



Outokumpu Stainless

Stainless Steel for Structural & Architectural Applications

Tallinn University of Technology – 2nd February 2011

www.outokumpu.com

**OUTO
KUMPU**

Outokumpu – who are we?

Stainless Steel, Grades & Properties

Grade Selection - Corrosion

Surface Finishes

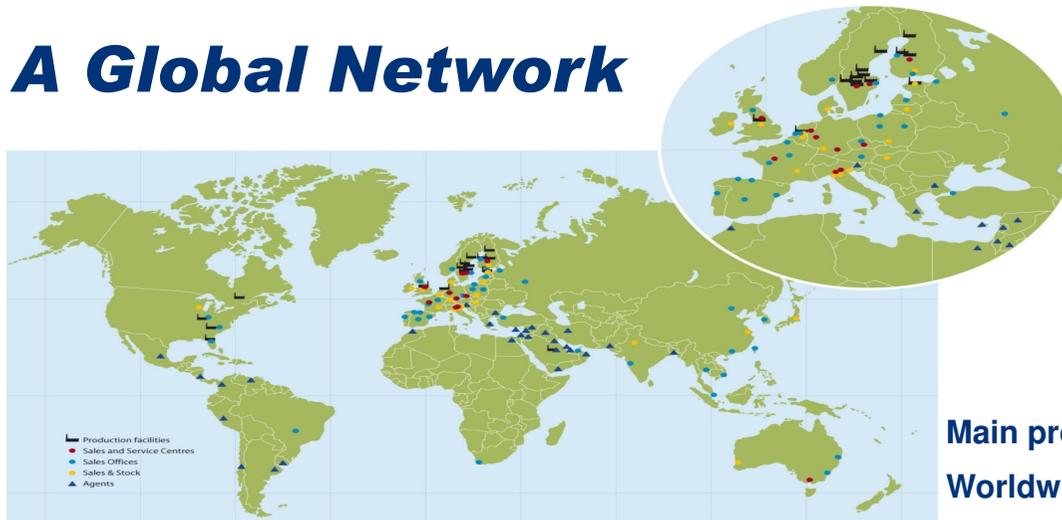
Duplex Grades - Bridges

Outokumpu – an International Stainless Steel Company

- Outokumpu is a global leader in Stainless Steel. Our vision is to be the undisputed number one in stainless, with success based on operational excellence.
- Outokumpu Group employs over 7 600 people in some 30 countries
- Group's sales of EUR 2.4 billion in 2009
- Outokumpu has been listed on the NASDAQ OMX Helsinki since 1988
- Extensive R&D facilities, situated in Finland & Sweden



A Global Network



Main production sites are in Finland, Sweden, UK and USA
Worldwide network of Service Centres and Sales Offices

Corporate Responsibility

- Responsibility - an integral part of all activities and decision making
- Outokumpu expects its business partners, subcontractors and suppliers to apply the same high standards
- Outokumpu adheres to the strictest ethical principles in conducting business:
 - Human dignity
 - Our planet for the future
 - Good corporate citizenship
 - Healthy workplace
- Outokumpu participates in the UN Global Compact leadership initiative



Broad Range of Products and Grades of Stainless Steel

- Coil, sheet and plate
- Quarto plate
- Thin strip
- Tubular products
- Long products



Outokumpu – who are we?

Stainless Steel Grades & Properties

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Duplex Grades - Bridges

What is Stainless Steel?

- A family of corrosion resistant steels
- An alloy mixture of Iron & Chromium
 - often with: Nickel, Molybdenum, Titanium, Sulphur, Niobium, Manganese and a small amount of Carbon

Steel Scrap

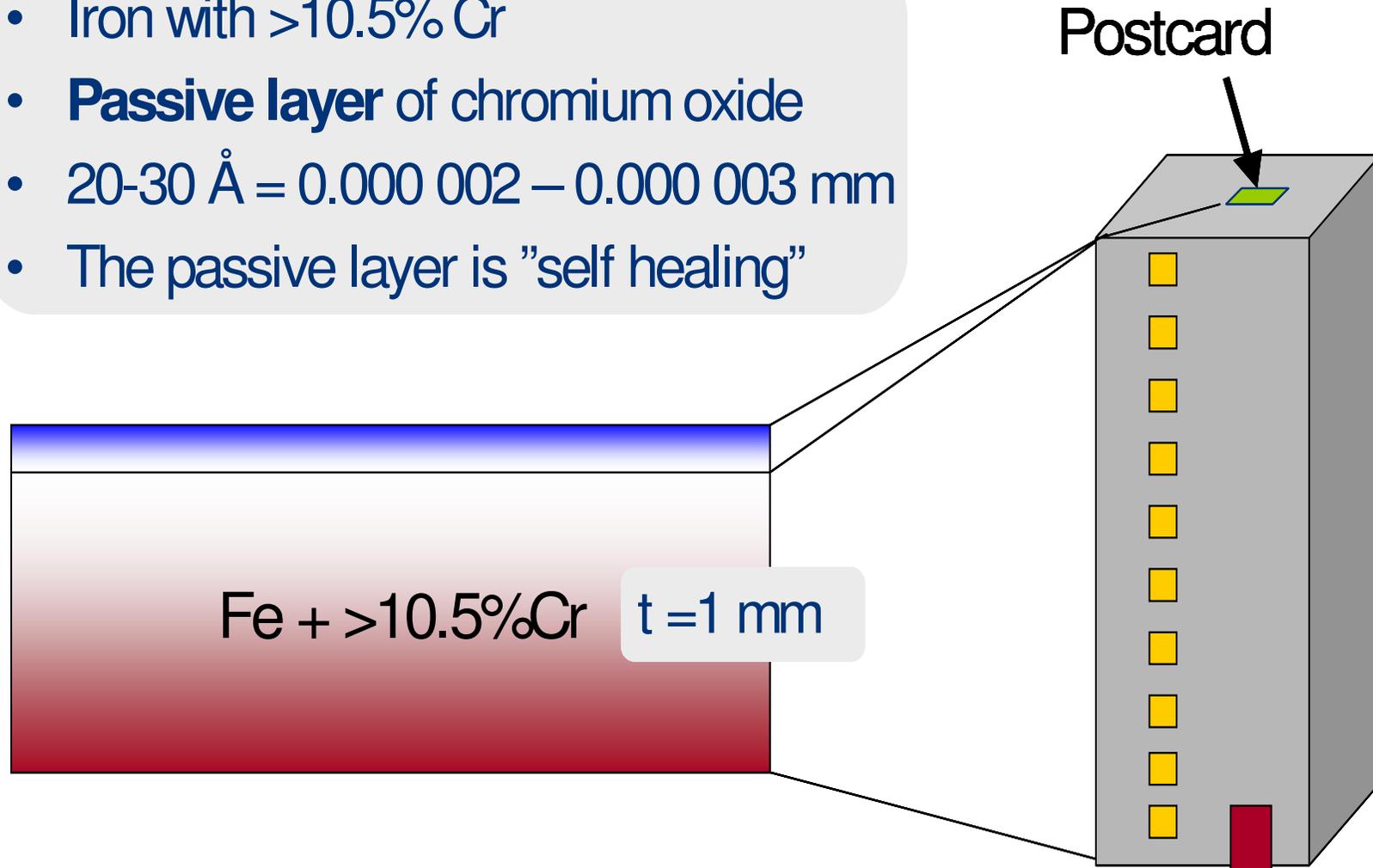


Electric Melting



What makes Stainless Steel 'stainless'

- Iron with $>10.5\%$ Cr
- **Passive layer** of chromium oxide
- $20\text{-}30 \text{ \AA} = 0.000\ 002 - 0.000\ 003 \text{ mm}$
- The passive layer is "self healing"



Variety of Stainless Steels

- Good to Excellent Corrosion Resistance
- Mechanical Properties; Excellent Ductility, Low to Medium Strength, Rp0.2: 200 - 300MPa, A5: 35-45%
- Very Good Weldability
- Applications: Façades, Paneling, Roofing

- **Excellent Corrosion Resistance**
- **Mechanical Properties; Good Ductility, High Strength, Rp0.2: 400 - 530MPa, A5: 25-30%**
- **Good Weldability**
- **Applications: External Curtain Walls, Roofing**

- Good Corrosion Resistance
- Mechanical Properties; Good Ductility, Medium Strength Rp0.2: 250 - 300MPa, A5: 25-30%
- Good Weldability
- Applications: Interiors

Austenitic
(Nickel-containing)

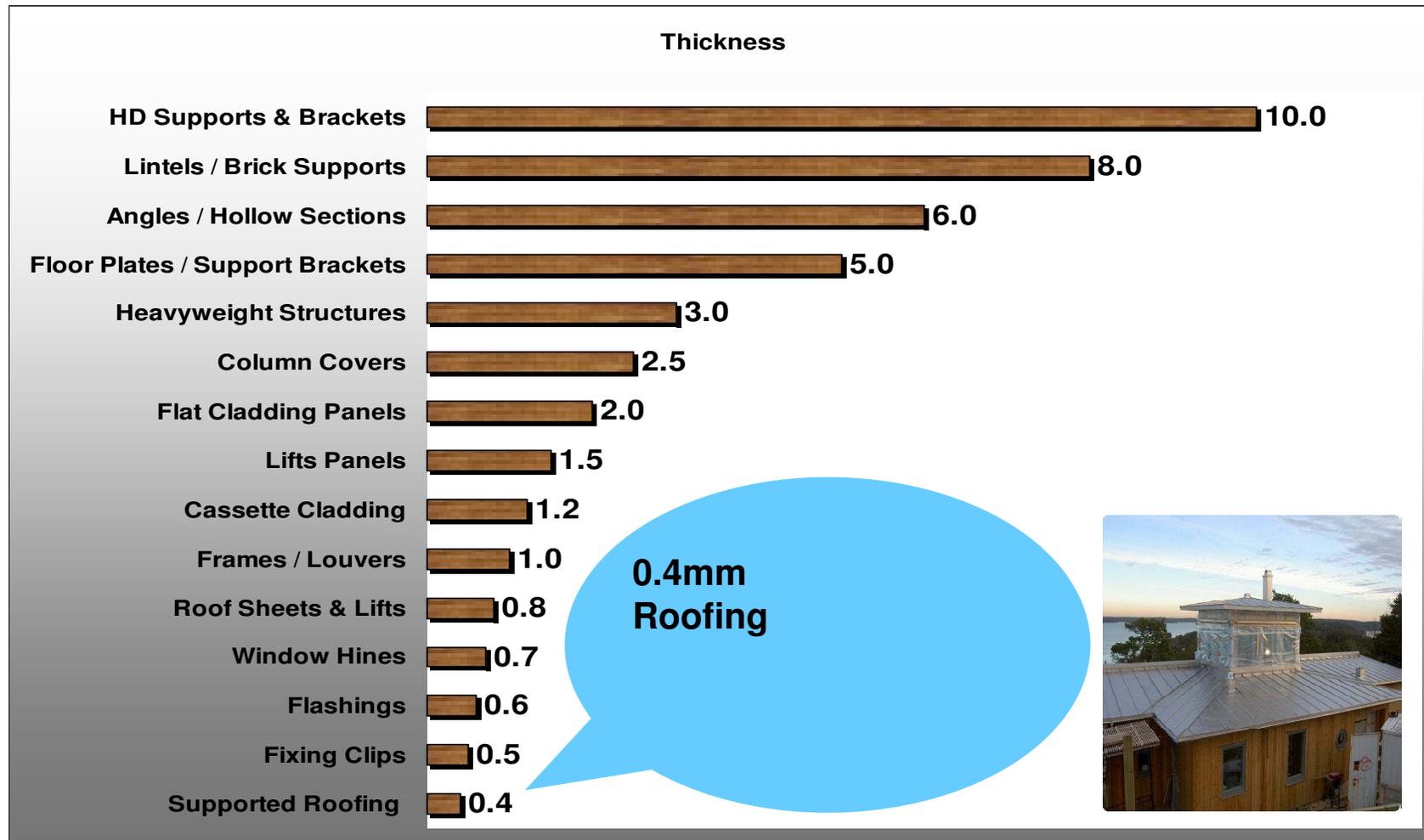
Duplex
(Low-nickel)

Ferritic
(Non-Nickel)

Why Choose Stainless Steel?

- Aesthetic Appearance
- Availability
- Cleanability
- Corrosion Resistance
- Cost Effective
- Durable, Long Life
- Finishes Range
- Fire Resistant
- Formability
- Functional performance
- 100% Recyclable
- Lightweight
- Non-Toxic
- Product Form & Range
- Ready for use
- Scrap Value
- Stable
- Weldable
- Workable
- Work Hardenable

Which Applications



Outokumpu – who are we?

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No one wants see Stainless Steel like this!



Prevention of Corrosion

Causes & Risk factors

- Chloride
 - Salt (sodium chloride)
 - Coastal locations
 - De-icing salt, mortar cleaners
- Higher concentrations
- Higher atmospheric temperature
- Highly polluted atmospheres
- Damp conditions (condensation?)
- Crevices in the structure
- Rough surface finishes

Prevention

- Correct grade selection

..then...

- Smoother surface finish
- Regular cleaning/rain water washing
- Good design & fabrication practices

Austenitic Stainless Steels

- Nickel Containing (around 7 – 20%)
- Usually non-magnetic
- Versatile, and therefore widely used
- Can be easily formed & welded at all thicknesses
- Good – Excellent corrosion resistance
- Ductile & tough at cryogenic temperatures



Ferritic Stainless Steels

- No Nickel
- Strongly magnetic
- Moderate – Good corrosion resistance
- Standard grades have poor weldability in thick section
- Poor toughness at low (subzero) temperatures



Duplex Stainless Steels



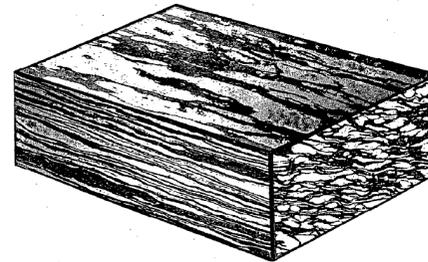
- Mixture of austenitic and ferritic
- Low - moderate nickel content
- Magnetic
- Good to excellent corrosion resistance
- Good weldability & formability

Yield Strength (Design Strength)

Austenitic 304, 316 ~ 240 MPa

Ferritic 430 ~ 280 MPa

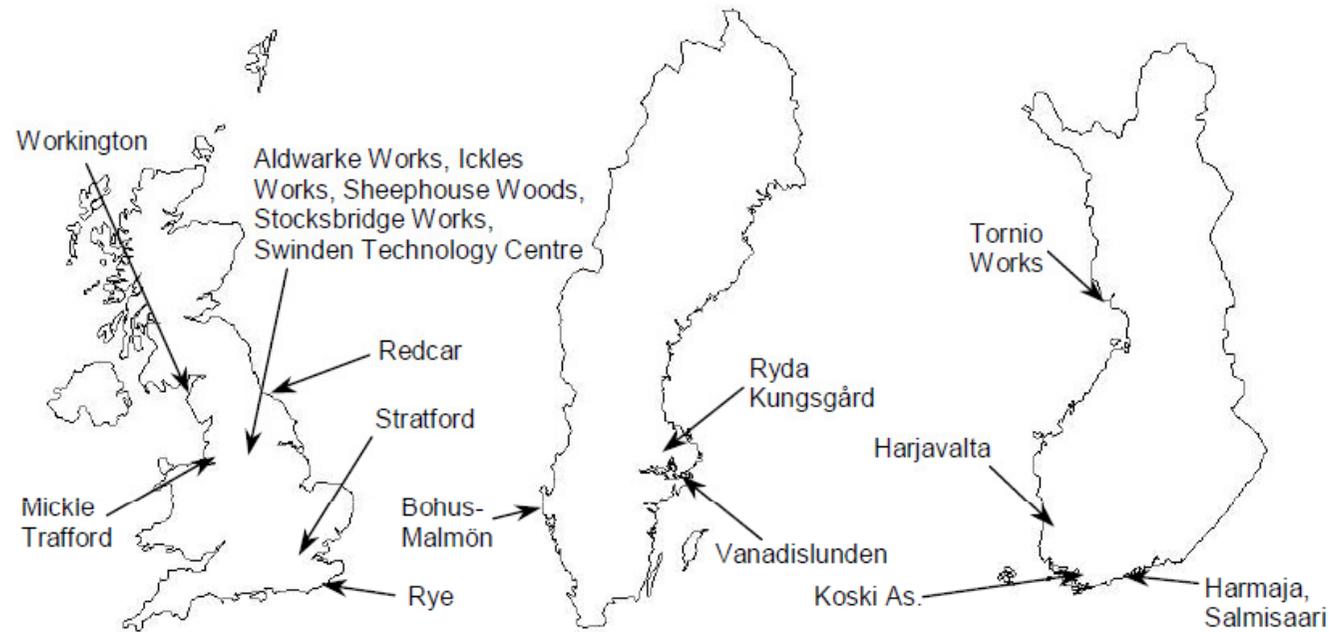
Duplex LDX2101 ~ 480 MPa



(a)

Approximately twice as strong as austenitic steels

Outokumpu Atmospheric Corrosion Test Sites



**Sites also now established in
Dubai, Beijing and Western
Australia**

Rough Guide to Selection for Atmospheric Conditions

Steel grade	Location											
	Rural			Urban			Industrial			Marine		
	L	M	H	L	M	H	L	M	H	L	M	H
304L (1.4307)	✓	✓	✓	✓	✓	(✓)	(✓)	(✓)	X	✓	(✓)	X
316L (1.4404. 1.4432)	○	○	○	○	✓	✓	✓	✓	(✓)	✓	✓	(✓)
2205 (1.4462)	○	○	○	○	○	○	○	○	✓	○	○	✓

L Least corrosive conditions within that category, e.g. tempered by low humidity, low temperatures.
 M Fairly typical of that category.
 H Corrosion likely to be higher than typical for that category, e.g. increased by persistent high humidity, high ambient temperatures, and particularly aggressive air pollutants.
 ○ Potentially over-specified from a corrosion point of view.
 ✓ Probably the best choice for corrosion resistance
 X Likely to suffer excessive corrosion.
 (✓) Worthy of consideration if precautions are taken (i.e. specifying a relatively smooth surface and if regular washing is carried out).
 NOTE: National regulations may contain more onerous requirements.

Adapted from SCI Design Guide for Stainless Steels

Note: Duplex grades LDX2101 and 2304 could be good alternatives to 304L/316L

Outokumpu – who are we?

Stainless Steel Grades & Properties

Grade Selection - Corrosion

Surface Finishes

Duplex Grades - Bridges

EN Surface Finishes

EN Product Conditions

1D	Hot rolled, heat treated, pickled
1G	Hot rolled, ground
1Q	Hot rolled, quenched and tempered, pickled
2H	Work hardened
2E	Cold rolled, heat treated, mech. descaled & pickled
2D	Cold rolled, heat treated, pickled
2B	Cold rolled, heat treated, pickled, skin passed
2F	Cold rolled, heat treated, pickled, skin passed on roughened rolls
2R	Cold rolled, bright annealed
2G	Ground
2J	Brushed or dull polished
2K	Satin polished
2M	Patterned
2W	Profile rolled
2L	Coloured

Surface Finish v Stain Resistance

Smoother

Mirror 2P BA 2R

Higher

2B

**Surface
Finish**

No 5, 2K

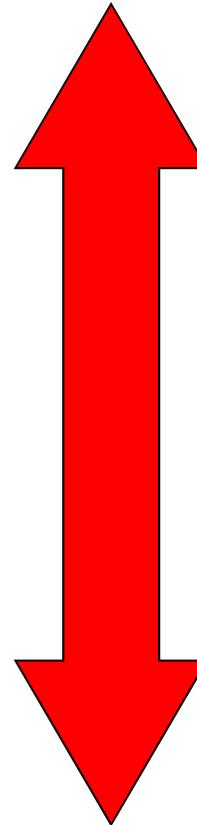
**Stain
Resistance**

No 4, 2J

Rougher

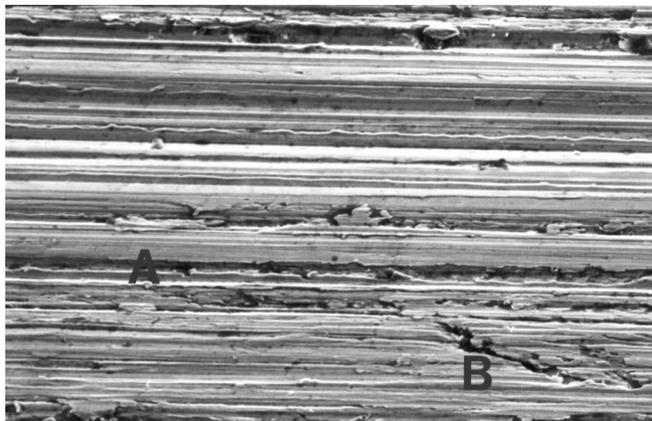
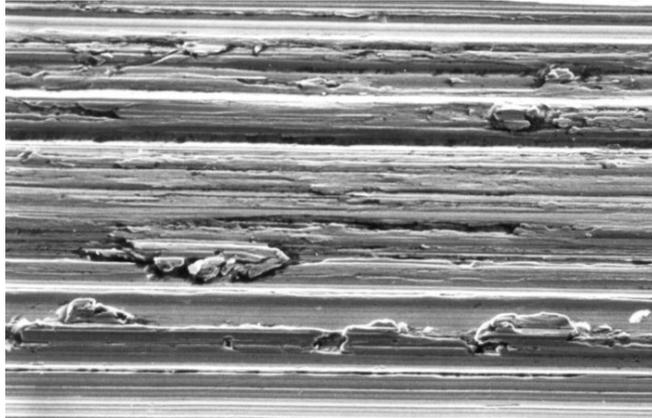
2G

Lower

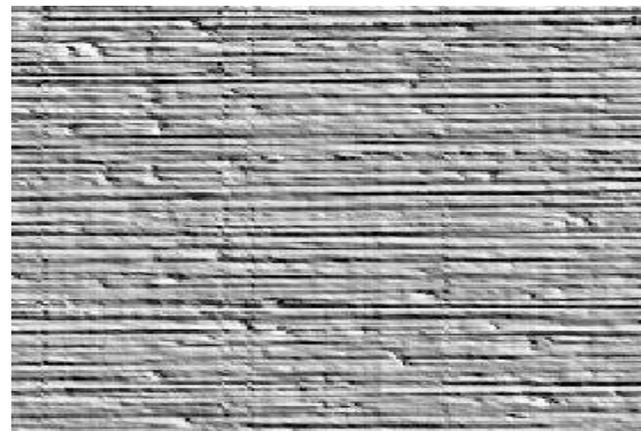
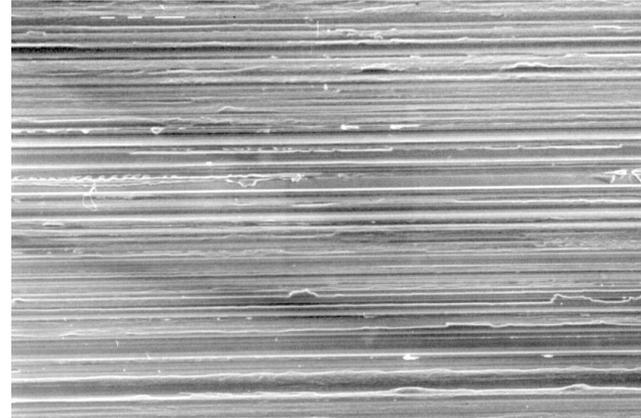


Surface Characterisation of Final Product

Polished & Brushed Finishes



Poor Polish Finish

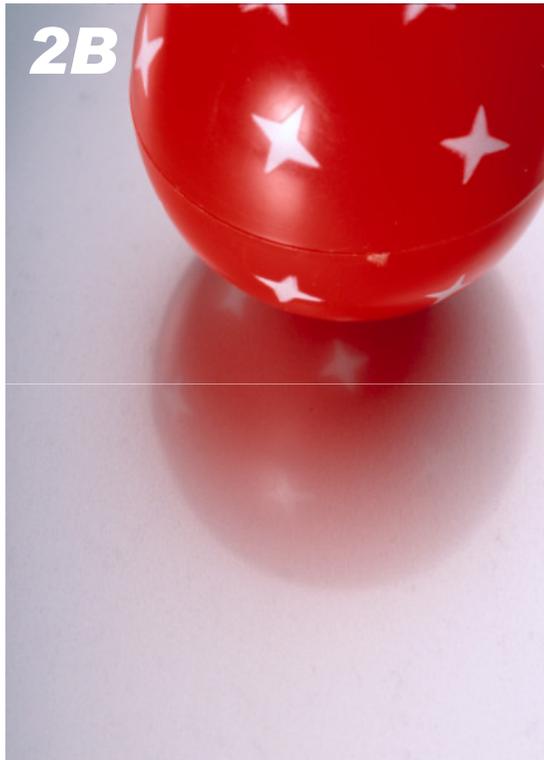


Good Clean Finish

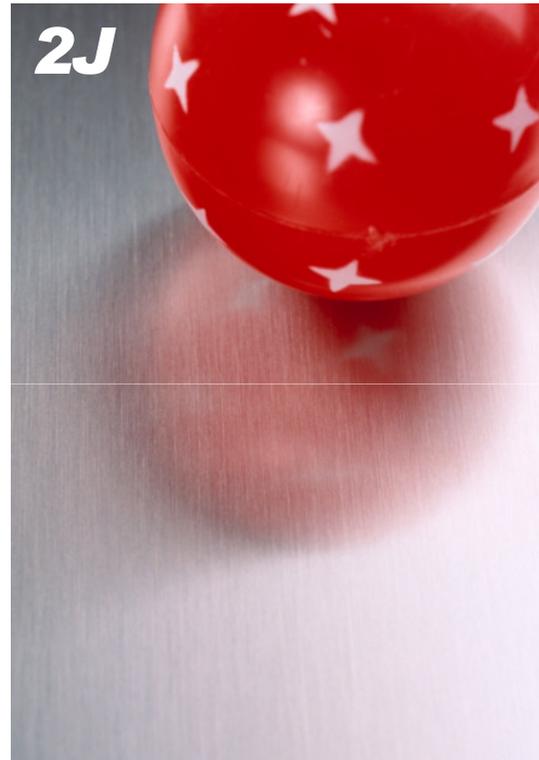
Grit Polish

Dry Brushed

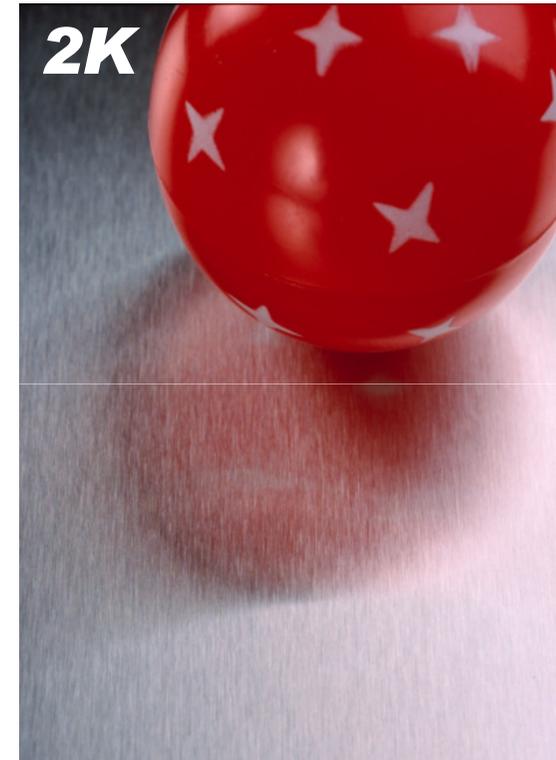
2J - Dry Brushed / Dull Polished **2K- Satin / Fine Polished**



Good levels of flatness,
smoothness & corrosion
resistance



Brush or Belt polished, less
reflective than 2K

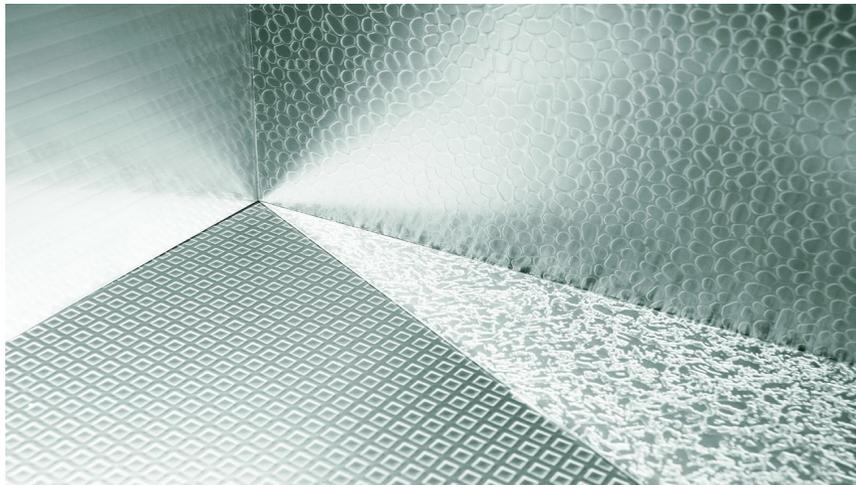


Fine / Wet Polished,
Ra value < 0.5 μ m

Outokumpu Architectural Finishes

2M - Deco Rolled

- **Single side texture, plain reverse**
- **13 Different Patterns**
- **Thickness Range 0.40 – 3.0mm**
- **Applications: Panels, Cladding, Roofing**

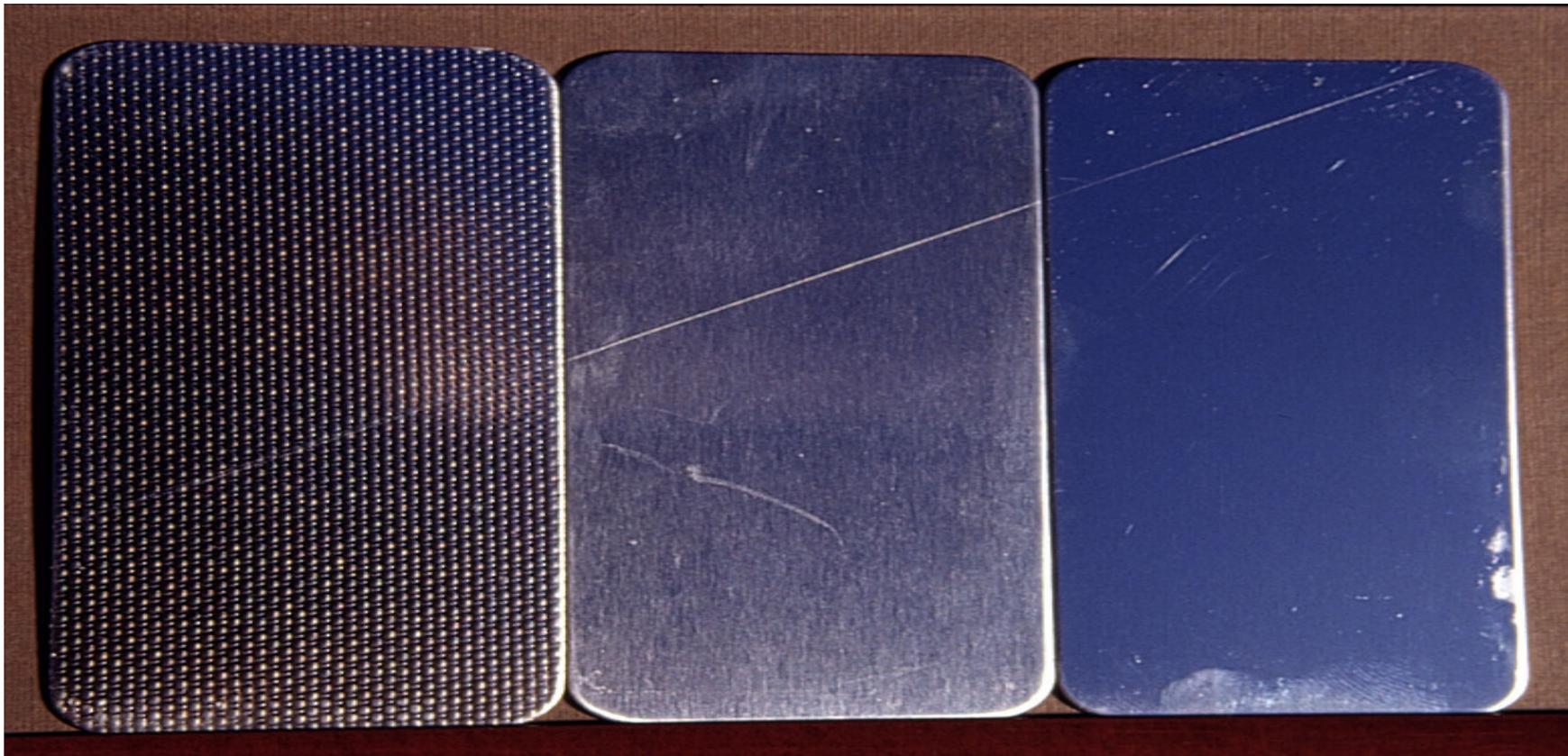


2W - Pattern Rolled

- **Double Sided, Rigidised**
- **3 Different Patterns**
- **Thickness Range 0.4 – 1.50mm**
- **Applications: Counters, Ticket Booths**



Scratch & Wear Resistance



Source: Geoff Stone

Patterned

Polished

Bright Annealed

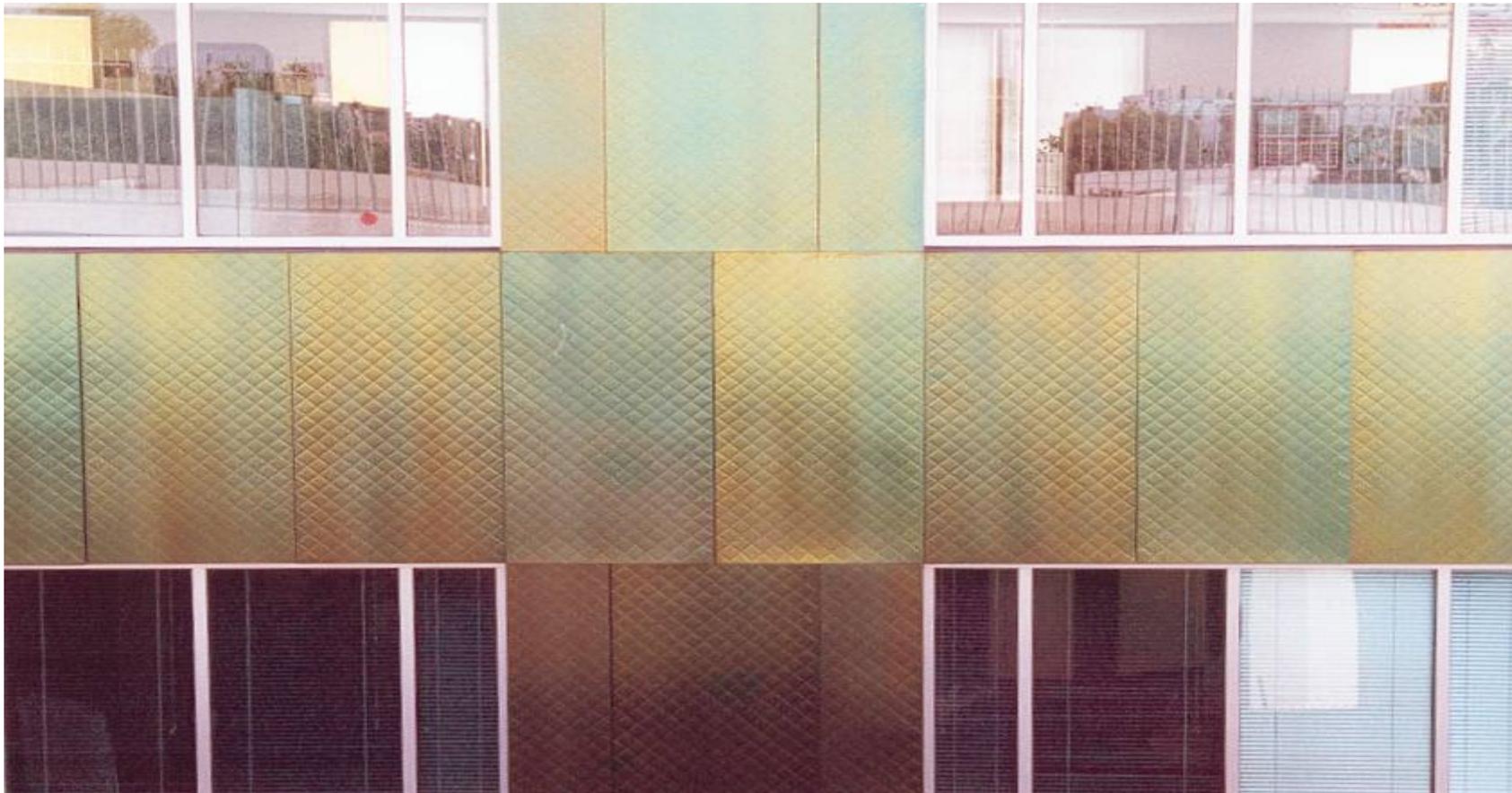
Special Finishes - Painted surfaces

Kuala Lumpur International Airport roof

* 0.5 & 0.6 mm Thick Painted Type 316



2L – Electrolytic Coloured



Source: Geoff Stone

Team Disney Building, Frank Gehry

2F – Matt Finish – CR using Roughened Rolls

Low lustre, less reflective finish which helps reduce glare and reflection from sunlight and retains a long lasting matt appearance. It offers an eye catching alternative to the bright, brushed and polished surfaces.



Court of Human Rights Building, Strasbourg

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Duplex Grades - Bridges

Positioning of Duplex grades

Great combination of both high strength and adequate corrosion resistance!

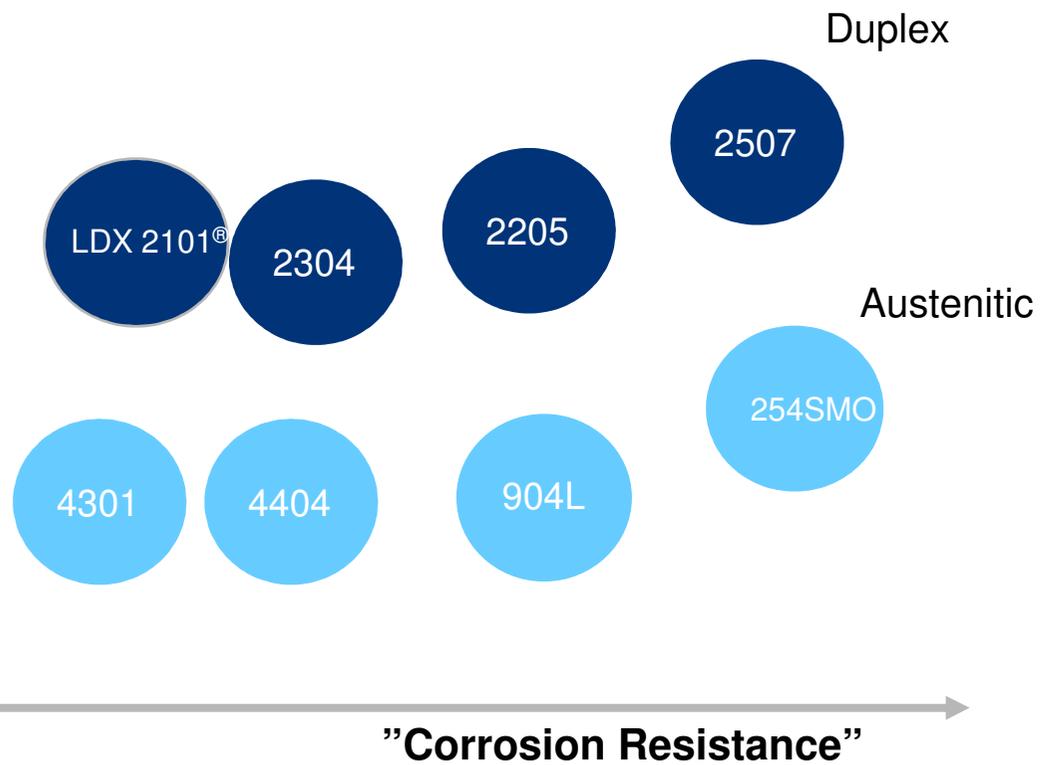
Strength

$R_{p0.2}$ [MPa]

750

500

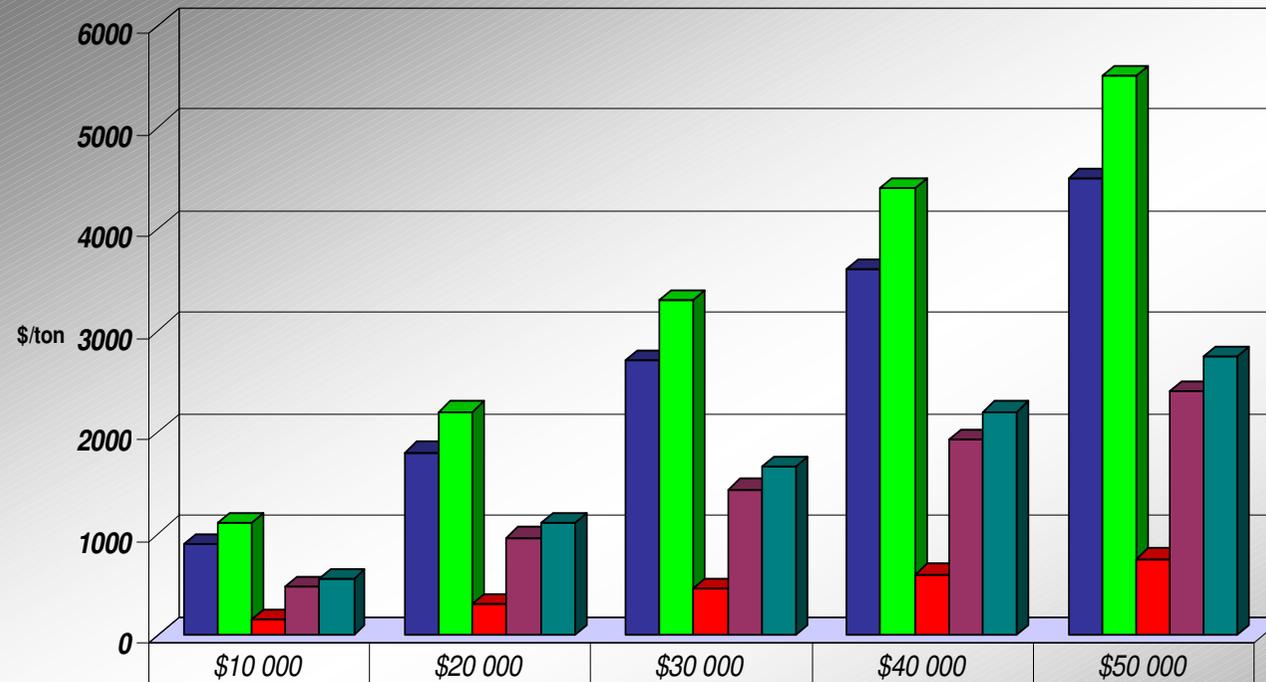
250



”Corrosion Resistance”

(Pitting and crevice corrosion)

Nickel price effect on Austenitic and Duplex alternatives



	\$10 000	\$20 000	\$30 000	\$40 000	\$50 000
304	900	1800	2700	3600	4500
316	1100	2200	3300	4400	5500
LDX2101	150	300	450	600	750
2304	480	960	1440	1920	2400
2205	550	1100	1650	2200	2750

Nickel levels

Case: Stonecutters Bridge, Hong Kong

Challenge

Selecting the optimal steel grade to provide both structural strength and appealing appearance in the upper sections of the towers, minimizing maintenance needs in this exceptionally long cable-stayed bridge.

Environment: hot, humid and maritime

Solution

A maintenance free concrete – duplex 2205 composite design of the upper half of the bridge pylons. Fully utilising the duplex 2205's strength, durability and sustainability to match Hong Kong's image.



Case Studies: Bilbao bridge, Spain

Challenge

Achieving the highest standards in the passage that links the Guggenheim Museum to the University of Deusto, to match the museum's architectural design and to educate students about the aesthetic merits and potential of stainless steel.

Solution

Duplex 2304 with a special plate surface finish for enduring beauty. A great example of value creation, where weight reduction, lower life cycle costing and sustainability is realized.



Case study: Celtic Gateway footbridge, Holyhead, UK

Challenge

Identifying the right material for the bridge's tubular, load-bearing arches.



photo courtesy: Cimolai

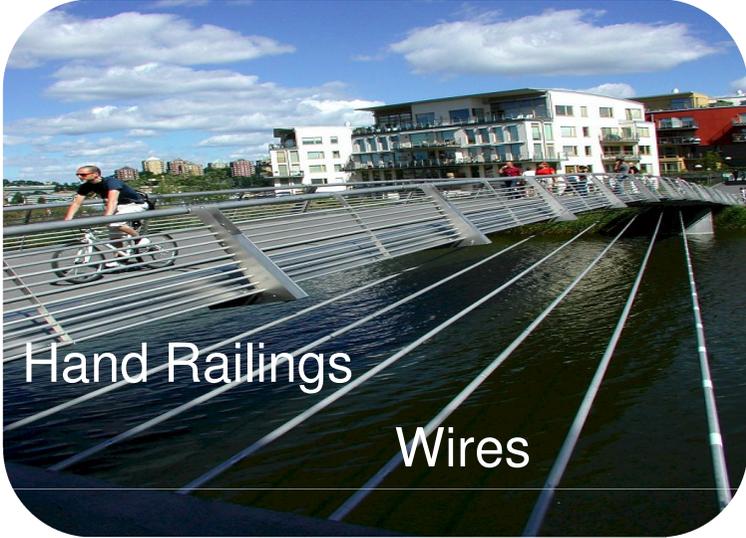
Solution

Duplex 2304 to provide first-rate corrosion resistance in the atmospheric conditions coupled with excellent mechanical properties, cost-efficiency, and ease of fabrication.



photo courtesy: Cimolai

Which parts of a bridge can utilise the advantages of DUPLEX?



The Helix – An Iconic Stainless Steel Walkway, Singapore

Challenge

To build a landmark stainless steel bridge to symbolize Singapore's urban ambitions. The Helix represents unique architecture, being the world's first double-helix pedestrian bridge.

Solution

Duplex 2205 (EN 1.4462) pipes and plates from Outokumpu to build the main structures; Duplex stainless steel provides durability and adequate corrosion resistance in the hot, humid and maritime environment; Outokumpu's high quality, service and comprehensive capabilities ensured successful project implementation.



Stainless Steel Applications in AB&C



- Structural Components
- Bridges
- Fixings
- Masonry Supports
- Reinforcement including Rebar
- Sluice & Flood Gates
- Cladding & Façades
- Roofing
- Street & Playground Furniture
- Lifts & Elevators
- Swimming Pools
- Mass Transport Systems
- Handrails & Balustrades



Technical References

Wealth of details & knowledge:

Outokumpu:

Applications, Corrosion

www.outokumpu.com

Architects Guide to Stainless Steel:

Surface finishes, Cases studies

www.steel-stainless.org/architects/

Euro Inox:

Practical solutions, References

www.euro-inox.org

British Stainless Steel Association:

Technical queries, Grade Selection, Suppliers

www.bssa.org.uk

Steel Construction Institute:

Design Calculations, Architects Guide

www.steel-stainless.org

Avesta Welding

Welding consumables & advise

www.avestawelding.com

IMOA:

Climate Data, Case Studies, Applications

www.imoa.info

Nickel Institute:

Technical Literature

www.nickelinstitute.org

Thank You !

Activating Your Ideas

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