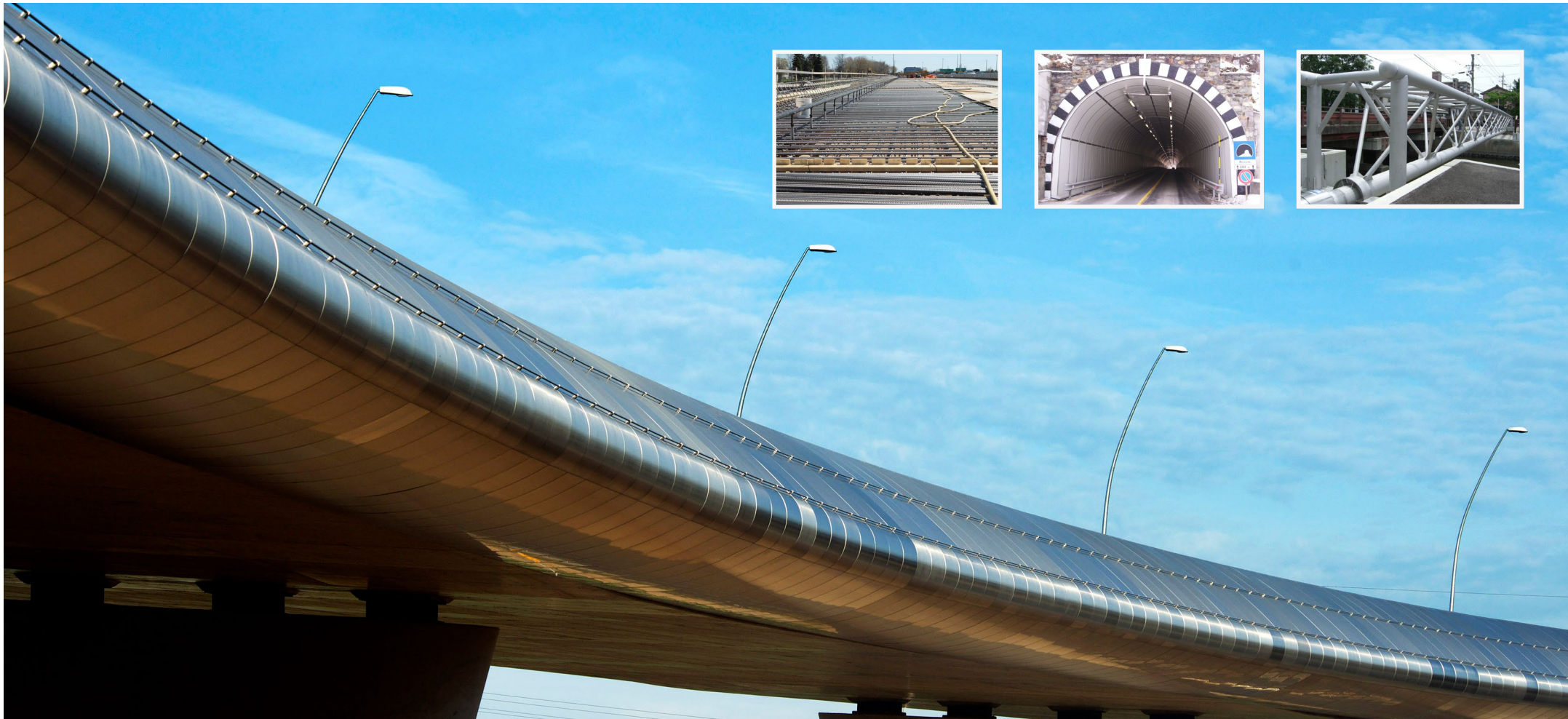


## Stainless Steel in Infrastructure



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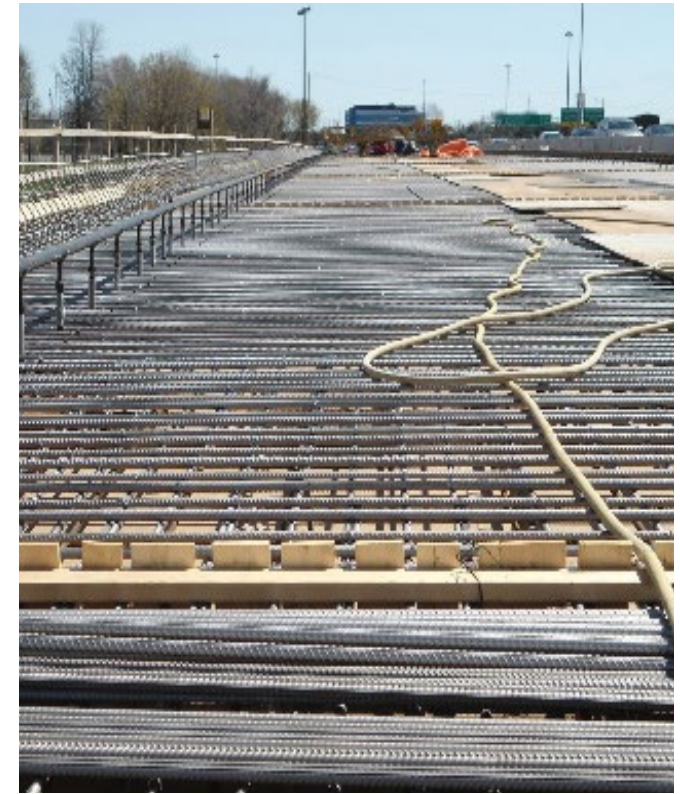
*In waste water plants, stainless steel defies the combined effect of corrosion attacks and abrasion.*

*Photo: Euro Inox, Brussels, Belgium*

## Introduction

The efficient operation of public infrastructure has a strong effect on the quality of our daily lives: reliable access to energy and drinking water; the ease of travelling by road, rail, air or water; the safe disposal of waste and sewage; all determine how we live and work. In these sectors, stainless steel plays an important but often unnoticed role.

Material selection is a decisive factor for the durability of infrastructural buildings and installations. It is the key to maximum availability and low life-cycle cost. The present brochure illustrates examples of stainless steel use in infrastructural applications in different parts of the world. It will foster the exchange of best practice and encourage authorities, private investors and design engineers to consider the stainless steel option whenever they embark upon infrastructural projects.



*Stainless steel reinforcement prevents the premature failure of concrete structures in road bridges which will be exposed to sea water or de-icing salt.*

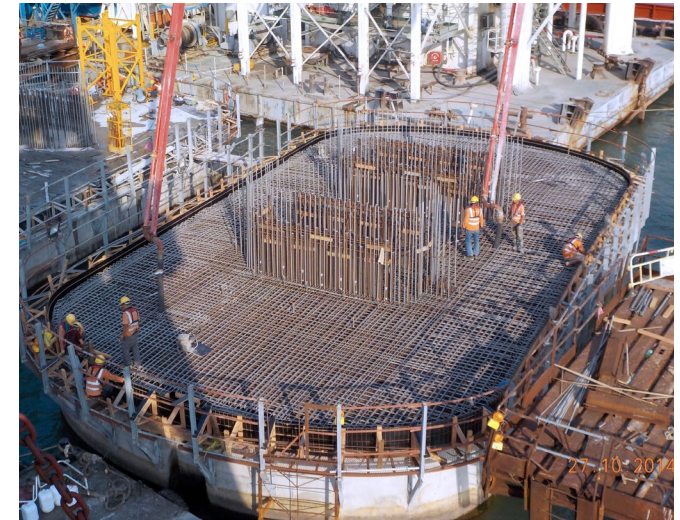
*Photo: Frank Smith*



## River delta crossing

### Hong Kong, Macau, China

The Hong Kong-Zhuhai-Macau Bridge is an ongoing construction project which consists of a series of bridges and tunnels that will connect three major cities on the Pearl River Delta in China. The proposed 50 km link is expected to cost US\$ 10.6 billion (HK\$83 billion). The longest bridge section will be 29.6 km (18.4 mi) long and include three cable-stayed spans between 280 m and 460 m (920 m and 1,510 ft). Construction formally began on 15 December 2009. The bridge is due for completion in late 2016. As corrosion damage would be impractical to repair at a later point in time, duplex stainless steel grade EN 1.4362 was selected for the outer parts of the reinforcement which may be exposed to elevated chloride levels when the carbonation of the concrete advances and cracks develop.



## Details

Environment:	Marine
Structural engineers:	HPDI (China Highway Planning and Design Institute)
Owner/developer:	China Government
Fabricator:	Arminox and others
Stainless steel grade:	EN 1.4362
Product type:	Rebar
Dimension:	10 mm to 32 mm
Surface finish:	Ribbed
Total quantity:	about 15,000 t
Producer or supplier:	Roldan (Acerinox group) and others
More information:	<a href="http://cedinox.es">cedinox.es</a>



## Road bridge renewal

### Allt Chonoglais, Scotland (UK)

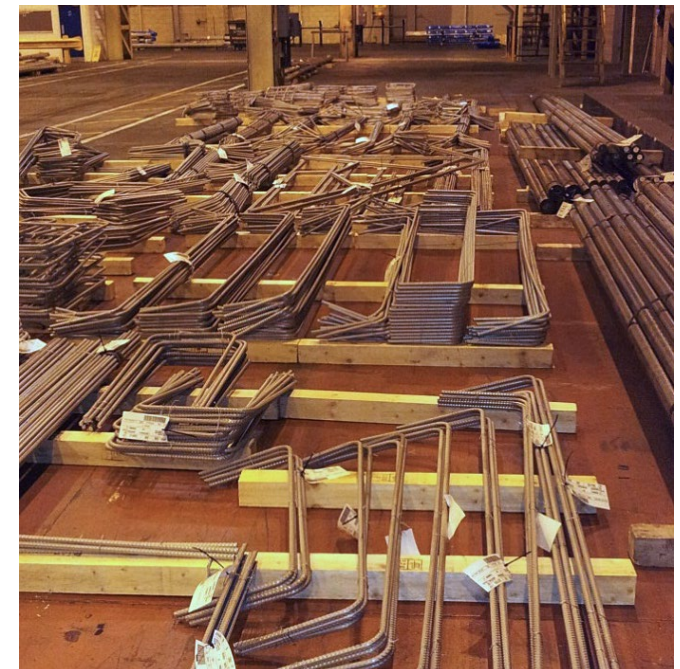
The existing A82 Allt Chonoglais Bridge was identified as being understrength to carry future traffic loads. Its repair and strengthening was deemed uneconomic and so in August 2012 work started to demolish and replace the existing bridge with a new stronger reinforced concrete structure, incorporating both carbon steel and stainless steel rebar.

In order to create a durable and economic bridge over the full design life period it was decided by the consultant engineers that stainless steel rebar should be used in the areas which are at greater risk from chloride induced reinforcement corrosion due to the application of de-icing salts during the winter

months. This included the bridge deck, abutments, wing walls and bearing plinths. The original specification called for EN 1.4301 (304) stainless steel rebar, but after in-depth discussions with the supplier, steel designation EN 1.4362 (2304) was accepted as an alternative. Tests show that this grade has a Critical Chloride Threshold Level (CCTL) over 4% per mass of cement at room temperature, which is over ten times the figure usually associated with carbon steel rebar and beyond the levels normally expected at typical rebar depths of cover, concrete quality, and for a 120 year design life, even in the most severe of chloride environments. In order to avoid contamination with carbon steel, all of the stainless steel rebar was fully cut and bent to shape on machinery designed and used solely for stainless steel.

### Details

Structural engineers:	Scotland Transerv, Glasgow
Owner/developer:	Transport Scotland, Glasgow
Fabricator:	Morrison Construction Ltd.
Stainless steel grade:	2304 (EN 1.4362)
Product type:	Reinforcement bar
Dimension:	Diameters 10, 16 and 25 mm
Total quantity:	67 t
Producer or supplier:	Otokumpu
More information:	<a href="http://otokumpu.com">otokumpu.com</a>



From left to right: Demolished bridge - Replacement - Cut and bent stainless steel rebar segments

## Road bridge refurbishment

### Nou, Itoigawa, Niigata Prefecture, Japan

The concrete road bridge of a coastal road in the West of Japan had developed severe corrosion in its formwork. Besides the chloride-bearing marine atmosphere, the use of de-icing salts in winter was another cause of the damage. For the refurbishment of the bridge, the selective use of ferritic stainless

steel was a rational and cost-saving choice. Out of the four spans of the bridge structure, the exposed outer two needed to be replaced. The new concrete spans were cast on site and reinforced with type SUS410 stainless steel, which ideally fulfilled both the corrosion resistance and cost reduction requirements. While the use of stainless steel reinforcement in new roads and bridges is not uncommon, this case shows that the stainless steel option is also technically and economically viable in repair and renovation.

### Details

Environment:	Marine
Stainless steel grade:	SUS410
Product type:	Reinforcement bar
Total quantity:	60 t
More information:	<a href="http://jssa.gr.jp">jssa.gr.jp</a>





## Concrete bridge reinforcement

### Ottawa, Ontario, Canada

The Canadian capital is exposed to a climate that is characterized by cold winters which require large quantities of deicing salt to be used. Concrete is porous and cracks are difficult to avoid. Over time, salt-containing water penetrates into the concrete and makes coated carbon steel reinforcement corrode. The resulting rust increases the bar's volume and causes cracks which accelerate concrete degradation further.

Over a decade ago, the Province of Ontario studied the behaviour of galvanized and epoxy-coated carbon steel rebar and its stainless steel counterparts. The results confirmed the superior durability of stainless steel. Besides the direct cost of corrosion repair, the authorities also took into account the indirect cost resulting from traffic disruptions caused by bridge repair. In a memorandum, they stipulated that in bridges used by more than 100,000 vehicles per day only stainless steel rebar should be specified. A recent project in which this policy was implemented is the Hurdman Bridge, finished in 2014. It is part of one of the country's busiest highways and duplex stainless steel reinforcing bars were selected for the deck and barrier walls. For tie wires, which keep the rebar in place when the concrete is poured, austenitic alloy 316 was used and also the rebar couplers were made from stainless steel. The decision for the stainless steel option is an

indicator of the responsible use of taxpayers' money and motorists' time. (Adapted from Moly Review 1/2015, courtesy of IMoA)

### Details

Environment:	Urban
Owner/developer:	Ministry of Transportation, Ontario
Stainless steel grade:	2205 (EN 1.4462) for rebar, 316 (EN 1.4401) for connectors
Product type:	Rebar
Total quantity:	320 t
Producer or supplier:	Valbruna
More information:	<a href="http://imoa.info/tmrstainless.com">imoa.info/tmrstainless.com</a>



Where de-icing salt is used in winter, stainless steel reinforcement is an advantage. Photo: Frank Smith



## Tension rods in a road bridge

### Jemeppe-sur-Sambre, Belgium

When renewing a road bridge over a railway line, the Belgian public infrastructure management company Infrabel selected duplex stainless steel for the tension bars. Its long-term durability was an advantage in an environment where deicing salt is regularly used in winter.

#### Details

Environment:	Urban
Owner/developer:	Infrabel
Fabricator:	GTM, Denain, France
Stainless steel grade:	UGI 4462 (EN 1.4462)
Product type:	Bar
Dimension:	80 mm
Surface finish:	Work hardened
Producer or supplier:	Ugitech
More information:	<a href="http://ugitech.com">ugitech.com</a>



## Motorway flyover

### Kerensheide, The Netherlands

In 2012, work began on an overpass to improve traffic flow in a busy highway interchange in the south of the Netherlands. Being close to the border and spanning a main entrance route from neighbouring Belgium, the structure should be representative and welcome motorists to the country.

The location was adjacent to one of the Netherlands' biggest clusters of the chemical industry. In winter, sub-zero temperatures are common and de-icing salt is regularly applied to the roads. The designers took the resulting corrosion risks into account by three measures. Firstly, an appropriate grade was selected. Secondly, the polishing direction was vertical to ensure that rainwater flows off easily

and rapidly, washing away potential contaminants that may adhere to the surface. Thirdly, a geometry was designed which involved a rounded upper part to avoid stagnation, an inclined outer surface to maximize exposure to rain and a lower part only slightly slanted inwards, which ensured that the run-off water would flow along the recessed areas and only drip off at the lower edge, carrying away with it most of the pollutants.

In total, more than 4,000 panels were mounted to form 1,200 m of bridge-edging. For damage-less transportation custom-made pallet boxes with foam padding were developed. On site, specially designed mounting cars were used to take the panels to their final position. They made it possible to install the panels without disturbing the traffic underneath so motorway closures were made redundant.



### Details

Environment:	Industrial
Owner/developer:	Rijkswaterstaat (Dutch department of civil works)
Fabricator:	Jos van den Bersselaar constructie b.v., Udenhout, The Netherlands
Stainless steel grade:	316L (EN 1.4404)
Product type:	Sheet
Surface finish:	Matt polished (2K)
More information:	<a href="http://bersselaar.com">bersselaar.com</a>

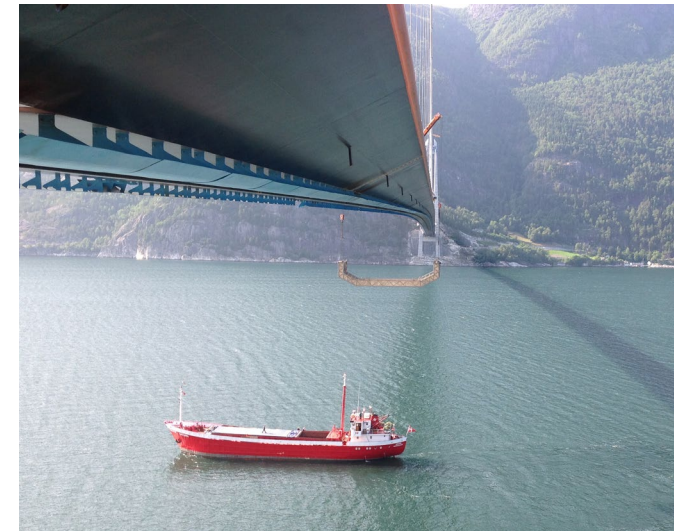
## Maintenance cradle of a suspension bridge

### Hardanger, Norway

The mountainous Norwegian coastline with its fjords makes the building and subsequent maintenance of bridges an exceptionally complex operation.

At Hardanger, a bridge measuring 1,350 metres (4,530 ft) in length replaced a ferry connection and considerably shortened the travel time between the capital Oslo and the well-known tourist destination Bergen. Opened in 2012, it is the longest tunnel-to-tunnel suspension bridge in the world.

Given the sailing height of 55 metres (180 ft), strong winds and the long, harsh winters in Scandinavia, the service cradle involves closed side walls to protect the workers. As the bridge is directly connected to tunnels at both ends, future painting and repair of the cradle itself would be complex and costly. The designers therefore selected molybdenum-containing stainless steels of the 316 family for the structurally relevant parts.



*Both the tubular structure and the side walls of the service cradle are made from stainless steels of the 316 family.*

*Photos: Vistal Gdynia S.A., Gdynia, Poland*

### Details

Environment:	Coastal
Structural engineers:	Public Roads Administration
Fabricator:	Vistal, Gdynia, Poland
Product type, grade, dimension and surface:	316L (EN 1.4404) as Sheet: 1 mm to 5 mm Rod: 40 mm to 100 mm Circular hollow sections, 42.4 mm x 2 mm
	L sections: 40 mm x 40 mm
	316 Ti (EN 1.4571] 1D and 1B
Total quantity:	28 t (stainless steel only)
Supplier:	Outokumpu, MTL, Nova Trading
More information:	<a href="http://vistal.pl">vistal.pl</a>



## Cladding of the underside of a road bridge

### Turku, Finland

Located in the centre of Turku, the original Myllysilta bridge - a pre-stressed concrete box girder design - had developed serious structural problems and needed to be demolished in 2010 after only 35 years of service. It was replaced by a steel construction with concrete deck and a span of 90 m, which also

allowed cables and pipes to be accommodated. To achieve an aesthetically pleasing solution, the designers clad the underside with 320 stainless steel panels of 4 m x 2 m, which reflected the LED lighting integrated into the structure.

Due to the brackish water of the Aura river, the cladding had to be highly corrosion resistant. Besides the coastal location, de-icing salt used on the bridge during the winter months created a corrosive environment.

Despite its decorative nature, the requirement for the surface was to remain bright and shiny with minimal maintenance. An austenitic-ferritic stainless

steel, grade 2205 (EN 1.4462), was used which had a track record of performing well in comparable environments. Otherwise, this type of stainless steel is mainly found in heavy structures, which are made from hot-rolled material and consequently have a matt surface. The Myllysilta bridge showed that duplex stainless steel as a cold-rolled sheet material can be as glossy as its austenitic counterparts. (For full reference, please see: [imoa.info](http://imoa.info))



Photo: WSP Finland / Esko Keski

### Details

Environment:	Coastal, urban
Architects and Structural Engineers:	WSP Finland, Helsinki
Owner/developer:	City of Turku
Fabricator:	Hermann's Finland Oy, Raisio, Finland
Stainless steel grade:	2205 (EN 1.4462)
Product type:	Cold-rolled sheet
Dimension:	4 mm, 2000 mm wide
Surface finish:	2G (ground)
Total quantity:	82 t
Producer or supplier:	Outokumpu
More information:	<a href="http://outokumpu.com">outokumpu.com</a>

## Footbridge pillars

### Reykjavik, Iceland

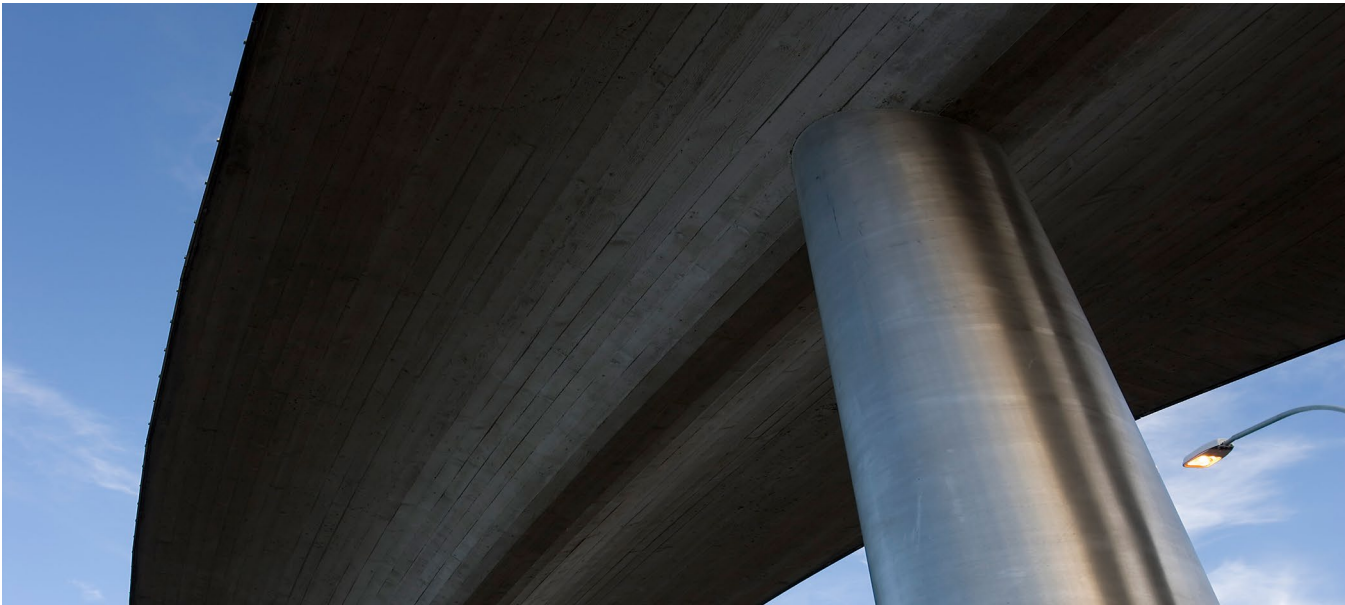
The pillars of a series of three pedestrian bridges in Reykjavik consist of concrete-filled stainless steel circular hollow sections (CHS). The structures have spans of 169, 90 and 56 m respectively. In pillars, the mechanical properties of steel, on the one hand, and concrete, on the other, are ideally complementary. They make it possible to minimise the dimension of the columns and increase their resistance to impact stress. Stainless steel was preferred because

it improved visual appearance, was long-term independent of applied coatings and made it easy to remove graffiti. The casting of the concrete core of the columns, which varied in length between 4.4 m and 57.1 m, was facilitated because the stainless steel CHS served as lost formwork. The handrails were also made from stainless steel to match both the maintenance friendliness and the surface effect of the columns.

In 2009, the footbridges won an award by the Icelandic Road Administration for outstanding infrastructure project and were nominated for the Icelandic Architecture award in 2007.

### Details

Environment:	Coastal
Architects:	Studio Granda, Reykjavik, Iceland
Structural engineers:	Línuhönnun, Reykjavik, Iceland
Owner/developer:	City of Reykjavik / Public Roads Administration
Stainless steel grade:	EN 1.4435 (a "high-end" alloy within the 316L composition range)
Product type and dimensions:	Circular hollow sections with a wall thickness of 10 mm and various diameters between 244 mm and 508 mm
Surface finish:	Brushed
Total quantity:	9.5 t of circular hollow sections
More information:	<a href="http://studiogranda.is">studiogranda.is</a>





## Tension rods in a footbridge

### New Delhi, India

A footbridge spanning a major sixteen-lane road involves tension rods in 22% Cr 5% Ni duplex stainless steel. Urban pollution resulting from road traffic makes corrosion resistance an important criterion of choice.

Tension rods require particular attention: in the threaded end parts, zinc layers become difficult to apply with a reproducible and consistent thickness. Additional damage during the installation process,

which would make the threads susceptible to corrosion, cannot be excluded. In a busy urban environment, conventional steel would have required a dual metallic and organic protective layer to meet the durability requirements on bridges.

The designers decided to use stainless steel tension rods for the structure that is otherwise made from hot dip galvanized and painted structural steel. The visual qualities of the stainless steel were an additional advantage because the footbridge is part of a major access route to a stadium and is regularly used by thousands of visitors.



### Details

Environment:	Urban
Stainless steel grade:	UGI 4462 (EN 1.4462)
Product type:	Bar
Dimension:	M36
Surface finish:	Bright
Total quantity:	2.5 t
Producer or supplier:	Ugitech
More information:	<a href="http://ugitech.com">ugitech.com</a>



## Pedestrian and cycling bridge

### Sölvesborg, Sweden

When designing a pedestrian and cycling bridge between the centre and a newly developed residential district, the town of Sölvesborg in the south of Sweden looked for a material that would last with no or minimal maintenance. Duplex stainless steel was the answer.

As the salinity of the nearby Baltic Sea is lower than that of, for instance, the North Sea, lean duplex stainless steel was fully adequate and turned out to be an advantageous solution both technically and economically. Any re-painting at a later point in time is made redundant, which is tantamount to a saving of €500,000 per maintenance event (at 2012 price levels). The nearby bird conservation area will also benefit because the noise and pollution associated with the sand blasting of conventional steel structures will be avoided.

At 756 m in length, this is currently the longest pedestrian bridge in Sweden. The extra weight saving which is made possible by the high-strength properties of duplex stainless steel was an additional advantage in the design of the attractive and uniquely shaped arch.



### Details

Environment:	Coastal
Bridge designer:	Ronny Södergren, Sölvesborg, Sweden
Owner/developer:	Municipality of Sölvesborg
Fabricator:	Stål & Rörmontage, Sölvesborg, Sweden
Stainless steel grade:	LDX 2101 (EN 1.4162)
Product type:	Plate
Dimension:	5 mm - 30 mm
Surface finish:	1D
Total quantity:	150 t
Producer or supplier:	Outokumpu
More information:	outokumpu.com



## Pre-assembled pedestrian bridge

### Malmö, Sweden

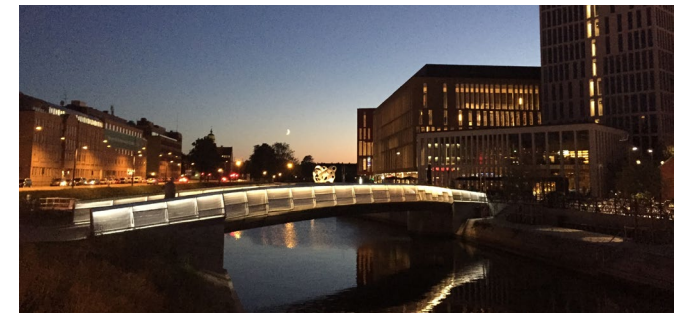
Malmö's redeveloped former harbour district is a model of the Swedish approach to modern urban architecture at a human scale: a mixture of high-rise and low-rise residential buildings, hotels and an event location; easy access for pedestrians and cyclists, combined with the highest standards of energy efficiency. As part of this architectural concept, a pedestrian bridge 40 metres in length and 6.5 m in width was designed.

The curved structure was completely pre-fabricated in Poland and transported in one piece to Sweden by sea and road in a spectacular action ([youtube.com](https://www.youtube.com)). The mixed-material design involves duplex stainless steel specifically for the cantilevers and parts of the railing. Austenitic stainless steel was specified for the visible parts of the railings and the reflective perforated cladding which is lit from within at night. The stainless steel components are fastened mechanically to the carbon steel sections to avoid the complexity of welding dissimilar metals. Galvanic interaction is prevented by the coating of the carbon steel sections, which serves as an insulator.



### Details

Environment:	Coastal
Fabricator:	Vistal Gdynia S.A., Vistal Eko sp. z o.o., Vistal Construction sp. z o.o.
Stainless steel grade:	316L (EN 1.4404), 2205 (EN 1.4462)
Product type:	Plate, perforated sheet, circular hollow sections
Stainless steel product, finish and dimensions:	316L (EN 1.4404) perforated sheet, 1.5 mm; hot and rolled sheet 6 mm and 10 mm 2205 (EN 1.4462) plate, 15 mm and 20 mm 316L (EN 1.4404) circular hollow sections, 48.3 mm x 2.0 mm
Surface finish:	2B, 1DC
Total quantity:	12 t of stainless (out of 45 t in total)
Producer or supplier:	Industeel, Outokumpu, Acroni
More information:	<a href="http://vital.pl">vital.pl</a>



The bridge was fully pre-fabricated and transported to the site in one piece.  
Photos: Vistal Gdynia S.A., Gdynia, Poland

## Railway bridge structure

### Añorga (San Sebastián), Spain

Heavy corrosion had damaged a previous steel bridge structure beyond repair and made its replacement necessary. The local authorities extended the durability requirement to 130 years without major maintenance. Lean duplex stainless steel, which had already performed well in other types of bridges, struck the balance between technical and economic criteria. The structure is the first railway bridge fully designed in stainless steel.



### Details

Environment:	Urban
Structural engineers:	TECSA, Madrid, Spain
Owner/developer:	Eusko Trenbide Sarea, Bilbao, Spain
Fabricator:	Iturmo, Avilés, Spain
Stainless steel grade:	LDX 2101 (EN 1.4162)
Product type:	Quarto plate
Dimension:	12-23 mm
Surface finish:	1D, shot blasted
Total quantity:	130 t
Producer or supplier:	Outokumpu
More information:	<a href="http://outokumpu.com">outokumpu.com</a>

*Lean duplex grade LDX 2101 (EN 1.4162) was selected for the first railway bridge whose entire metallic structure is in stainless steel.*



## Rail bridge cappings

### United Kingdom

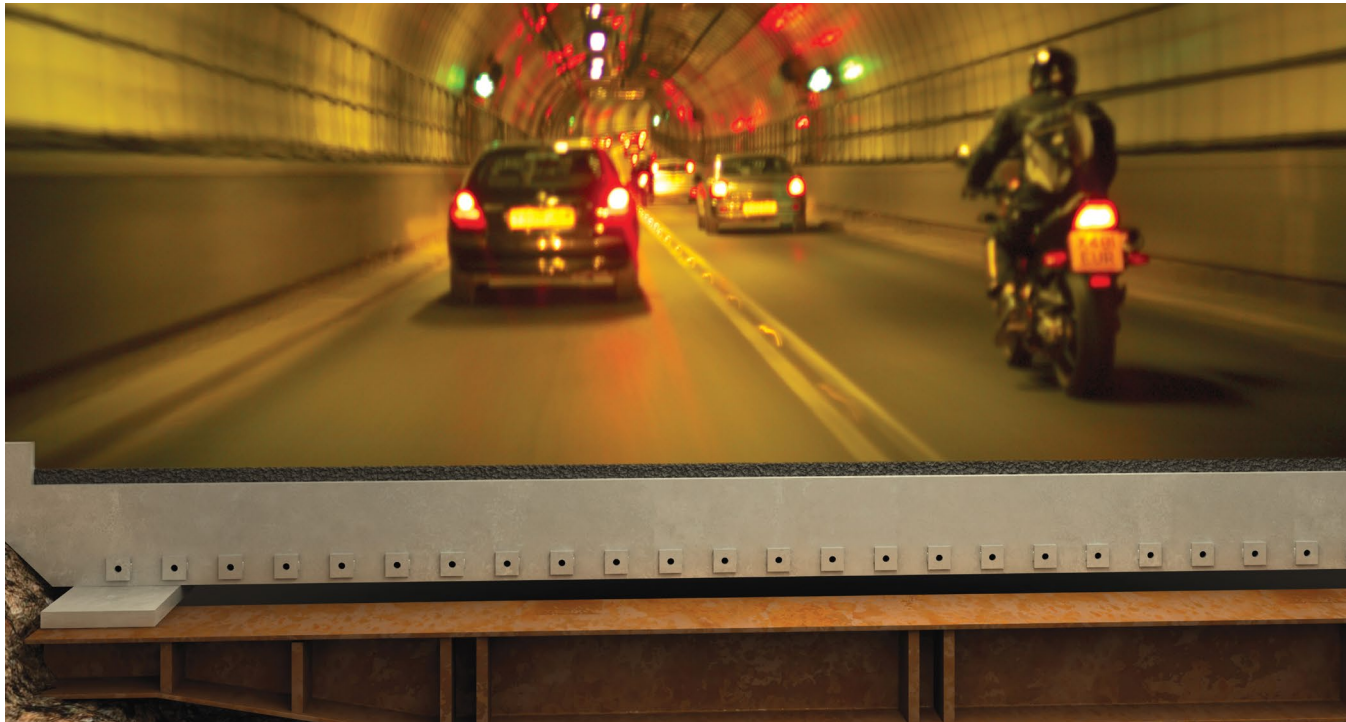
Stainless steel was specified for the cappings and all associated support brackets for bridges of the Channel Tunnel Rail Link. This high speed rail line, which links London with the European continent, cuts through industrial urban suburbs, residential areas as well as coastal regions. The cappings had to fulfill high standards in terms of function, aesthetics and durability.

Each capping was supplied in a perforated pattern. The curved sheet metal added to the height of the walls - a key factor of their noise absorption capability - with only a minimal addition to the weight of the bridge. However, in the case of coated metallic materials, the cut borders of the holes would have been prone to corrosion, which made an intrinsically corrosion-resistant material a priority. The specialised polished finish applied to its exposed face served as an architectural feature.



### Details

Environment:	Various, including urban and coastal
Fabricator:	Ancon Building Products, Sheffield (UK)
Product type:	Sheet
Surface finish:	Specialised polish
More information:	<a href="http://ancon.co.uk">ancon.co.uk</a>



## Road-deck replacement in a river-crossing tunnel

### Dartford, UK

Spanning the river Thames, the Dartford River Crossing forms a vital part of Britain's busiest orbital road, the M25. The crossing comprises two dual-lane tunnels carrying traffic to the north and a four-lane cable-stayed bridge carrying traffic to the south. Essential remedial work on the East Tunnel required more than one kilometre of road deck to be replaced. The replacement road deck was installed as slabs of 4.5 metres; each slab had two endplates. In total, 474 stainless steel endplates were delivered. Each endplate measured 7.34 m in length, 0.62 m in height and 25 mm in thickness, weighed 835 kgs and had 18 gussets welded to one side. The contract required that the endplates were supplied as match-drilled pairs to guarantee the precise positioning of 34 close tolerance bolts at each shear connection.

### Details

Environment:	Road Tunnel
Fabricator:	Ancon Building Products, Sheffield (UK)
Stainless steel grade:	316 (EN 1.4401)
Product type:	Plate
Dimension:	7.4 m x 0.62 m x 25 mm
Total quantity:	474 t
More information:	<a href="http://ancon.co.uk">ancon.co.uk</a>



## Cladding of a refurbished tunnel

### Valtournenche, Italy

The refurbishment of a 283 meter-long road tunnel in the mountainous area of the Aosta Valley involved the installation of a new cladding. As a material, colour-coated stainless steel was specified. The stainless steel substrate served to ensure long-term corrosion resistance, especially in view of the inevitable exposure of the rear side of the sheet to humidity. On the front side, reflective metallic surfaces had to be avoided to prevent glare. In-line

colour coated stainless steel fulfilled both these critical requirements. The proven ferritic 17 % chromium grade 430 (EN 1.4016) was a cost-effective solution. The selected colour, white, spread the light evenly without causing glare. The chemical composition of both the primer and the coating ensured that no toxic gases could develop even in the case of fire. Installation was fast and efficient, making it possible to complete the refurbishment within two months.



### Details

Environment:	Rural
Fabricator:	S.P.A.I., Timoline di Cortefranca, BS, Italy
Stainless steel grade:	430 (EN 1.4016)
Product type:	Coil-coated sheet
Dimension:	1 mm
Surface finish:	Coil-coated sheet; polyester-based organic double-layer coating, 20-25 µm thick
Total quantity:	c. 35 t
Producer or supplier:	Acciai Speciali Terni
More information:	<a href="http://centroinox.it">centroinox.it</a>

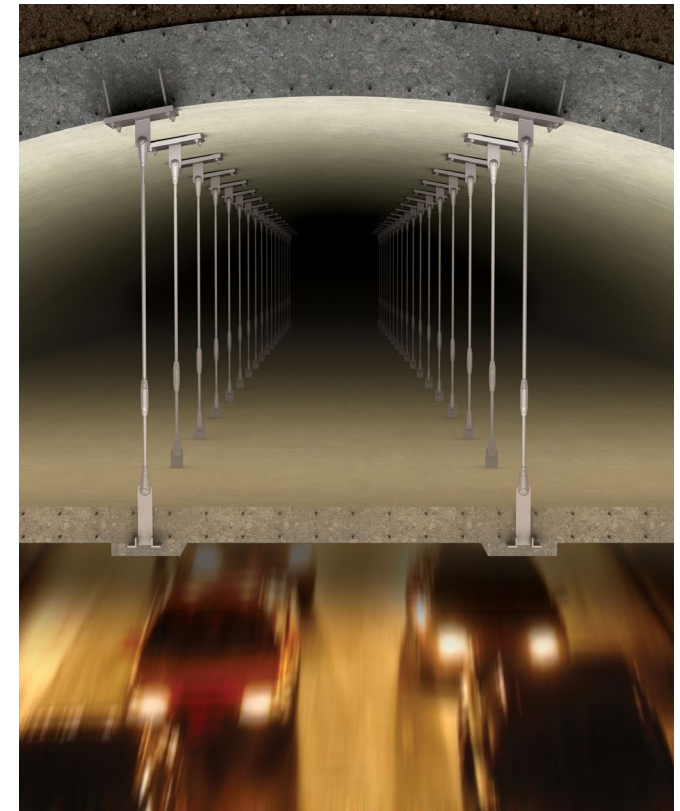
## Slab suspension in a bypass tunnel

### Brisbane, Australia

The CLEM7 Tunnel, known as the North-South Bypass Tunnel during construction, is a toll road built under the Brisbane River. It includes two 4.8 kilometres twin-lane tunnels which bypass the city's central business district and serve to reduce

congestion significantly.

In addition to being the longest road tunnel in Australia, it is also the most advanced with many safety features. In the event of a fire or explosion, a high-tech ventilation system comprising 100 jet fans will rapidly extract smoke to a longitudinal duct high above the road deck. A stainless steel suspension system holds the immense concrete slabs which form the duct. In addition to the suspension system, 33,000 light gauge stainless steel posts support the architectural lining around the tunnel walls.



### Details

Environment:	Coastal
Fabricator:	Ancon, Sheffield, UK
Stainless steel grade:	EN 1.4462 (22% Cr 5% Ni duplex stainless steel)
Product type:	Bar
More information:	<a href="http://ancon.co.uk">ancon.co.uk</a>



## Wall cladding of an Underground station

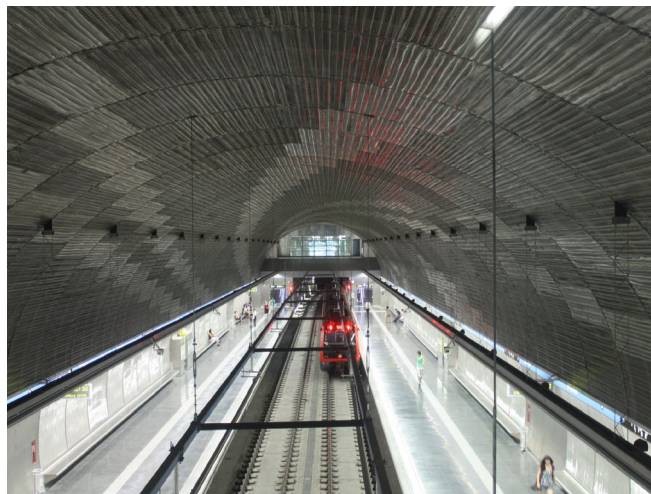
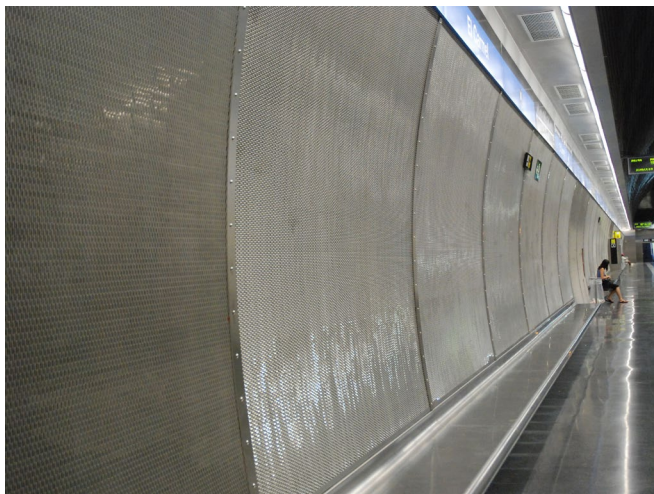
### Barcelona, Spain

In the Underground system of the vibrant Spanish city of Barcelona the authorities opted for “three-dimensional” stainless steel for cladding walls and ceilings: woven metal in various shapes and dimensions. The molybdenum-alloyed stainless steel grade is on the safe side with regards to durability and maintenance friendliness.

Mesh is efficient in noise absorption. It invites users to come closer and discover the intricate interplay of wires, bars and strips in the cladding. Despite its smooth metallic nature, the complex geometrical structure of the surfaces makes them look matt from a distance so glare is avoided. Stainless steel contributes to a feeling of safety and comfort.

### Details

Environment:	Urban
Architects:	Sanchez Piulachs
Structural engineers:	Acciona, Isolux-Corsán & Proinosa
Owner/developer:	Barcelona Council
Fabricator:	Codina, La Torre de Claramunt (Barcelona), Spain; Vargasa Metal; Inoxarte
Stainless steel grade:	316 (EN 1.4401)
Product type:	Mesh, sheet
Total quantity:	8700 square meters of stainless steel mesh
Producer or supplier:	Acerinox and Inoxfil
More information:	cedinox.es



## Walkway suspension in an Underground station

### Bilbao, Spain

In the recent Underground stations across the capital of the Spanish Basque region, stainless steel grade 316 is a common feature for stairwells and claddings, where their aesthetic qualities and proven low-maintenance properties are an asset.

There is, however, one additional feature that makes some of them quite special: the landings seem

to hover above the platforms and rails. Filigree stainless steel suspension bars make this elegant construction possible.

As the stairs and elevated access paths are part of the escape route, they have to meet high fire resistance requirements. Stainless steel 310S (EN 1.4845) is a 24-26 % Cr, 19-22 % Ni austenitic grade that is otherwise used for its heat resistance in industrial high-temperature applications. The structural engineers used their mechanical and physical properties to translate the architect's daring concept into a technical solution.

### Details

Environment:	Urban
Architects:	Norman Foster
Structural engineers:	Ingenería Metro de Bilbao, S.A. (IMEBISA)
Owner/developer:	Bilbao Council
Fabricator:	Gramometal, Ortuella, Spain
Stainless steel grade:	316 (EN 1.4401) and 310S (EN 1.4845)
Product type:	Sheet, bar
Surface finish:	2B
Total quantity:	50t of grade 310S and 70t of grade 316 per station
Producer or supplier:	Acerinox
More information:	cedinox.es





## Entrance structures of Underground stations

### Granada, Spain

In the Granada Underground stations of Alcázar Genil, inaugurated in June 2015, stainless steel was also used for its mechanical properties. In the entrance building, a curved structure cantilevers out to form a smooth transition with the glazing which is installed without any visible fasteners. The versatile standard grade 304 (EN 1.4301) is also used to produce bollards, which prevent vehicles damaging the glazed structure.



### Details

Environment:	Urban
Architects:	Antonio Jiménez Torrecillas
Owner/developer:	Granada Council
Fabricator:	Lasergran, Santa Fe (Granada), Spain
Stainless steel grade:	304 (EN 1.4301)
Product type:	Sheet
Surface finish:	2B
Producer or supplier:	Acerinox
More information:	<a href="http://cedinox.es">cedinox.es</a>



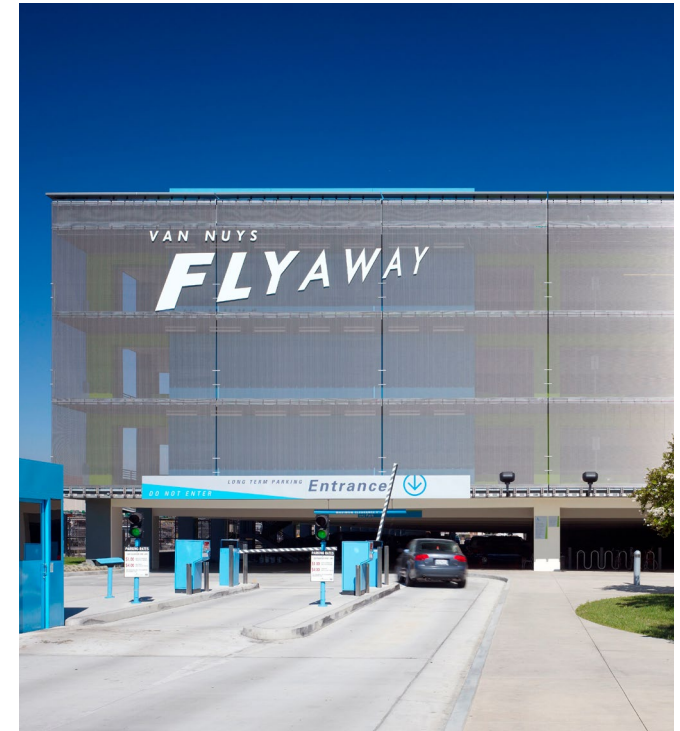


## Enclosure of a car park

### Los Angeles, California, USA

Located north of Los Angeles in the San Fernando valley, a bus terminal provides an opportunity for travellers to park their cars and use a convenient bus connection to Los Angeles, Santa Monica, Hollywood and LAX airport. The multi-storey car park is clad with stainless steel woven mesh which provides both solar shading and natural ventilation. The skin of the building looks translucent from

inside but forms a homogeneous visual enclosure from outside. The open area is about 44%. The light transmittance, however, changes with the angle of incident light. At noon, when the sun is high, it is only 15%; when the sun is low, it can be up to 51%. The solar shading effect is therefore auto-adaptive. Despite its overall reflective character, the woven metal avoids glare and heat islands. Only between 16% and 24% of the light is reflected. The mechanical properties of stainless steel also make it possible to fasten large-scale lettering to the weave.



### Details

Environment:	Coastal
Architects:	DMJM, Los Angeles, CA, US
Fabricator:	GKD, Düren, Germany
Stainless steel grade:	316 (EN 1.4401)
Product type:	"Lago" woven mesh
Dimension:	2,500 m <sup>2</sup>
Total quantity:	17 t
More information:	<a href="http://gkd.de">gkd.de</a>

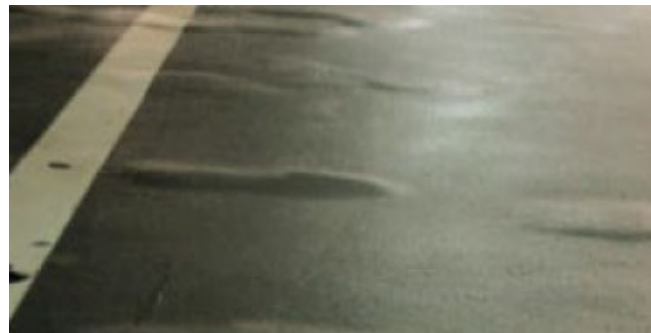
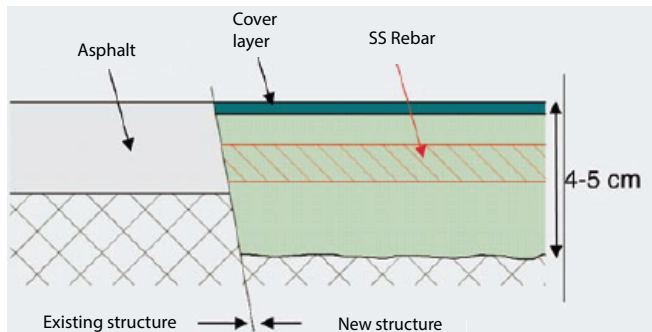
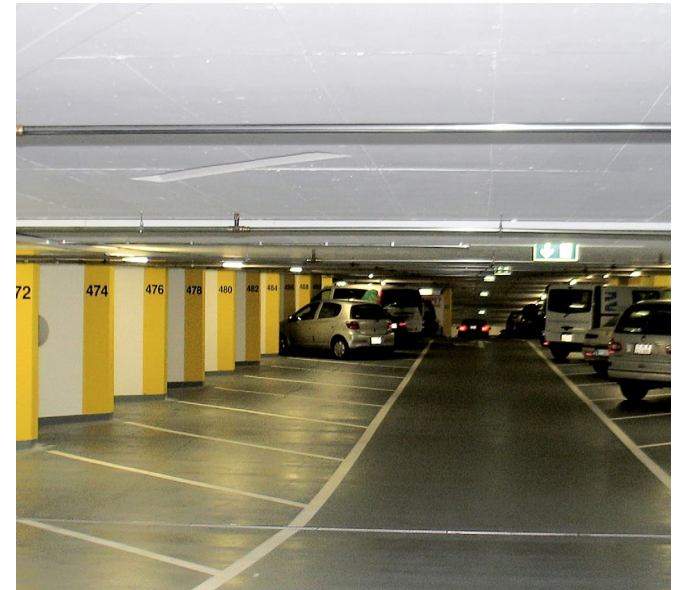


## Refurbishment of a multi-storey car park

### Bern, Switzerland

The Swiss capital Bern can have cold winters with heavy snowfall, which makes the use of de-icing salts indispensable. In the case of the Town House Car Park, erected in 1966, arriving cars carried chloride-containing water and melting snow into the garage, where the salt accumulated. The result was the penetration of chloride into the concrete. An initial refurbishment aimed at stopping any further exposure to salt. To this end, a protective asphalt layer was applied, however, without prior chloride removal. As the layer was not 100% tight, it was progressively undermined by further ingress of salt-containing water. The resulting massive corrosion of the reinforcement jeopardized the load bearing capacity of the floor ceiling and led to the

delamination of the asphalt. In 2006, a second refurbishment had to be carried out. It encompassed the removal of the asphalt and the chloride-contaminated upper concrete layer, a replacement of the reinforcement followed by the pouring of fresh concrete. In addition, new shear walls were built to improve the load bearing capacity of the floor ceiling. The obvious solution - a thicker layer with increased concrete covering of the steel reinforcement - was not an option because any loss of overall height would have been unacceptable. The structural engineers specified type EN 1.4003 ferritic stainless steel for the reinforcement and an additional surface coating. The added fresh concrete layer could be kept to a minimum and did not add to the overall height of the slab. Despite a concrete cover of only 15 mm, the combination of stainless steel reinforcement and the surface coating of the parking decks provided a reliable solution for the next 50 years.



Left: Cross-section of slab before and after; Right: Delamination of the asphalt

### Details

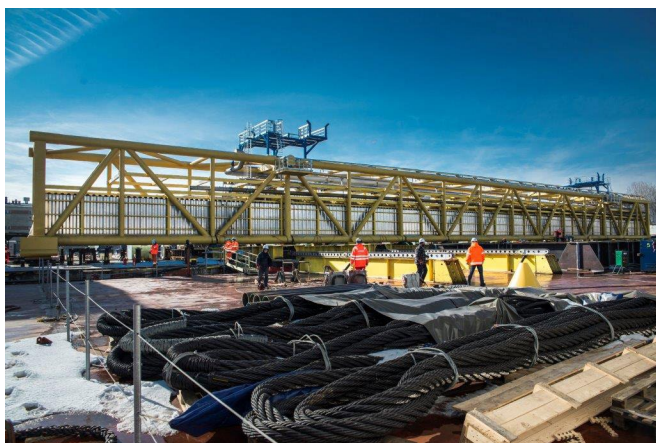
Environment:	Chloride-exposed covered environment
Structural engineers:	Diggelmann + Partner AG, Bern
Owner/developer:	City of Bern
Fabricator:	Marti Bau, Bern
Stainless steel grade:	EN 1.4003
Product type:	Top12-500 reinforcement bar (EN 1.4003)
Dimension:	12 mm
Producer or supplier:	Swiss Steel AG
More information:	swiss-steel.com

## North Sea platform bridge

### EldFisk oil field, Norway

In large parts of Europe, piped gas is the most common source of primary energy for both residential heating and industrial use. The reliable service of gas pipes from source to consumer is therefore of key importance for the workability of the energy infrastructure.

Technical components on gas rigs are exposed to extremely corrosive conditions: the - usually sulphur containing - gas on the inner surfaces and marine atmosphere on the outside. Deposits and bio corrosion caused by algae can aggravate the situation. Duplex stainless steels have become accepted as the most cost-effective solution for this application profile.



### Details

Environment:	Marine
Operator:	ConocoPhillips
Fabricator:	Vistal Gdynia S.A., Vistal Stocznia Remontowa Sp. z o.o.; Vistal Eko Sp. z o.o.
Stainless steel grade:	Pipes: 2205 (EN 1.4462) 2507 (EN 1.4410), UNS S32760 (EN 1.4510) UNS S31254 (EN 1.4547) Pipe supports: LDX2101 (EN 1.4162), UNS S32003
Dimension:	Pipes: DN25-DN750
Total quantity:	Pipes: 126 t Pipe supports: 3 t
More information:	vistal.pl

*Stainless steel is part of the natural gas production and supply infrastructure.*

*Photos: Vistal Gdynia S.A., Gdynia, Poland*



## Rail electrification

### Port Elizabeth, South Africa

In 1982, the electrification of a railway line on the South-Eastern coast of South Africa involved masts fabricated from utility ferritic stainless steel with a chromium content of about 11 %. Following positive earlier experience in freight handling equipment and structural applications in the mining industry, the designers were guided by a philosophy that aimed at combining long service life and reasonable cost. The

focus was on structural integrity whereas superficial discolouration of the unprotected material would be acceptable.

In some places, the railway line was less than 100 m from the shore. In heavy surf conditions, the masts would occasionally be wet by sea water. Inspection 30 years after installation confirmed the corrosion loss of the subsequent 20 Year Atmospheric Corrosion Exposure Programme which showed that 3CR12 corrodes at about 1  $\mu\text{m}$  in severe marine environments.



### Details

Environment:	Coastal/marine
Owner/developer:	Transnet, Johannesburg, South Africa
Fabricator:	AlloyFab
Stainless steel grade:	3CR12
Product type:	Fabricated sections
Dimension:	4.5 and 6 mm
Surface finish:	No. 1/1D
Total quantity:	1,500 t
Producer or supplier:	Columbus Stainless (Pty) Ltd
More information:	<a href="http://sassda.co.za">sassda.co.za</a>



## Cable tunnel

### Sydney, Australia

A cable tunnel was constructed as part of EnergyAustralia's major upgrade of electricity infrastructure of Sydney. Measuring 1.7 kilometres in length and 3.5 metres in width, the tunnel carries transmission cabling across the city's central business district. Stainless steel brackets have been used to support the heavy duty cables along the full length of the tunnel. The maintenance-free life and proven integrity of stainless steel, combined with expert fabrication, means no costly remedial measures will be required for the life of the structure.

### Details

Environment:	Coastal
Fabricator:	Ancon Building Products
Stainless Steel Grade:	316 (EN 1.4401)
Product type:	Bracket support system
More information:	<a href="http://ancon.co.uk">ancon.co.uk</a>



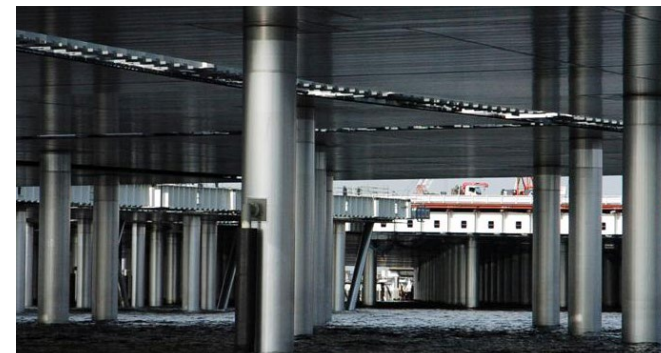


## Runway extension into the sea

### Tokyo, Japan

When Tokyo Haneda International Airport was expanded, the scarcity of land made it necessary to build the new runway D out into the sea. The supporting structure of a connecting bridge to the artificial island is in direct contact with sea water. Reconciling the 100 year durability requirement with Life Cycle Cost constraints was a challenge. Organic coatings would have required regular repair and caused unacceptable maintenance cost. In the case of titanium, by contrast, initial cost would have been prohibitive. Technically and economically, the cladding of structural steel with high-end austenitic

stainless steel turned out to be an optimal solution. For the tidal zone, a 20% Cr, 18% Ni and 6% Mo grade with a PRE value of 43 was used. Contrary to common belief, the corrosion load is highest in the part which is not permanently wet. In such recessed areas, splash water dries without rainwater washing the chloride-containing deposits away. For these conditions, a 23% Cr, 35% Ni and 7.5% Mo grade with a PRE value of 51 was found most appropriate. The first-time application of this technique in an airport facility won the stainless steel producers the ISSF New Applications Award in May 2015.



### Details

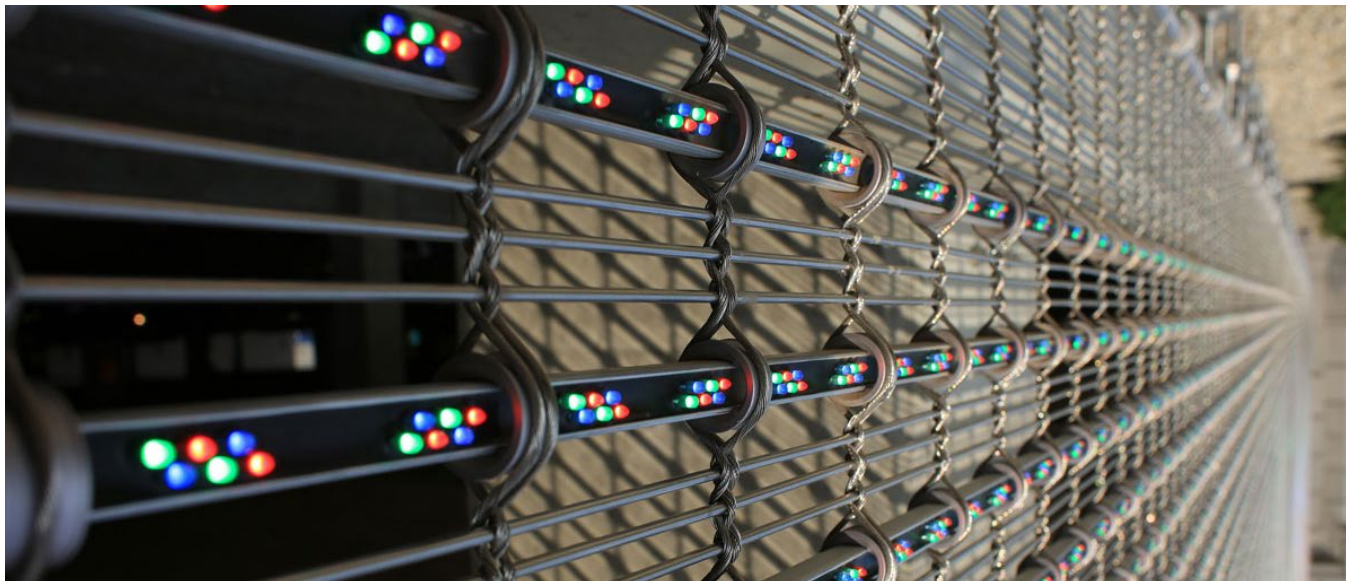
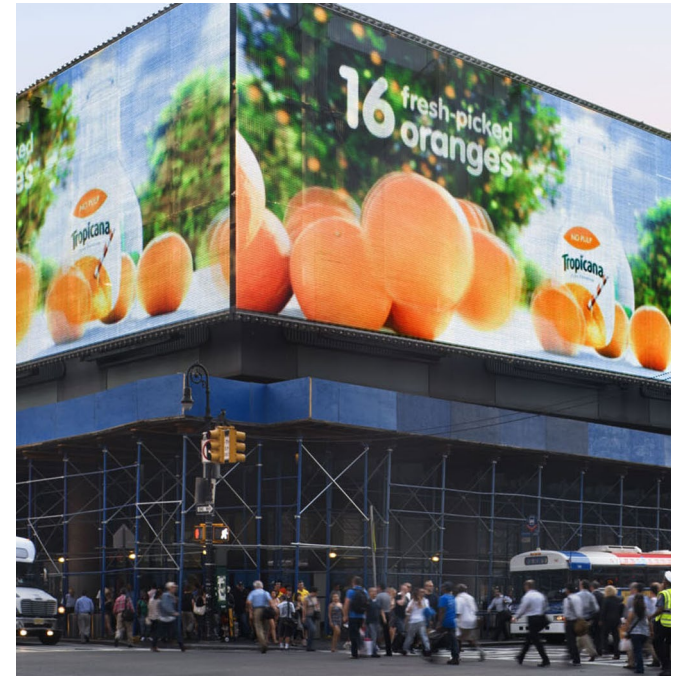
Environment:	Marine
Fabricator:	Nippon Steel Engineering Co., Ltd and Joint Ventures
Stainless steel grade:	NAS354N (UNS N08354) for the upper part in the splash zone; NSSC270 / NAS185N (SUS 312L, UNS S31254, EN 1.4547) for the lower part in the tidal zone
Product type:	Stainless steel-clad structural steel circular hollow sections
Dimension:	1.2 mm (upper part), 0.4 mm (lower part)
Surface finish:	No 4 finish (upper part), bright annealed (lower part)
Total quantity:	500 t
Producer or supplier:	Nippon Steel & Sumikin Stainless Steel Corporation/ Nippon Yakin Kogyo Co., Ltd.
More information:	JSSA; Nippon Yakin Kogyo

## Media wall for the cladding of a bus terminal

### New York, USA

Manhattan's well-known Port Authority Bus Terminal features a large-scale stainless steel media screen that wraps its way around the corner of 42<sup>nd</sup> Street and 8<sup>th</sup> Avenue. More than 1.325 million light emitting diodes (LEDs) are interwoven throughout a stainless steel fabric to project a high definition image. The installation, which is composed of 16 individual panels, forms the largest transparent media facade

in the world. The technology is durable and energy efficient. The electric and electronic components are sealed and work reliably in a temperature range between -20 °C and +70 °C (about -4 °F and +158 °F). Multiple LEDs per pixel ensure consistent image quality, almost independently of light conditions and viewing angle. In contrast to closed-surface panels, the woven metal solution provides sunshading and air flow as additional benefits. This type of media screen can also withstand wind speeds of up to 235 km/h (150 mph). The media facade added a new functional dimension to the bus terminal, which is used by 200,000 passengers twice a day.



Photos: GKD / Tim Griffith

### Details

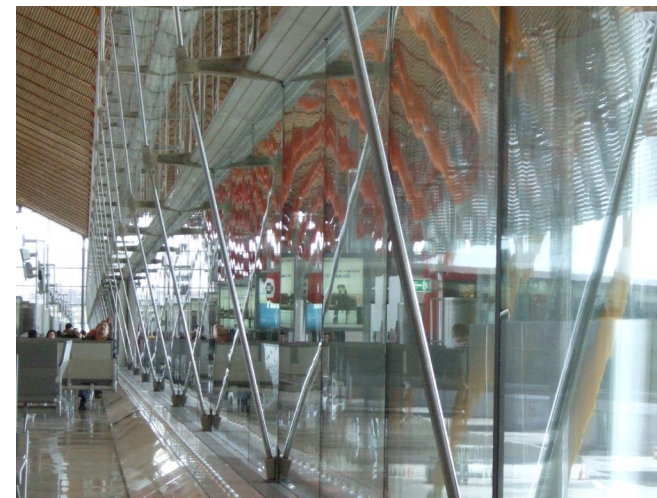
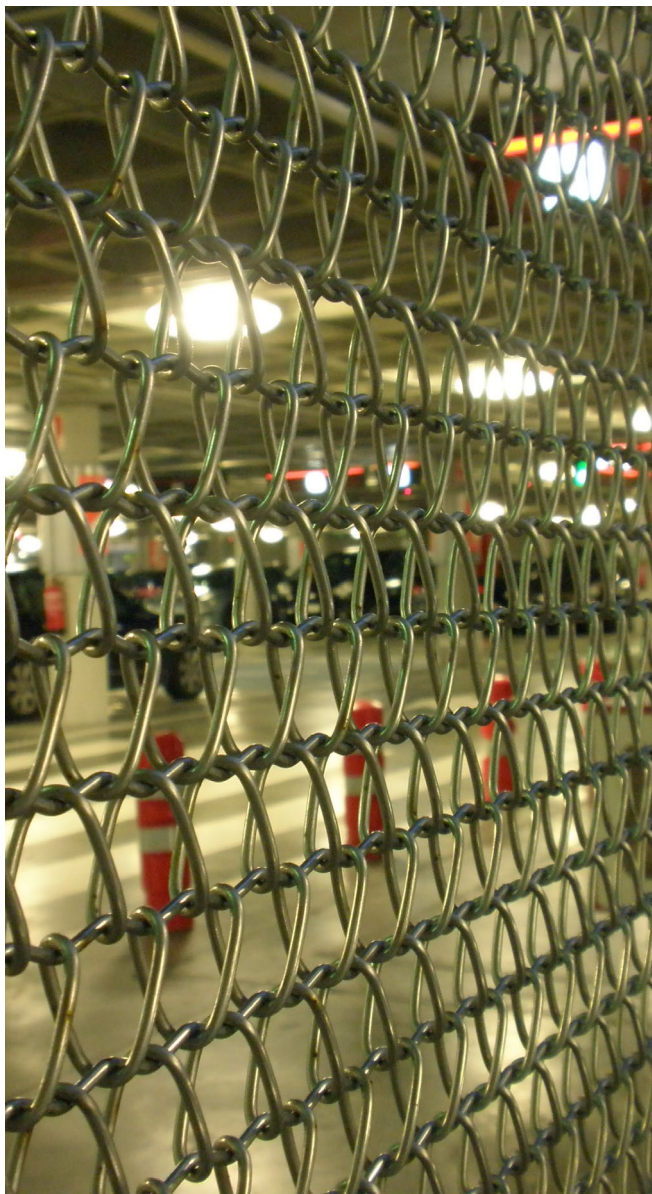
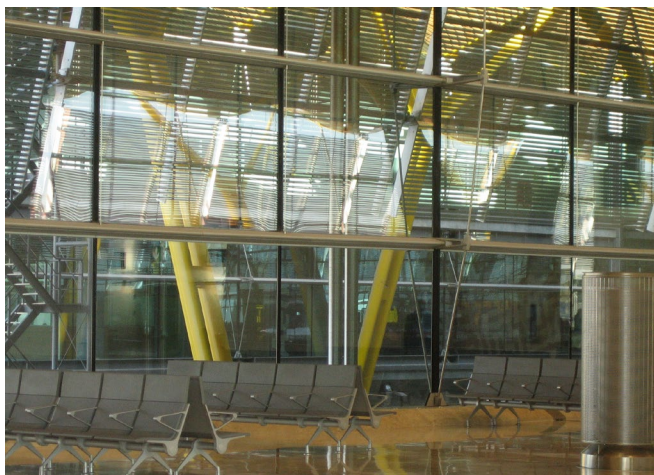
Environment:	Urban
Owner/developer:	Garage Media LCC / Port Authority of NY and NJ
Fabricator:	GKD, Düren, Germany
Stainless steel grade:	316 (EN 1.4401)
Product type:	Mediamesh® woven metal with integrated LEDs
Dimension:	560 m <sup>2</sup> (6,000 ft <sup>2</sup> )
Total quantity:	5 t
More information:	<a href="http://gkd.de">gkd.de</a>



## Enclosures for airport buildings

### Madrid, Spain

Terminal 4 of Madrid Barajas airport is known for its extensive use of stainless steel in technical equipment (baggage belts; rainwater drainage; ventilation). However, there is another dimension of stainless steel use which is equally important: enclosures. The glazed facade depends on Duplex stainless steel EN 1.4462. In the car park, stainless steel wire mesh, grade 316 (EN 1.4401) fulfills three functions: it ensures intrusion protection, provides ventilation and allows natural light into the building.



### Details

Environment:	Urban
Architects:	Richard Rogers and Carlos Lamela
Structural engineers:	Folcra
Owner/developer:	AENA
Fabricator:	Codina
Stainless steel grades:	316 (EN 1.4401), EN 1.4462
Product type:	Stainless steel bars, fasteners and mesh
Dimension:	Several
Total quantity:	>18,000 m <sup>2</sup> (mesh)
Producer or supplier:	Roldan, Inoxfil (Acerinox Group)
More information:	<a href="http://cedinox.es">cedinox.es</a>

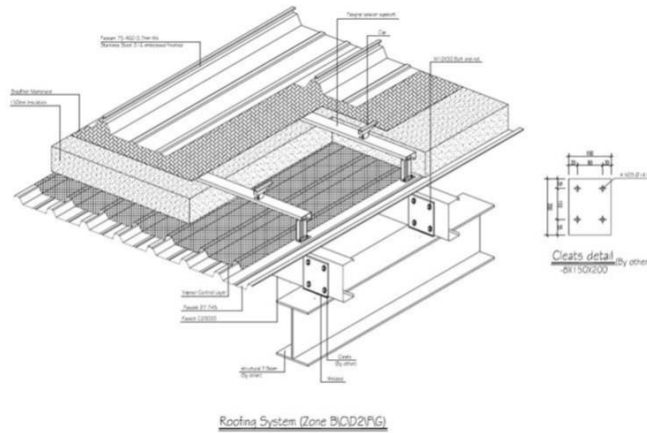
# Ferry terminal extension

## Macau, China

To cope with increasing numbers of users, the New Taipa Ferry Terminal of Macau has been extended to five times its original size. Taking into account the corrosive coastal atmosphere and the mechanical loads resulting from regular tropical storms, the architects identified stainless steel grade 316 as the preferred choice for large parts of the building's envelope. For the roofing, with an area of 100,000 m<sup>2</sup>, they chose an interlocking seam roofing system. Its principle is based on coiled stainless steel that is roll-formed into profiled trays on site. The surface of the stainless steel is embossed in the profiling process, which provides additional mechanical strength and lower reflectivity. The fixing clips and the fasteners are also manufactured from stainless steel. The same material and finish were used for the facade, but with a different – trapezoidal – panel geometry. The use of identical decorative surfaces for roofing and cladding contributed to the unity of style of the complex.



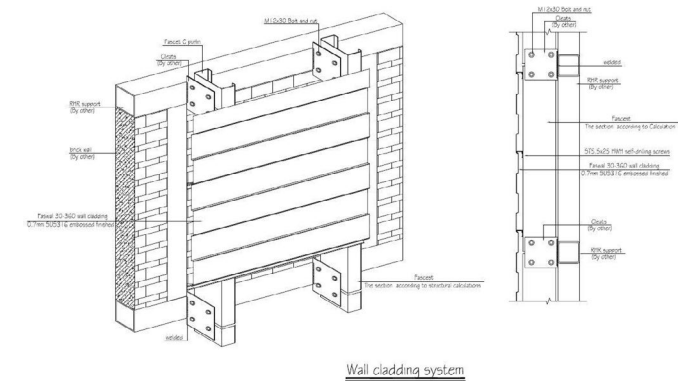
Stainless steel grade 316 is used in the building envelope of the extended Macau Taipa harbour terminal.



The roofing system includes thermal insulation to keep air conditioning needs to a minimum.



The roof consists of Interlocking profiled trays



Roof and façade cladding are made from the same material.

### Details

Environment:	Coastal
Designers:	PAL Asiaconsult Ltd., Macau, China
Owner/developer:	Governo da RAEM GDI
Fabricator:	P&L Building Material (Macau) Co. Ltd., Macau, China
Stainless steel grade:	316 (EN 1.4401)
Product type:	Cold-rolled sheet
Dimension:	0.7 mm
Surface finish:	Embossed
More information:	msmsmacau.org



## Airport Roof

### Incheon, Korea

Incheon International Airport is located west of Incheon's city center, on a revamped land between Youngjong and Yongyu islands. Terminal 1 was successfully opened in 2001 holding an unbreakable record of being ranked the Best Airport Worldwide for 11 consecutive years and with the increasing number of visitors Incheon airport has been extended by constructing Terminal 2, expected to open in 2017 at the soonest to increase capacity. Being located at the coast, the determination of roof material of Terminal 1 was a deliberate process and finally the designer specified 446M[26Cr-2Mo, 420ton(0.6mm & 1.0mm,

57,625m<sup>2</sup>)] ferritic stainless steel. The surface of stainless steel 446M was dull finished to maintain lower reflectivity. Over the past 15 years, the decisive material selection in the consideration of corrosion resistance and shape fixability proved its successful applications and experiences with this high-Cr ferritic stainless steels. Adding a second passenger terminal in the northern field of the airport, the choice of roof material was simple and obvious due to the experiences. 446M[360ton(0.6mm, Bead blasted)] ferritic stainless steel shall be applied again balancing with Incheon's cozy image and vibrant expansion plan.



### Details

Environment:	Roof
Owner/Developer:	HANJIN HI
Fabricator:	HANRIM E&C
Stainless steel grade:	STS 446M
Product type:	Sheet
Surface finish:	Bead blasting
More information:	posco.com



Aerial view



## Breakwater repair

### Bayonne, France

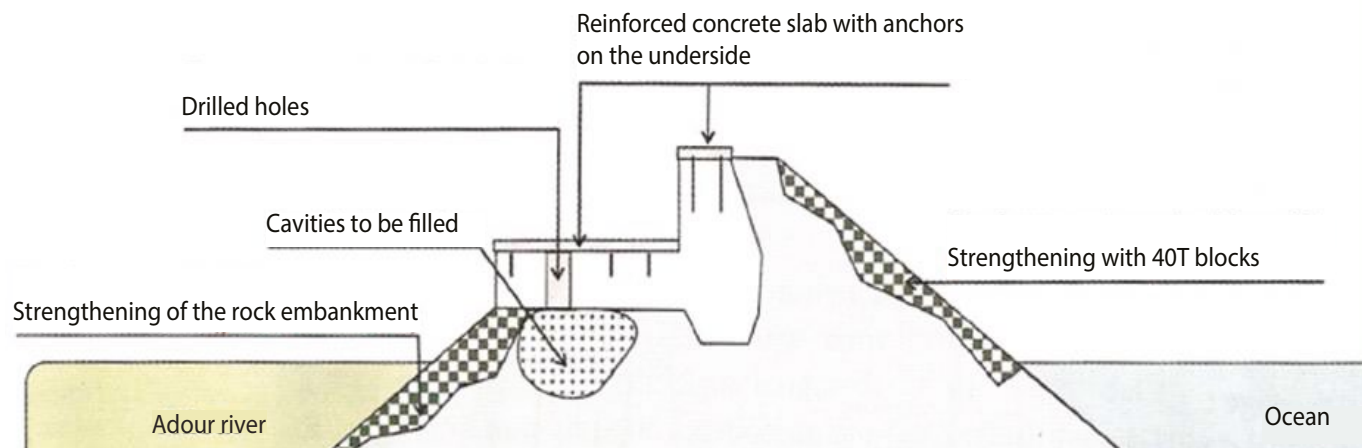
Being located at the Atlantic coast of France, the harbour of Bayonne is regularly exposed to stormy weather. In the 1960s, a breakwater was erected to protect the entrance channel. It included a wall and also a platform wide enough to accommodate a heavy duty crane used to place and re-position the 40t concrete blocks that cover the exposed outside of the structure.

For the renewal in 2014, the authorities specified stainless steel and opted for the proven 22% chromium, 5% nickel duplex stainless steel grade whose additional molybdenum and nitrogen

contents provide superior corrosion resistance and mechanical properties. As grade EN 1.4362 in the ribbed condition has a minimum yield strength of > 650 MPa, rebar diameters could be reduced, which contributes to the overall economics of the stainless steel solution.

### Details

Environment:	Marine
Stainless steel grade:	EN 1.4362
Product type:	Rebar
Dimension:	10 mm and 12 mm Ø
Total quantity:	130 t
Producer or supplier:	Ugitech
More information:	<a href="http://ugitech.com">ugitech.com</a>





## Water preparation plant

### Mosina, Poland

Poland's biggest and most advanced water treatment plant was opened in Mosina in 2015. It provides drinking water to 60 % of the residents of the Polish city of Poznań. The technology involves ozonation, a powder activated carbon installation and carbon filters together with the most advanced technologies of rinse water and sediment recycling.

Stainless steel is a common material for the preparation of drinking water; however, material selection is not trivial. In most parts of the installation, standard grades of the 304 and 316 types were identified as fully adequate whereas in specific areas, the highly alloyed grade 904L (EN 1.4539) was required. Pre-disinfection with chlorine dioxide can make such high-alloyed grades necessary.

The Mosina plant is an example of engineering for cost-effectiveness because each part of the installation was designed in the grade that was a technical and economic optimum for a given corrosive environment.



*The range of alloys used goes from 304 (EN 1.4301) to 904L (EN 1.4539)*



### Details

Engineering and fabrication:	Invest-tech
Fabricator and supplier:	Invest-tech, Torun, Poland
Stainless steel grade:	304/304L (EN 1.4301/1.4307), 316/316L (EN 4404/1.4404), 904L (EN 1.4539)
Product type:	Flanges and tubes
Dimension:	Din 40 - Din 1200
Total quantity:	430 t

## Water pipe bridge

### Hekinan City, Aichi Prefecture, Japan

When drinking water or sewage lines have to cross rivers and canals, they are often integrated into the girders of road and rail bridges or attached to them. In Hekinan, the steel water pipe of one such bridge had developed leaks and needed to be replaced. On this occasion, its capacity was increased to meet growing demand. However, the necessary larger pipe would have been impractical to integrate into the existing bridge. The municipal authorities therefore decided to erect a separate structure alongside the road bridge. The design was of the truss-stiffening type, in which the conduit has two functions: besides conveying the water, it also serves as the lower chord member of a truss. Molybdenum-alloyed grade SUS316 was used for three reasons. Firstly, this grade is known to be corrosion resistant in any usual drinking water composition. Water quality is unaffected. Secondly, under coastal atmospheric conditions the outer surfaces should be expected to be corrosion resistant. Repair coatings, which are typical of ageing steel or cast iron counterparts, become redundant. The stainless steel structure was found to be the most cost-effective option from a life cycle costing point of view. Finally, the exceptional ductility of austenitic stainless steels is an advantage in seismic conditions. Stainless steel is tougher than carbon steel or cast iron

and can undergo stronger deformation without breaking. In the event of earthquakes, it is essential to maintain drinking water supply as a key element of public infrastructure. The requirement to defy both chloride-containing coastal atmosphere and earthquakes is quite typical of Japanese locations. Therefore, it is not surprising that about 40 % of all pipe bridges involve stainless steel in this country.



### Details

Environment:	Coastal
Owner/developer:	Hekinan City
Stainless steel grade:	SUS316
Product type:	Welded pipe
Surface finish:	Pickled and passivated
Total quantity:	3 t
More information:	<a href="http://jssa.gr.jp">jssa.gr.jp</a>



## Tipping bucket in storm water basins

### Spain

In warm climatic regions like Spain, there can be long periods of drought followed by sudden violent thunderstorms and heavy rainfall. To ensure that the sewage treatment system can cope, huge buffer basins are built, which reduce the risk of flooding.

However, besides the sheer amount of water, there is another problem: when it starts raining, solid matter and pollutants, which may have accumulated over several months, are washed away within minutes. Consequently, the initial surge of water is heavily charged with sand, dirt and pollutants. For this reason, the sewer system is designed to allow sedimentation of the solids, which can then be collected and disposed of safely. As hydrogen sulphide is likely to be present, stainless steel is preferred to prevent corrosion.

### Details

Environment:	Urban or coastal
Fabricator:	Hidrostant
Stainless steel grade:	304 (EN 1.4301), in coastal locations 316 (EN 1.4401)
Product type:	Cold rolled
Surface finish:	Glass bead blasted
Producer or supplier:	Inoxcenter (Acerinox Group)
More information:	<a href="http://cedinox.es">cedinox.es</a>



## Water Reservoir

### Seoul, Korea

In recent decades, stainless steels have been widely used in the water treatment plants (WTP), the water reservoirs(WR), and the water supplying pipes in South Korea. Since 2003, Seoul Metropolitan Government has launched the Project of Arisu which is the brand name of the drinking water of Seoul. In this project, to improve the quality of drinking water, six water plants were renovated with newly developed water technologies and here stainless water pipes were widely installed. Water reservoir is one of these examples, which is traditionally built to be a concrete structure in which the polymer lining was applied to prevent the

leakage of the water.

POSCO and Seoul Metropolitan Government have researched together to determine the best grade of stainless steels for the reservoir lining. In 2016, the stainless steel sheets were supplied to construct the lining on the wall of the reservoir which is located in the downtown of Seoul, in which total area of the wall is around 500 square meter.

In Seoul, more than one hundred of water reservoirs are in use and half of them are older than 20 years. Increasing demand and the activities for the clean lining will be active in Korea.



### Details

Environment:	drinking water
Owner/Developer:	Seoul Gov. & POSCO
Fabricator:	MoonChang Co.
Stainless Steel Grade:	S31803
Product type:	Cold plate
Surface finish:	2B
More information:	<a href="http://posco.com">posco.com</a>



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## About ISSF

The International Stainless Steel Forum is a non profit association, based in Brussels, which represents the interests of the producers of stainless steel and the Stainless Steel Development Associations (SSDAs) towards end-users, the media, the general public and regulatory authorities. The association has 56 members from all over the world and currently represents approximately 90% of the total production of stainless steel.

### More information

For more information about ISSF, please consult our website [worldstainless.org](http://worldstainless.org).

For more information about stainless steel and sustainability, please consult the [sustainablestainless.org](http://sustainablestainless.org) website.

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