COR-TEN STEEL
MATERIAL COLLECTION

INNOMETAL

IMAR Singular Metal Solutions

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Singular Metal Solutions

Imar's metal solutions allow the full customization of a façade. Unlimited possibilities provide unique character and personality with excellent performance. The solutions are strong, safe and non-flammable (even Euro Class A1). They allow light to enter the interior, reduce energy consumption and are long-lasting with minimum maintenance.


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TABLE OF CONTENT

Cor-Ten surfaces create an on-going visual dialogue with their environment, evolving as time goes by.

COR-TEN INTRODUCTION

Since its development, Cor-Ten[1] has captivated the imagination of designers. The beautiful and ever-changing of Cor-Ten surfaces create an on-going visual dialogue with their environment, evolving as time goes by.
Most of what makes Cor-Ten great is the rusting effect. When Cor-ten is exposed to the atmosphere, it develops an ordinary layer of rust. But, as time passes by, this early product gradually converts to a protective and fine-textured rust that adheres to the base metal developing a beautiful patina that both protects the base metal and supresses further corrosion. The marvellous paradox of weathering steel is that rust cures rust.

Cor-Ten steel is versatile and can be used for façade or roof applications. It is easily formable and allows to be used for architectural elements of all shapes with minimal constraints. Surfaces can be flattened, curved or faceted. They can be expanded, perforated or embossed with different patterns to create architecturally distinguished facades with an elegantly natural brown patined texture.

This publication aims to provide you with a good understanding of Cor-Ten steel for application in facades. We have also included several examples of successful projects realised in Cor-Ten steel to inspire your future projects. At IMAR, we enjoy working in partnership with designers, contractors and clients to materialise innovative projects.

1 Cor-Ten is a registered trade name of United States Steel Corporation

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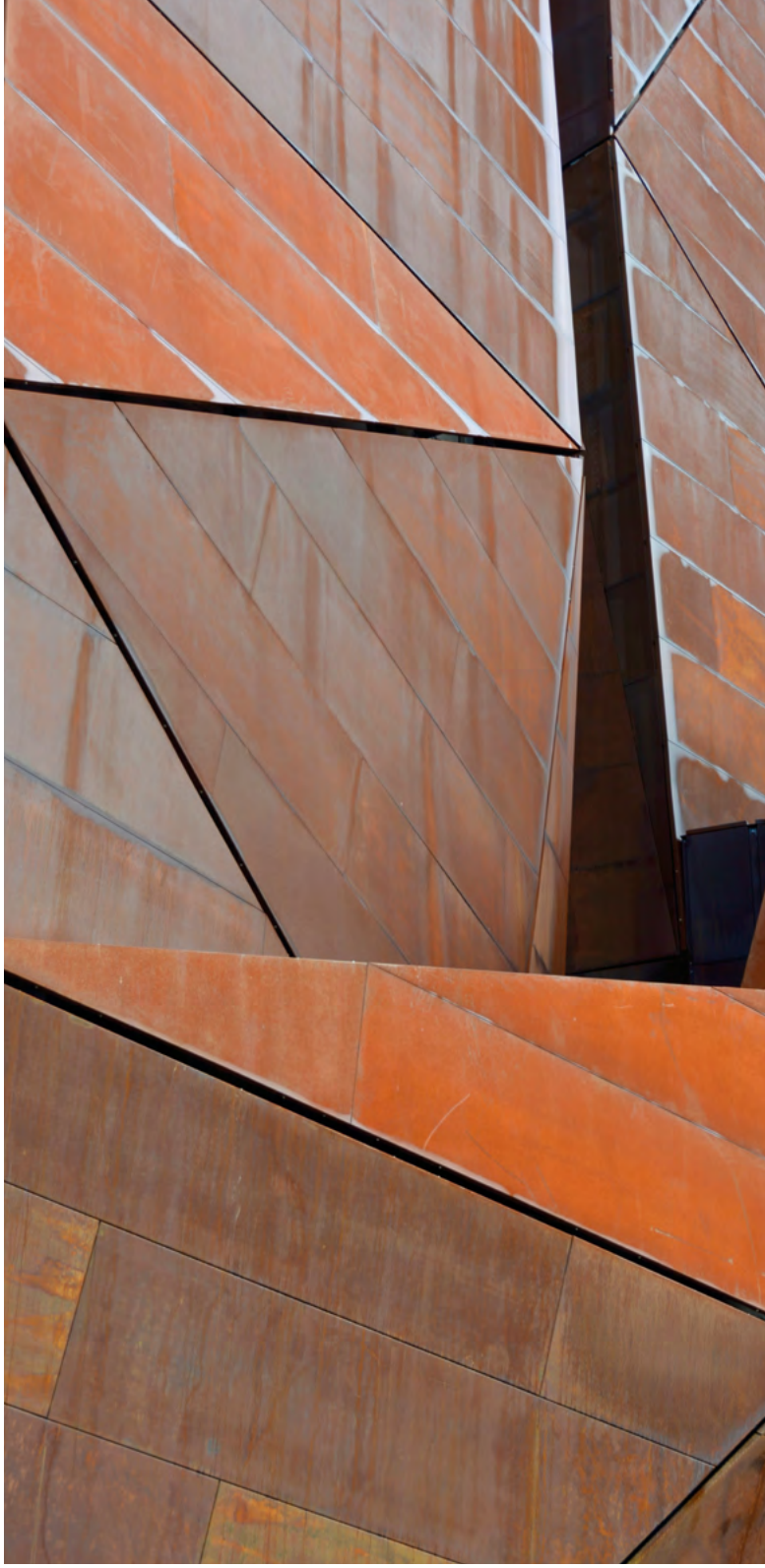
WHAT IS COR-TEN?



Cor-Ten steel, which comes from Corrosion resistance and Tensile strength, is used in architectural and art applications, for both outdoor and indoor conditions, without any separate surface treatment. Use of weather-resistant steel thus eliminates the need for surface treatments during the manufacturing and operational periods, in turn lowering the environmental impact and costs throughout the product's life cycle. The corrosion retarding effect of the protective layer is produced by the nature of its structure composition and the particular distribution and concentration of alloying elements.

Cor-Ten steel is mainly an iron-carbon alloy which includes copper also chromium, nickel, phosphorus, silicon and manganese comprising all of them less than 5% of the total metallurgic composition. The characteristics are specified in the European standard EN 10025-5 and in the American standard ASTM G101:4.

When utilising Cor-Ten, it is required to account for the expected loss of thickness due to corrosion, and as far as necessary, compensate for it by increasing the thickness of the material depending on the durability requirements. In this sense, the annual steel loss due to corrosion for a C4 environment (industrial and coastal areas) is estimated as a linear function and accounts for 0.02 mm/year during the first two (2) years.

Example of corrosion allowance for untreated COR-TEN B Steel

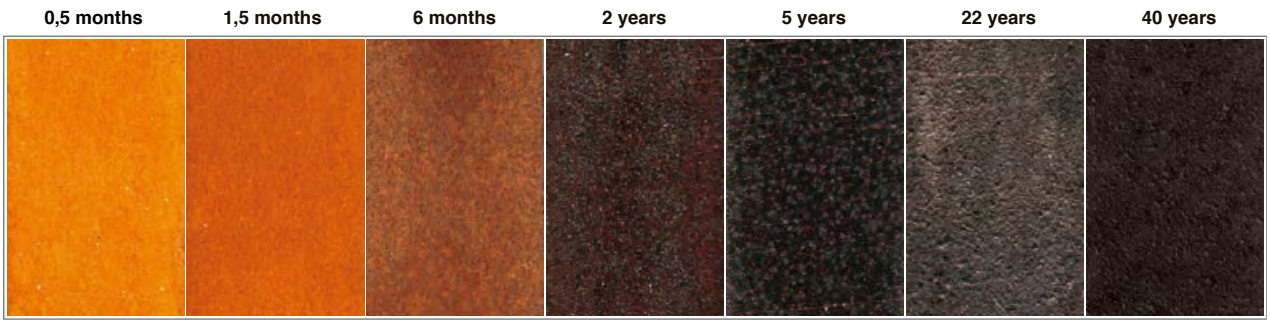
Type of atmosphere	Corrosion allowance to be added for one side of the nominal thickness for each 10-year period of working life.	
	First 10 year period mm	**Each following 10 year period mm**
Rural	0.10	0.05
Urban [1)]	0.20	0.05
Industrial [2)]	0.20	0.10

1) With the chief impurity in the air being sulphur dioxide, SO_2
1) In addition to SO_2

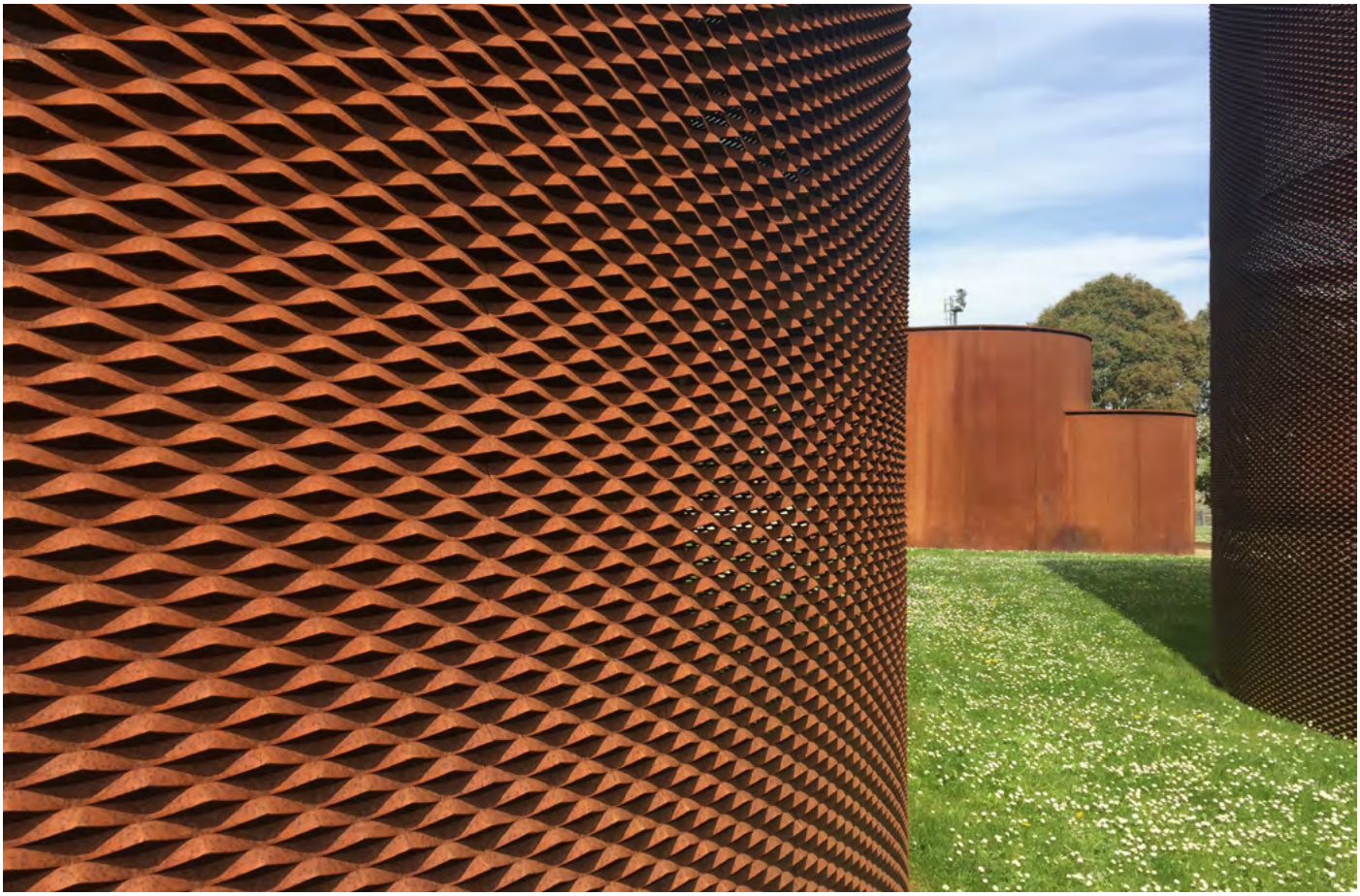
Source: Hot rolled Steel Plates, Sheets and Coils Structural steel - Weather resistant structural steels EN10025-5 and COR-TEN by Ruukki.

DEVELOPMENT OF THE PATINA & THE COLOUR

The patina of Cor-Ten evolves over time. It changes from its dark grey mill finish to an orange-reddish brown colour, reaching its final dark purple-brown coloration over the course of time. After some time, there is no coloration change except perhaps to a deeper dark brown. The evolution of colour in Cor-Ten is shown on the images below.



Source: COR-TEN by Nippon Steel & Sumitomo Metal

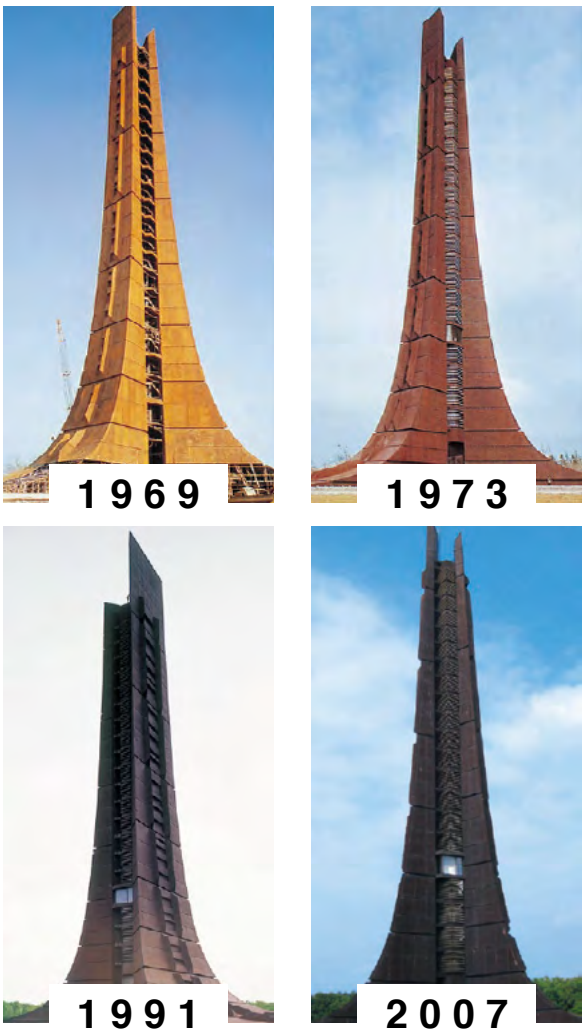


Nonetheless, it is difficult to predict the final colour of weathering steel due to its extremely reactive surface. The coloration is hardly guaranteed to be consistent. The evolution (characteristics and speed) of the patina, therefore the colour, varies and depends mainly on:

- Local weather conditions (i.e. exposure to sun, average temperature, orientation to prevailing winds, humidity, etc.)
- Location: industrial, urban, maritime or country-side climate.
- Orientation of façade (i.e. exposed to or shaded from the weather, vertical or horizontal position, etc.)
- Corrosive character of the atmosphere (i.e. concentration of sulphur dioxide, SO2, and chlorides).

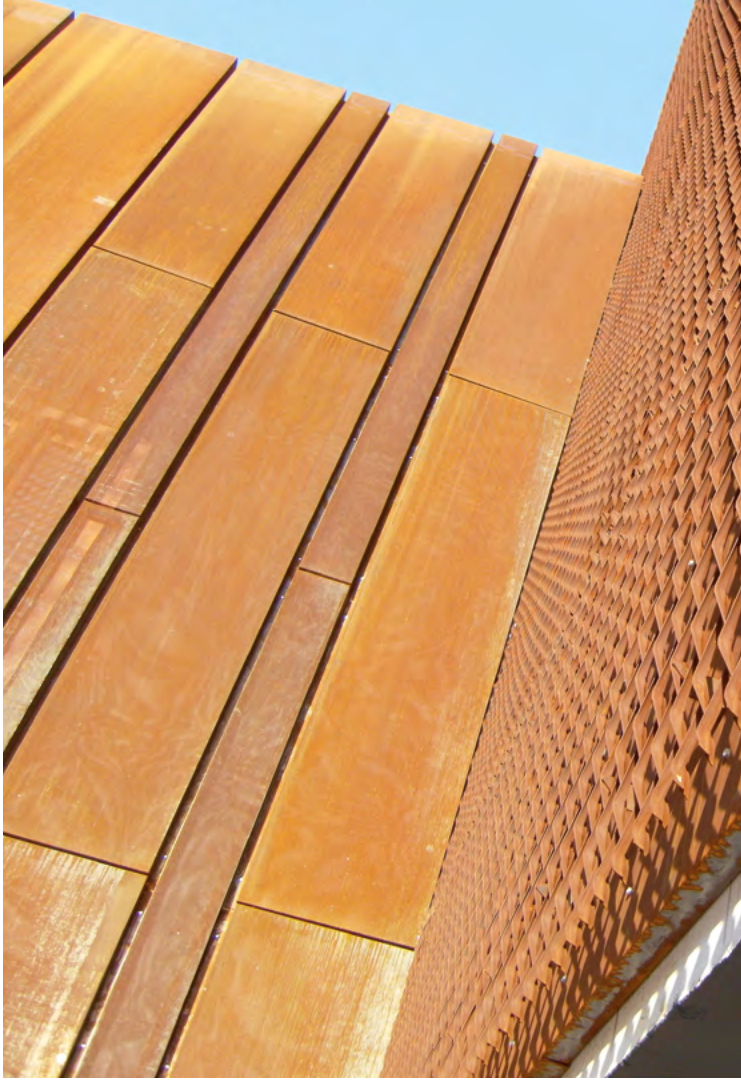
In industrial settings the patina forms more quickly and is darker in colour than in rural areas. In marine locations, the formation of the protective patina may be slower due to chloride exposure. However, in both cases, the patina does not adhere as well to the steel substrate and may not protect the steel from corrosion.
In the other hand, surfaces directly exposed to the weather will have a finer grain than sheltered facades. The patina formed on surfaces which are not directly exposed to weather are generally not as uniform as that on parts which are alternately made wet and dried. Small variations in colour may also occur on areas which are subjected to strong local variations of temperature, wind or humidity.

To get the best results and beautiful rust coating, weathering steel requires an alternating cycle of wet and dry conditions. Moisture helps to create the oxide layer. As it dries, the oxide layer starts to dehydrate, resulting in a compact adherent layer with low-permeability: the protective patina. During patina formation, some of the oxides are washed out by rain. The amount of oxide leached out by the rain diminishes over time, but never stops completely. This can stain neighbouring materials. Careful design of the facade is needed to ensure that the oxidised rainwater is collected and directed away from other materials to eliminate staining.



Source: Secular changes of appearance of the Hokkaido Centennial Memorial Tower (Sapporo, Japan) employing Cor-Ten steel. Image courtesy of Nippon Steel.

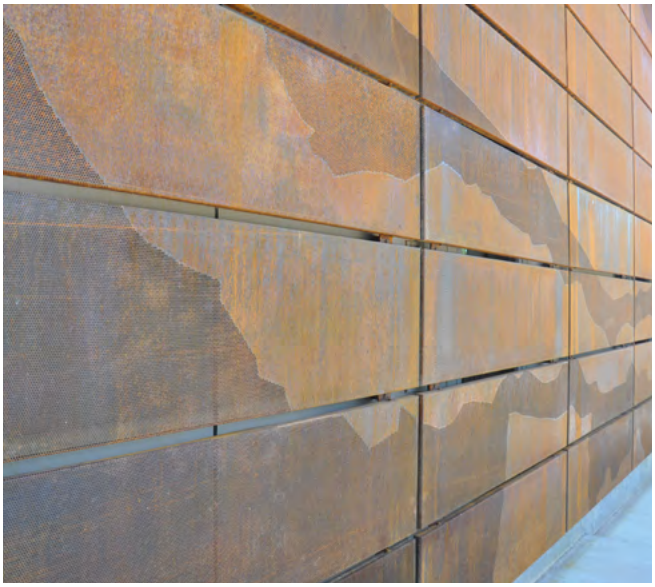
WORKABILITY OF THE MATERIAL



Weathering steel possesses workability similar to ordinary steels. Cor-Ten sheets or coils can be cut thermally or mechanically using similar procedures to those used on structural steels of the same thickness. It also can be welded, both manually and mechanically.

More specifically, and related to IMAR´s façade solutions, the panels can be perforated, expanded or embossed. The plates can be shaped into a wide range of geometries to achieve the required functional and aesthetic requirements, including curved shapes if required. We can manufacture and supply façade panels of different thickness and sizes, only limited by the size of coils.

FAÇADE APPLICATIONS



Cor-Ten steel is versatile and can be adapted to any building type and geometry. It can be utilised as an element in an exterior rain screen facade, within an interior panel system with a high performance clear top coat (or raw), as signage, or in artistic pieces.

Weathering steel should not be used in:

- Sheltered locations with damp conditions, constant humidity or persistent fog.
- Permanent contact with water.
- Cor-Ten steel should not be used within 2 (two) kilometres of coastal waters unless airborne chloride levels do not exceed the S2 salinity classification that is Cl<300 mg/m2/day, according to EN ISO9223 – Corrosion of Metals and Alloys.
- Soil or covered with vegetation.
- Direct contact to de-icing salts used on roads.
- Weathering steel should not be used without protection in an environment above P3 that is SO2 > 200 mg/m2/day which represents an aggressive atmosphere with high levels of atmospheric corrosion, in accordance with EN ISO9223 – Corrosion of Metals and Alloys.

KEY BENEFITS

- Natural protection against corrosion.
- Aged weathering steel brings multi-dimensional aspect to facades. The attractive natural appearance is able to fit within urban and natural environments with a patina that evolves over time. The patina can transform multiple times on a daily basis from a state of dry to wet (and back again) and with it brings a sense of depth and wonder. The weathered steel becomes something more than was originally perceived.
- Economic advantages: no maintenance cost, no need to re-coat, no coating costs.
- Easily formable and processed allowing to be used for architectural elements of all shapes with minimal constraints.
- Material is 100% recyclable.
- Reduced environmental impacts associated with Volatile Organic Compounds (VOC) emissions from paint coatings and cleaning functions required with painting.

COR-TEN CONSIDERATIONS

- Coloration is hardly guaranteed to be consistent.
- Over the time, the replacement of a façade panel becomes challenging since it is hardly impossible to match the colour of Cor-Ten.
- Thickness of panels necessary depends on the required durability. Cladding panels may be required to account for the expected loss of thickness due to corrosion, and compensate for it by increasing the thickness of the material.
- Surface weathering of bare Cor-Ten steel typically leads to heavy rust staining on nearby surfaces like concrete, white walls, fabrics, etc.
- To maintain the material´s excellent aesthetics, proper design and management of run-off water is required to avoid staining (i.e. using gutters, drainpipes, etc.)
- All joints and profiles must be designed so that rainwater can run off – there must be no retention of water. And all contact with other materials (fixings, electrical conduits, lightings, etc.) must be avoided.
- There are not warranties for weathering steel surfaces.
- Storage in transit, at yards, or onsite should be minimised. When storage is unavoidable, uneven weathering can be minimised by positioning the material in an exposed area with good drainage.
- In industrial and marine environments the patina does not adhere as well to the steel substrate and may not protect the steel from corrosion.
- The protective patina layer cannot form, however, if the surface of the steel is continuously damp or dirty.
- Surfaces of weathering steel can be painted using the same methods applied in ordinary steels. As a result of the special alloying of the steel, a coating may last twice as long as a coating on ordinary steel. If Cor-Ten steel is continuously exposed to water, it is generally recommended to be painted. Nonetheless, the painting process requires the steel surface to be completely free of oxide through preferably mechanical abrasion.
- Imposed weight on building structure must be considered.
- Material should be kept as clean as possible and away from mud, grease, oil, paint, concrete, mortar and other substances to minimise cleaning costs.
- In almost all cases where the Cor-Ten steel is used as a façade cladding, this is used as rainscreen system installed on a substructure or rail system typically specified in other architectural metal. Joining different metals may induce galvanic corrosion.

  Galvanic corrosion occurs when two metals with different electrolytic potential come into contact in the presence of an electrolyte such as water. The table below summarises the risks of pairing Cor-Ten steels with other metals commonly used in facades.

  The recommended option is to use fasteners or substructure made of weathering steel. If this is not possible, it is suggested to use nylon spacers among materials to avoid direct metallic contact.

PAIR	RISK
· Aluminium, zinc or copper and Cor-Ten steels	· Galvanic corrosion of the Cor-Ten steels
· Galvanised steel and Cor-Ten steels	· Galvanic Corrosion of the galvanised steels
· Carbon steel and Cor-Ten steels	
· Aluminium, zinc or copper and Cor-Ten steels	· No significant risk of galvanic corrosion if their chemical
· Stainless steel and Cor-Ten steels	· Galvanic corrosion of the Cor-Ten steels. There is usually no significant galvanic corrosion from stainless steel nuts and bolts as the stainless steel area remains small

Source: Hot rolled Steel Plates, Sheets and Coils Structural steel - Weather resistant structural steels EN10025-5 and COR-TEN by Ruukki.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OKE
ORTUELLA

AQ4
BILBAO

Cultural Centre
Ortuella - Spain
IMAR Natural - Microperforation

JULUIS
HQ's

MO2
ARQUITECTURA

Comercial Office
Palencia - Spain
IMAR Natural - Microperforation

MIHL LUGO

NIETO SOBEJANO

Interactive Museum
Lugo - Spain
IMAR Air - Expanded Mesh

LEWES HOME

SANDY RENDEL ARCHITECTS

Private Residence
Lewes - UK
IMAR Air - Expanded Mesh

SOCIAL ANTZOKIA BASAURI

MAAB

Theatre
Basauri - Spain
IMAR Imaging- Images & Patterns

GEOLOGICAL INSTITUTE

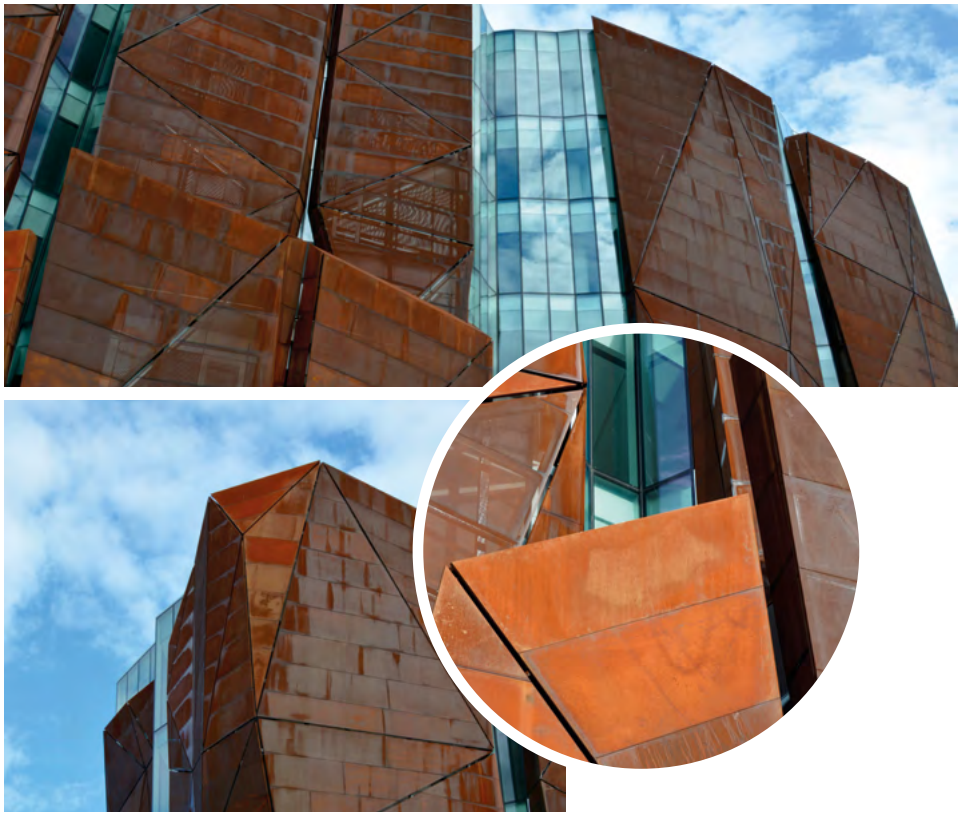
OIKOSVIA ARQUITECTURA

Administrative Office
Tremp - Spain
IMAR Imaging- Images & Patterns

GLASGOW FORT

COOPER CROMAR

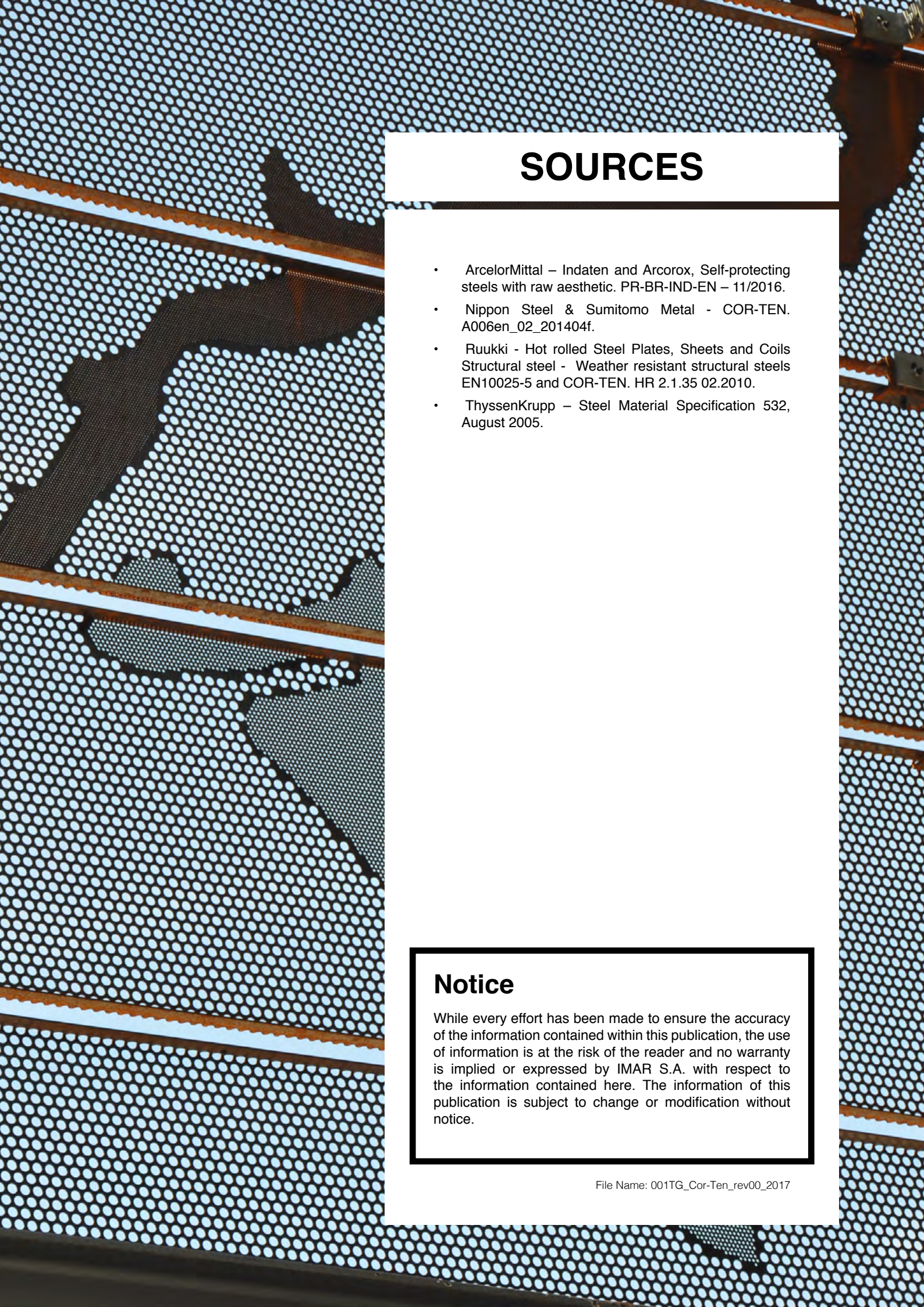
Shopping Mall Parking Garage
Glasgow - UK
IMAR Imaging- Images & Patterns



KULTUR ETXEA ROMO

TORRE ELORDUY

Cultural Centre
Getxo - Spain
IMAR Natural - Microperforation



SOURCES

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- Nippon Steel & Sumitomo Metal - COR-TEN. A006en_02_201404f.
- Ruukki - Hot rolled Steel Plates, Sheets and Coils Structural steel - Weather resistant structural steels EN10025-5 and COR-TEN. HR 2.1.35 02.2010.
- ThyssenKrupp – Steel Material Specification 532, August 2005.

Notice

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