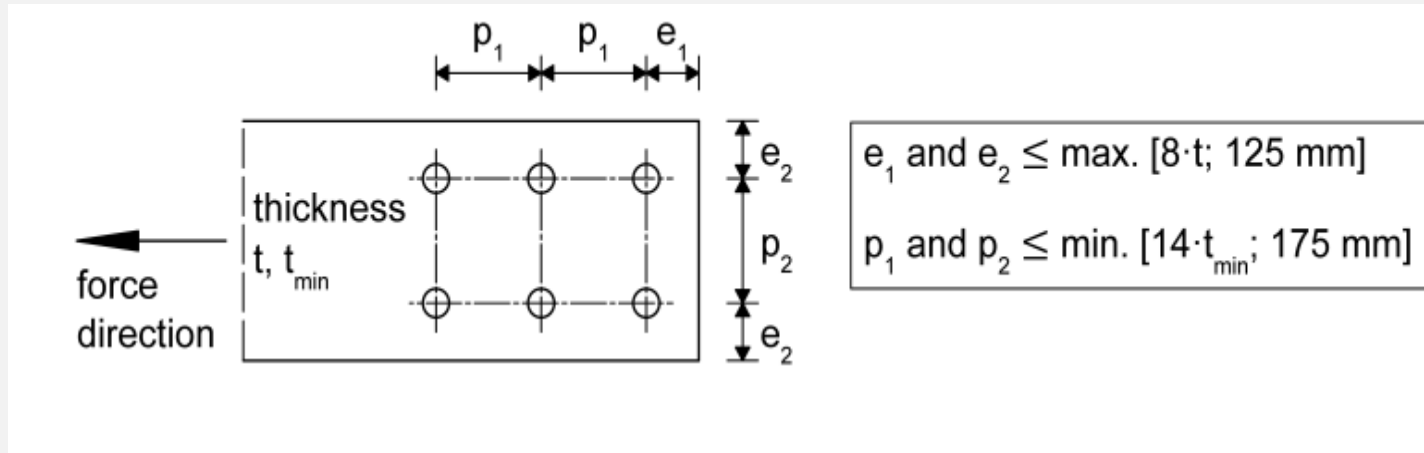
How to avoid crevice corrosion in lap joints?

- ▶ Avoid direct contact between steel surfaces
- ▶ Leave a ventilation gap of at least 1 mm between steel sheets to ensure
 - Free airflow together with water and moisture escape from surfaces and back side.
 - Surfaces must not collect dirt and water
- ▶ In facade cladding, sufficient ventilation to be given. Ventilation shall be full length and at least 30 mm wide.



How to avoid crevice corrosion in bolted connections?

Minimum and maximum spacing, end and edge distances



Tightness of the bolts is important to prevent crevice corrosion

Sealents

Fastening of a façade cassette's horizontal seam using acid-resistant stainless steel screws

Sealents are used to

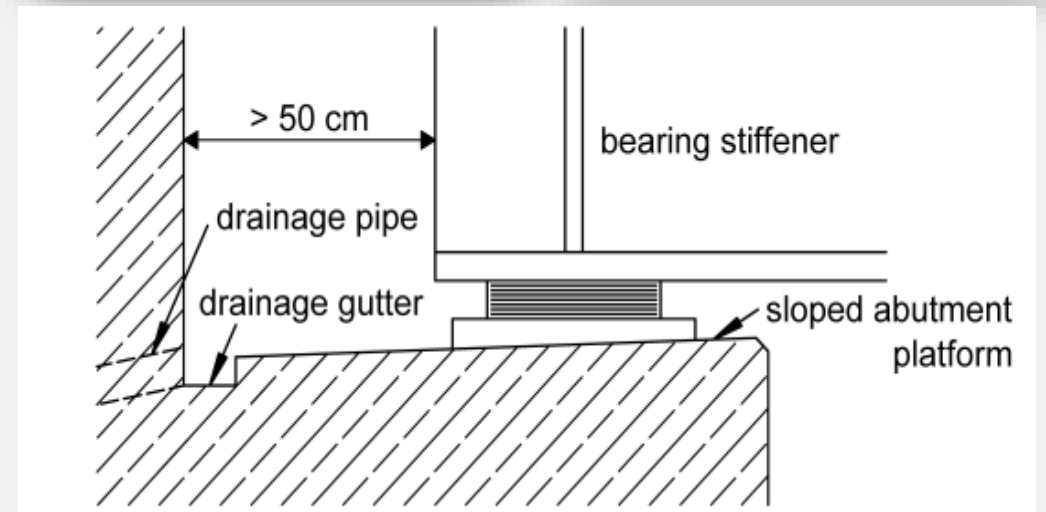
1. Avoid tightness between bolts/screws and connecting surface to prevent crevice corrosion
2. Avoid direct contact between materials so as to prevent galvanic corrosion
3. If stainless screws are used, use EPDM (ethylene propylene diene terpolymer) or neoprene "x" to avoid galvanic corrosion



How to avoid rust stains during initial years of patina layer stabilization?

- ▶ Water run-off to be collected and drained until patina layer stabilization
- ▶ If this is not possible, substructures could be sealed with washable organic coatings to facilitate cleaning

Materials that can be cleaned	Materials that are difficult to clean
Stainless steel	Concrete and Mortar
Aluminum	Galvanized steel
Semi-matte / glossy enamel coating	Matte enamel coating
Neoprene	Stone
Glass	Wood
Ceramic tiles/glazed tiles	Unglazed brick



Bolts – Materials

- ▶ **Blast cleaning the surface** – Faying surface quality has a role to play
- ▶ **Tensioned / high strength friction grip bolts** – to ensure close contact
- ▶ **Slip resistant connections** are needed when there are fatigue loads - to transfer of shear load between two faying surfaces or structural connections.
- ▶ **Even in patina surface slip resistant connections work** and patina does not have effect of this.
- ▶ **Weathering steel M24 & M30 bolts** are available from manufacturers in UK.

Weather resistant bolts

As per EN 1090-2, Type 3 Grade A fasteners to ASTM standard A325 would be suitable

Their mechanical requirements as per EN 14399-1 or EN 15048-1

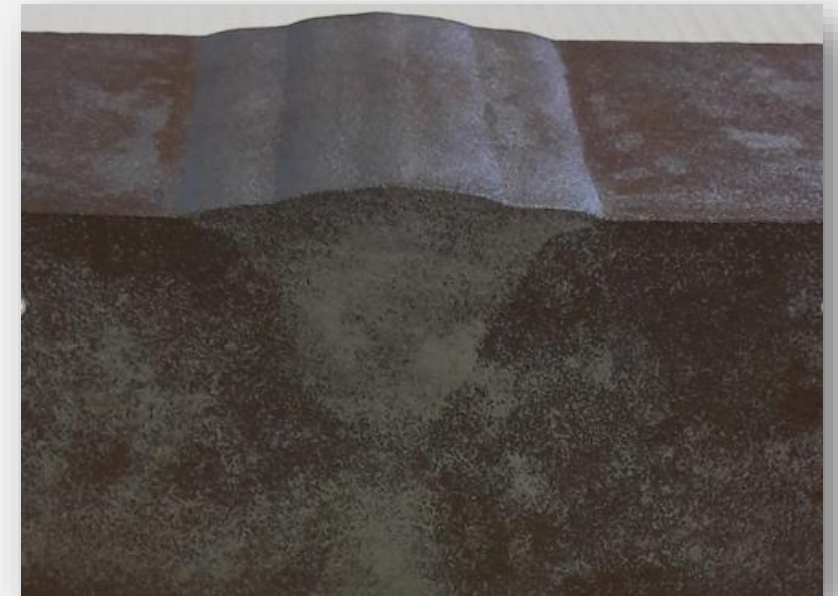


Materials for bolts/ screws in order of recommendation

1. Weathering steel
2. Stainless / other noble metals
3. Galvanized
4. Powder coated / painted

Welded connections of Weathering steel

- ▶ **Weathering steel is weldable using common welding processes**
- ▶ Welding is recommended between **weathering steel, carbon steel & weathering steel.**
- ▶ Welding consumables recommendations as per EN 1090-2
 - **Alternative 1** recommends consumables to be similar to parent material, typically with
0,5 % Cu + 0,5 % Ni in weathering steels (BA S2NiCu)
 - **Alternative 2** recommends using 2 % Ni when welding with SAW



Process	Alternative 1	Alternative 2	Alternative 3
Manual metal Arc Welding (MMAW)	Matching	2,5% Ni	1 % Cr 0,5 % Mo
MAG welding	Matching	2,5% Ni	1 % Cr 0,5 % Mo
Submerged Arc Welding (SAW) with strip & multiple wired electrodes	Matching	2% Ni	1 % Cr 0,5 % Mo

Matching: 0,5% CU and other alloy elements

Welding consumables to be as per EN1090-2

Typical connections in a Weathering steel bridge

Bolts



Weathering / acid resistant Stainless

Deck



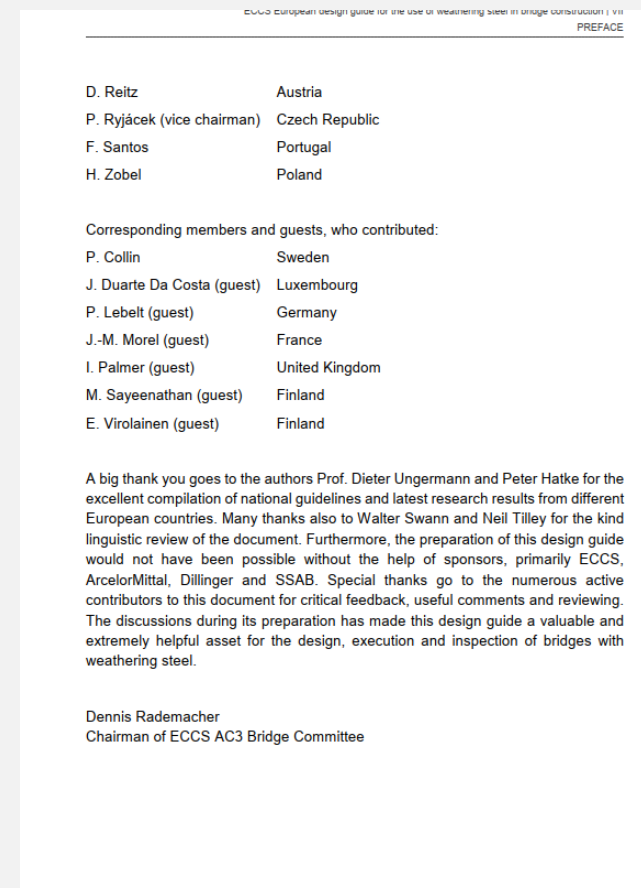
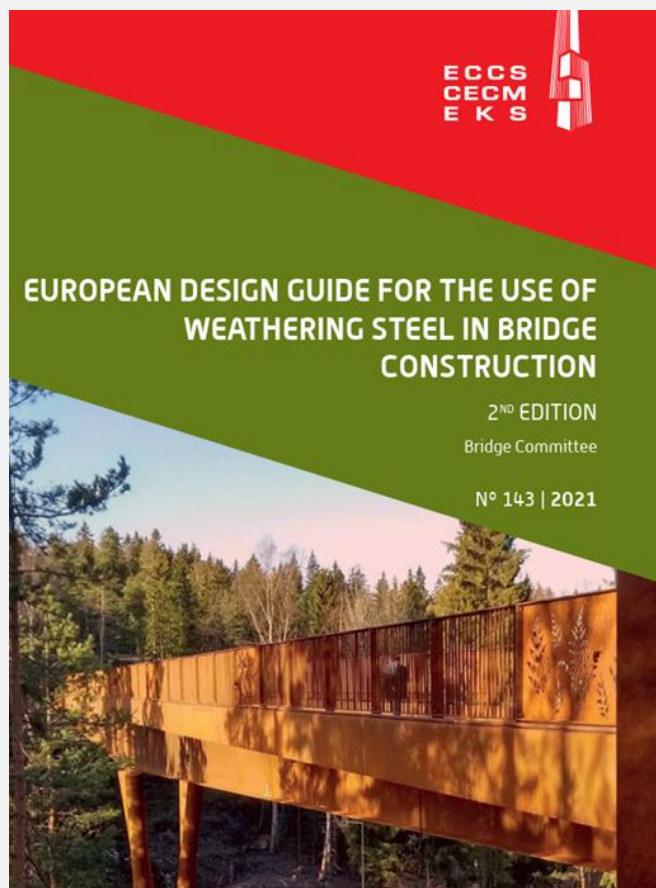
Wood / concrete / carbon steel

Bearings



Painted steel

ECCS guide for the use of weathering steel in bridge construction



<https://www.steelconstruct.com/wp-content/uploads/ECCS-Design-Guide-Weathering-Steel-Bridges.pdf>

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Paupys Office Building, Vilnius, Lithuania

The façade structure is a combination of concrete and COR-TEN® weathering steel sheet cladding, perforated steel sheet and rectangular hollow sections

®Photo: Ruukki Construction

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Kulturarena & Office Building, Tårnet, Norway

COR-TEN® weathering steel perforated sheet in combination with sheet cladding and sandwich panels.

©Photo: Ruukki Construction

SSAB

Upcoming weathering steel bridge in Sweden –Tullgarnsbro, Uppsala

Will be built with SSAB's 355 weathering steel



Source : Rundquist

New weathering steel bridge in Norway – YA bru, Tynset



SSAB Weathering 355 ML

Desinger : Norconsult; Fabricator : Prodtex; Length :45 mtrs

SSAB

Source : Prodtex

Upcoming high strength weathering steel bridge in Norway – Eleverhøy bru, Sunndal

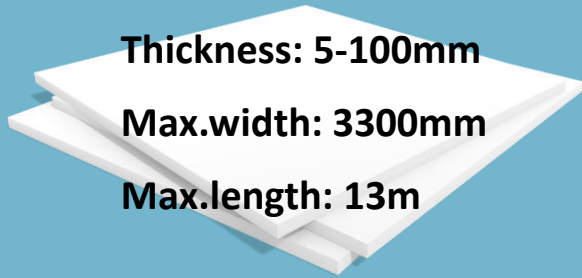
SSAB Weathering 420 ML

Fabricator : Prodtex; Length :600 mtrs



Source : Statens Vegvesen

SSAB WEATHERING PRODUCT PROGRAM



Thickness: 5-100mm
Max.width: 3300mm
Max.length: 13m

Hot rolled plates

COR-TEN B
COR-TEN B-D
SSAB Weathering 355
SSAB Weathering 355ML/NL
SSAB Weathering 420ML
SSAB Weathering 460ML

S355J0W/J2W/K2W/J4W/J5W

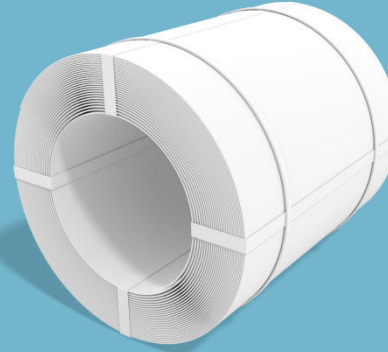


Thickness: 3-12mm
Max.width: 1800mm
Max.length: : 16m

Hot rolled strip

COR-TEN B
COR-TEN B-D
SSAB Weathering 355
SSAB Weathering 550
SSAB Weathering 700
SSAB Weathering 960

S355J0W/J2W/K2W



Cold rolled

SSAB Weathering 355
SSAB Weathering 700



Tubes & profiles

SSAB Weathering Tube 355WH
SSAB Weathering Tube 500WH

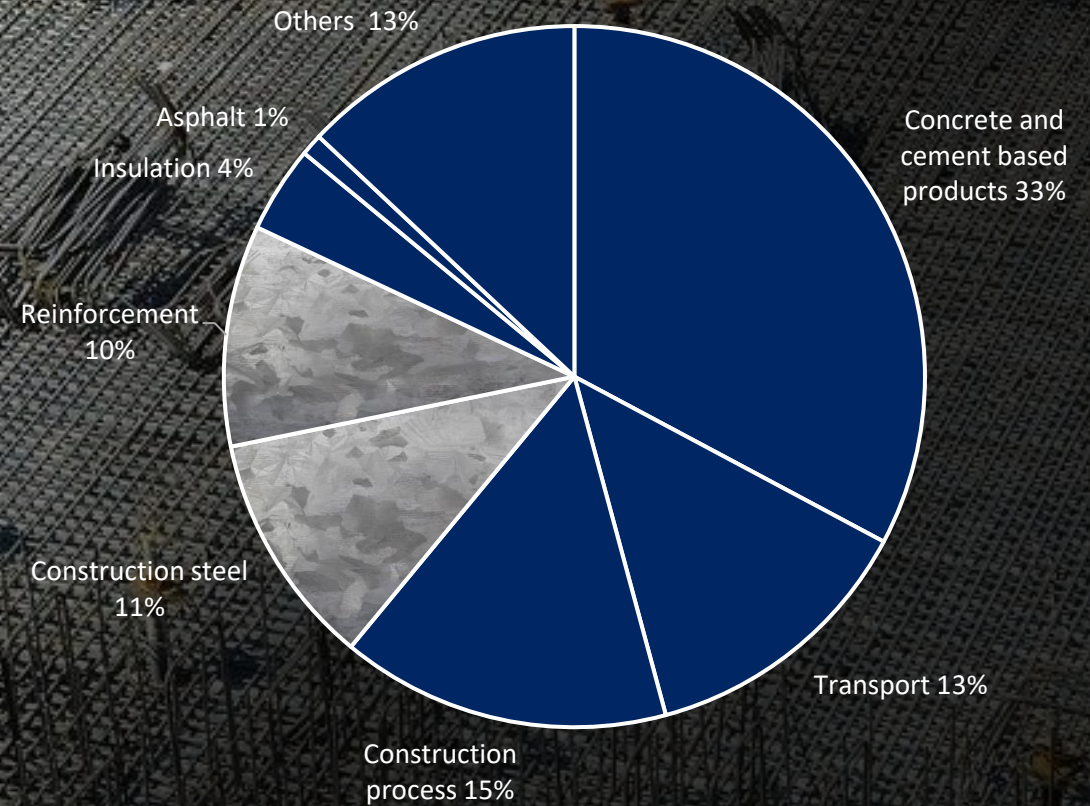


**Sustainable upgrading with
SSAB weathering steel**

Carbon emissions from the construction industry in Sweden

21%

of carbon dioxide emissions within the construction industry comes from steel.



Carbon emissions from the construction industry in Sweden.
Total: 9.5 million tonnes CO₂ (2015) including imports.

Sustainable upgrading with SSAB weathering steel

CO₂ efficient
steel production

Fossil-free steel 2026

**USE BETTER STEEL
AND GO FOSSIL-FREE**

No or less painting

High-strength

USE STEEL BETTER

SSAB

When a life cycle approach is considered (LCA, LCC)...

If the conditions are optimal and design and detailing are sufficient

Weathering steel offers one of the most economical and environmental friendly options for bridge construction.

Thank you!

World's First Object
in Fossil-free Steel

For further information , pls contact:

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Mobile: +358-(0)50-314 2970



Candle holder *A piece of the future*
Ø 150 mm. Design: Lena Bergström.

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