# Stainless Steel for Airport Infrastructure

**February 14, 2013**

**New Delhi**

**N C Mathur**

**President**

**Indian Stainless Steel Development Association**

# Indian Stainless Steel Development Association

Cooperative technical and market development arm of SS industry - Non-profit body

WE PROVIDE

Technical help on selection and use of stainless steel to end users like architects, builders, engineers, material specifier etc.

Help in sourcing of stainless steel products and services

**FREE OF CHARGE . . .**

**Supported by**

**Nickel Institute**

# What are stainless steels ?

- Stainless steels are alloys of iron containing a minimum of 10.5% chromium

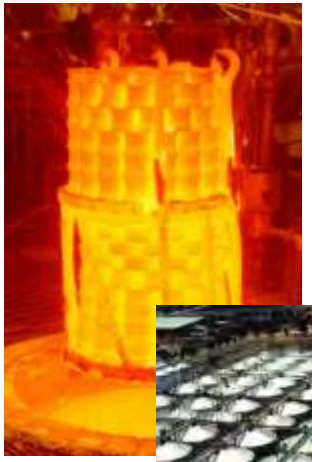
- Minimum chromium level is about 12% in commercially available grades

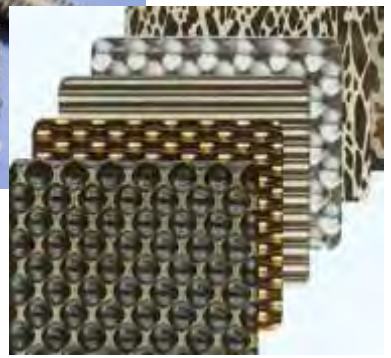
# Grades Suitable For Airport Use

| Chem / Grade | C | Mn | P | S | Si | Cr | Ni | Mo |
|---|---|---|---|---|---|---|---|---|
| 430 | 0.12 | 1.00 | 0.040 | 0.030 | 1.00 | 16.00-18.00 | 0.75 | -- |
| 304 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 18.00-20.00 | 8.00-0.50 | -- |
| 316 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 16.00-18.00 | 10.00-4.00 | 2.00-3.00 |
| 201 | 0.15 | 5.5-7.5 | 0.060 | 0.030 | 1.00 | 16.00-18.00 | 3.50-5.50 | |
| 202 | 0.15 | 7.5-10.0 | 0.060 | 0.030 | 1.00 | 17.00-19.00 | 4.00-6.00 | |
| Duplex Grades | | | | | | | | |

# Stainless Steel
## Attributes

- Excellent corrosion resistance – does not require coatings
- Strength increases with cold work
- Excellent elongation / formability
- Looks good with other materials –stone, wood, concrete, glass
- Available in a wide range of surface finishes
- Readily clad on carbon steel
- Excellent fatigue resistance
- Easy to clean – hygienic
- 100% recyclable
- Good strength – the strength of steel
- Good energy absorbing characteristics
- High rigidity (Young's Modulus) – the rigidity of steel
- Low thermal conductivity
- Easily formed and welded with conventional equipment
- Good high temperature resistance and strength
- Tough at cryogenic temperatures





# Comprehensive range of products for use in Architectural, Building & Construction at AAI

# ARCHITECTURAL APPLICATIONS

- BENCHES
- RAILINGS
- BARRICADES/BOLLARD
- LITTERBINS
- TICKETING COUNTER
- CLADDINGS
- SIGNAGES
- SKIRTING
- GATES/CRASH GUARDS
- WATER BOOTHS
- KIOSKS
- CANOPY/SPACE FRAME
- TELEPHONE BOOTHS
- PLANTERS/TREE GUARD
- FRISKING BOOTHS
- TOTEMS
- QUEUE MANAGERS
- GRATINGS
- ESCALATOR PANELING

# Some Indian Airports using Stainless Steel

## Bollards


## SS Bus Shelter


## SS Railing & Luggage Trolley

## SS Trolley Stand


# Mumbai International Airport

## Column Cladding & Trolley Fenders

## Embossed pattern Column Cladding & Trolley Fenders

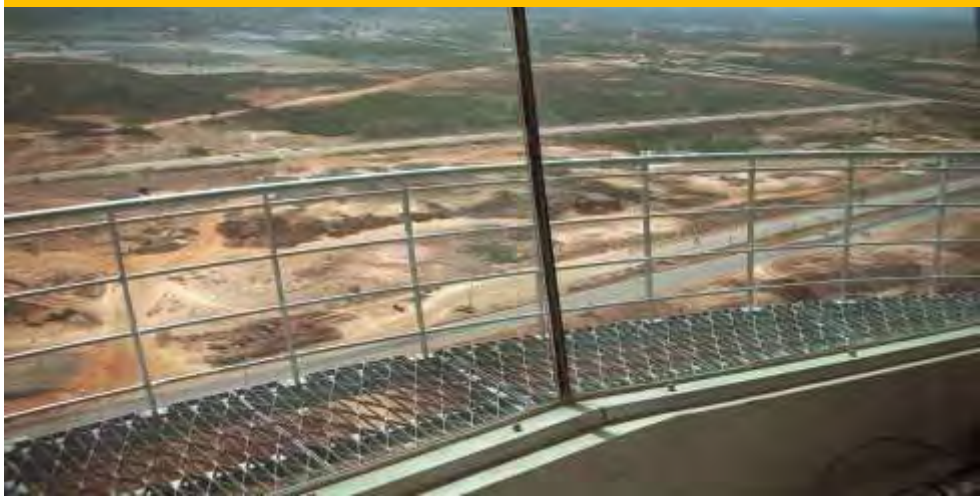
## SS Column Cladding in BA and Embossed Pattern Finish

## SS Main entrance Vestibules, SS Trolley Stand, LCD Stand, Trolley Fender

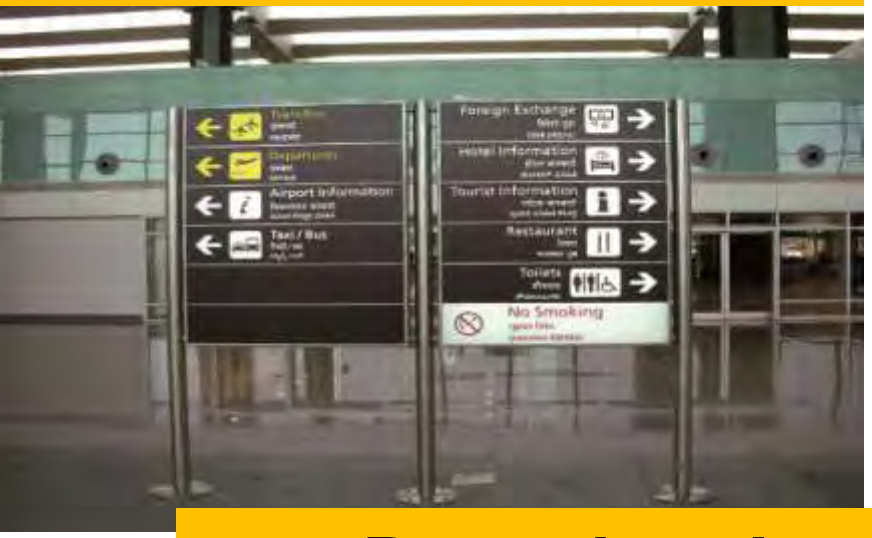
# Delhi International Airport

## ATC TOWER

## Stainless Steel Railings at ATC Tower



## Signage




## Barriers

***Bangalore International Airport***

## SS Glass Railing and Escalator

## Boarding Bridge Railing

## Ramp Railing

## Check-in-Counters


***Hyderabad International Airport***

## *ISSDA member companies has done work at airports Pan India……*

**Glass Railing, Trivandrum Airport**

**Jaipur, Chennai, Bhubneshwar**

**Raipur, Lucknow,**

**Amritsar**

**Varanasi**

**Port Blair Airport**

**Dehradun**

**Delhi Terminal 2/T1D**

**Indore**

**Gondia**

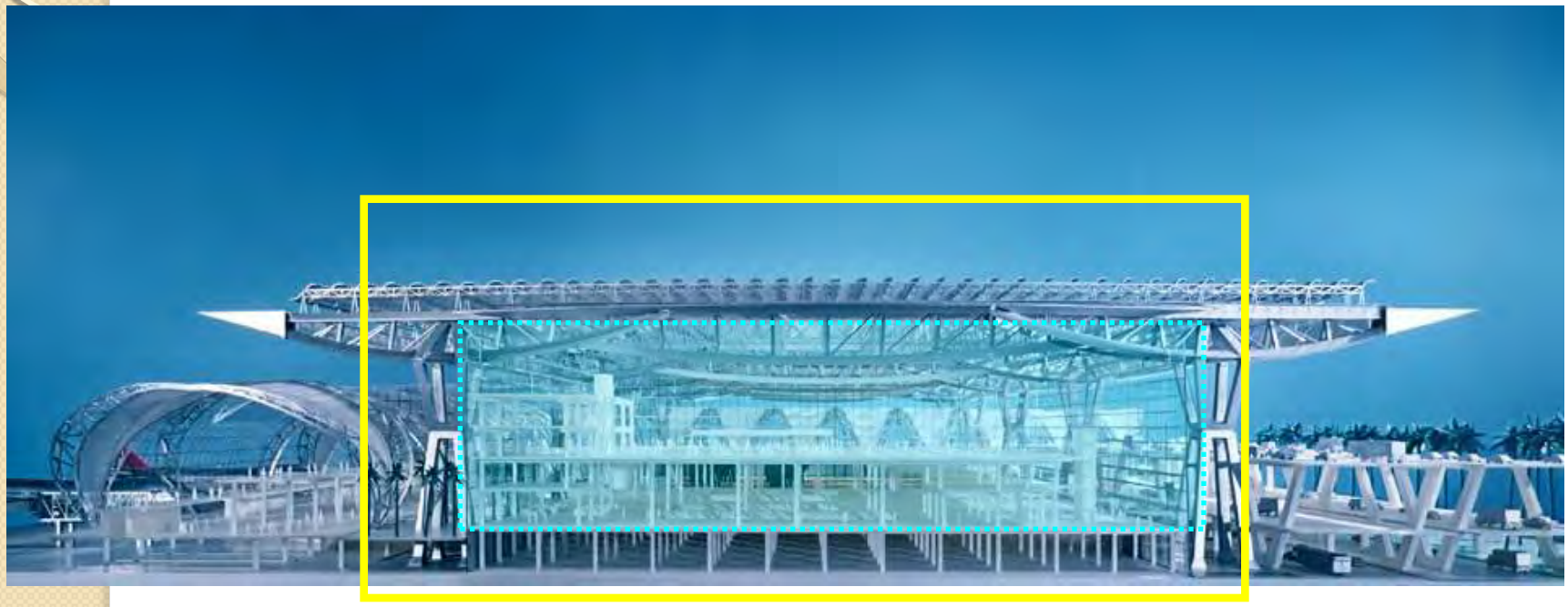
**Chandigarh**

An aquarium at the
Kochi airport lounge

# Foreign Airports using Stainless Steel

# Suvarnabhumi Bangkok International Airport

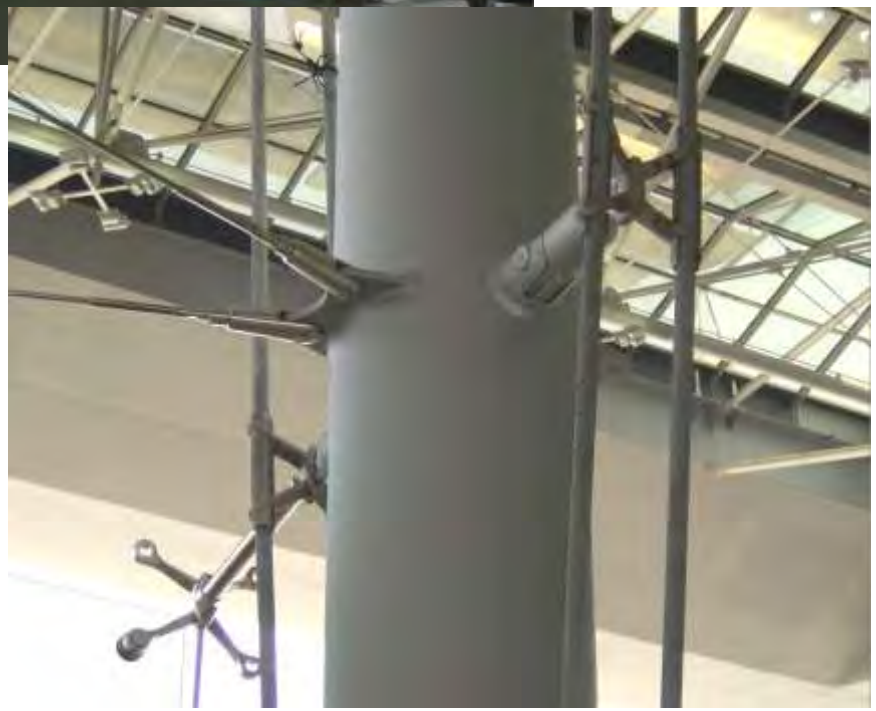
# Suvarnabhumi Bangkok International Airport



Green Facades, Kinzi Thailand

**A point-fixed glazed wall**
**10 storeys high (37m)**
**More than 1 kilometre perimeter**

# Suvarnabhumi Bangkok International Airport

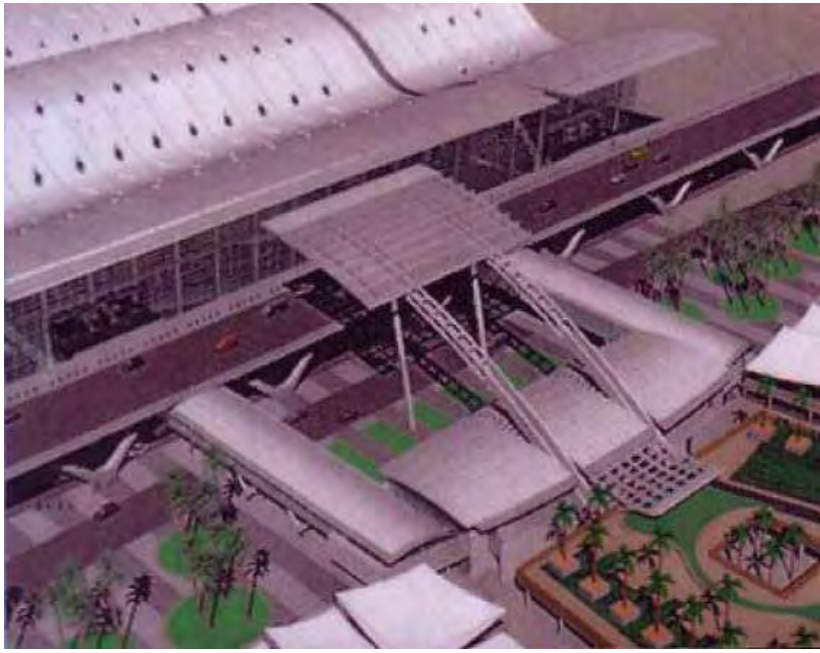



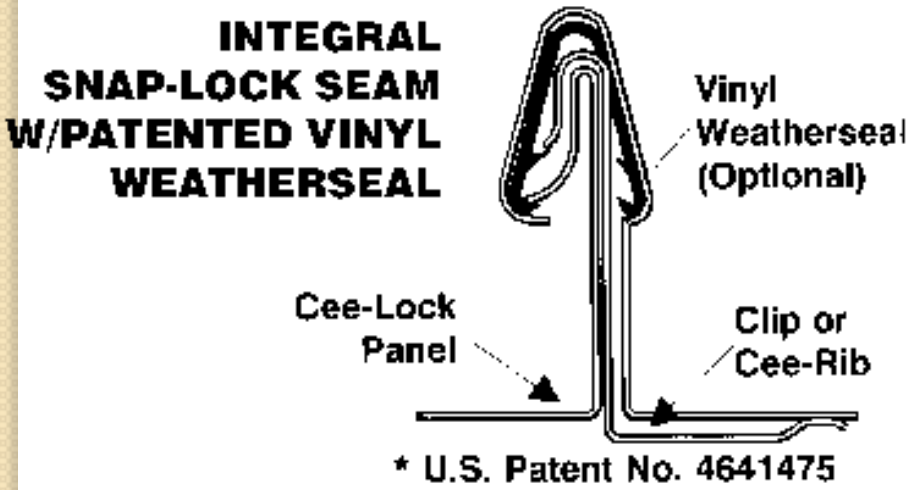
# Ronald Reagan Washington National Airport Terminal Roof

- Type 304; 0.559 mm; 4,461 sqm
- 54 small Bermuda domes 13 m x 13 m
- Batten seam landside canopy
- Dull rolled-on finish Architex® finish
- Completed in 1997

# Doha International Airport

## Under construction – estimated completion 2010

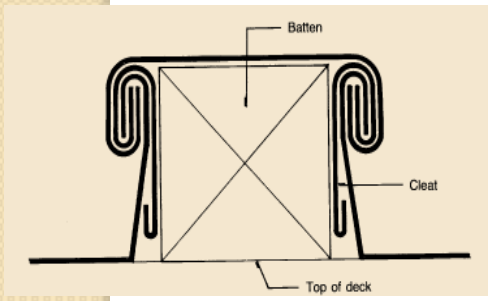




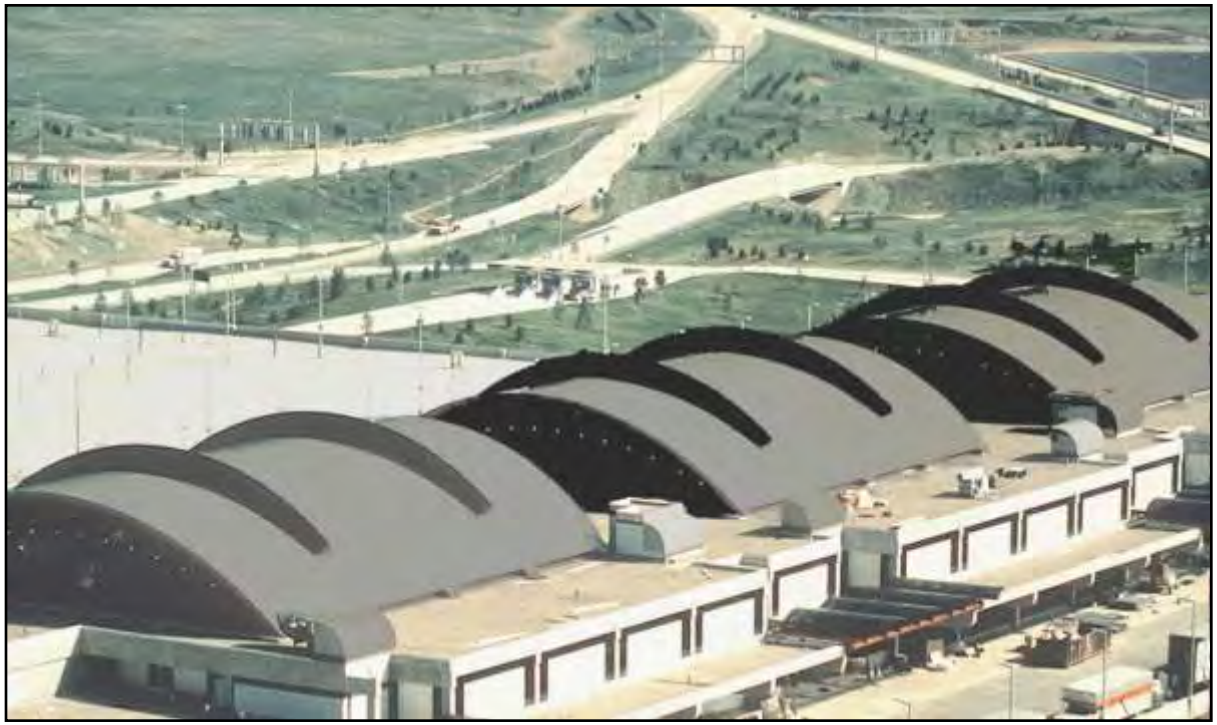

Roof: Duplex AL2003
and 2205
Interior: Type 304

# Detroit International Airport McNamara Terminal, 2001

Batten cap design
Dull rolled finish
Type 304



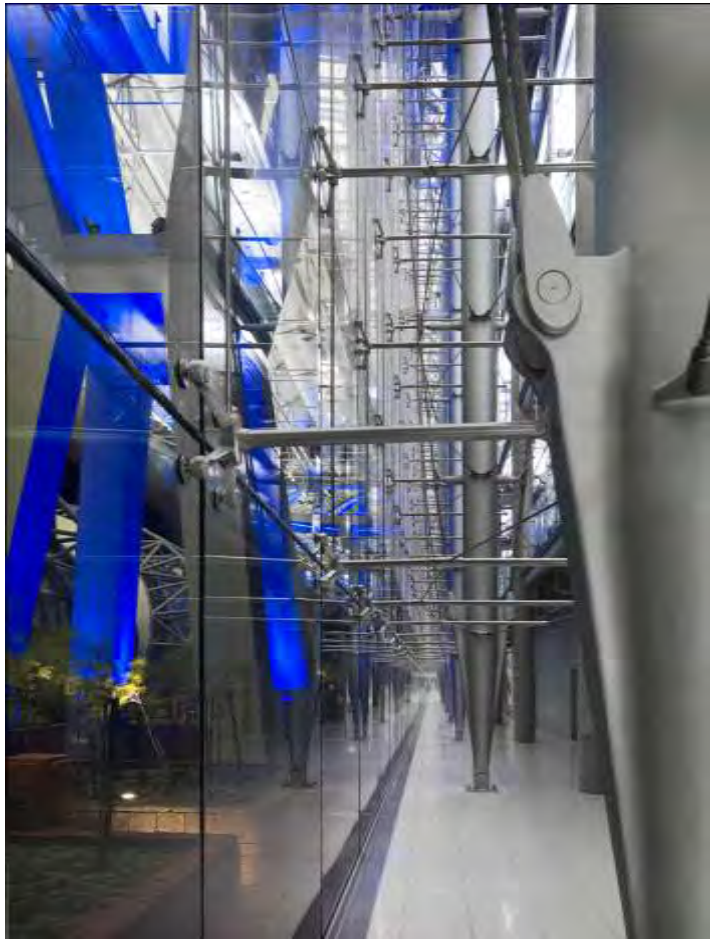

# Pittsburgh International Airport



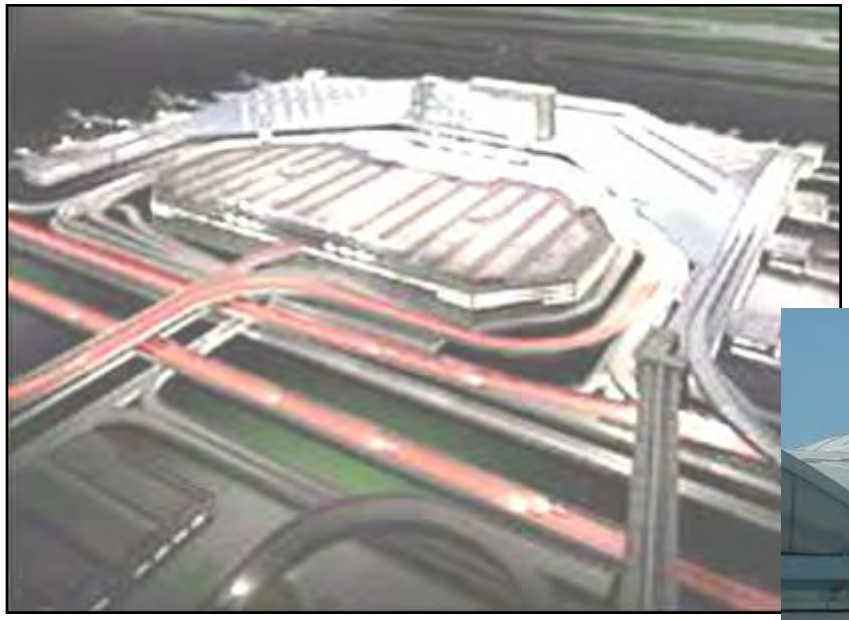
- Type 304
- Terne-coated finish
- Weathers to medium to dark gray
- Batten cap, high wind uplift roof design
- Completed in 1992

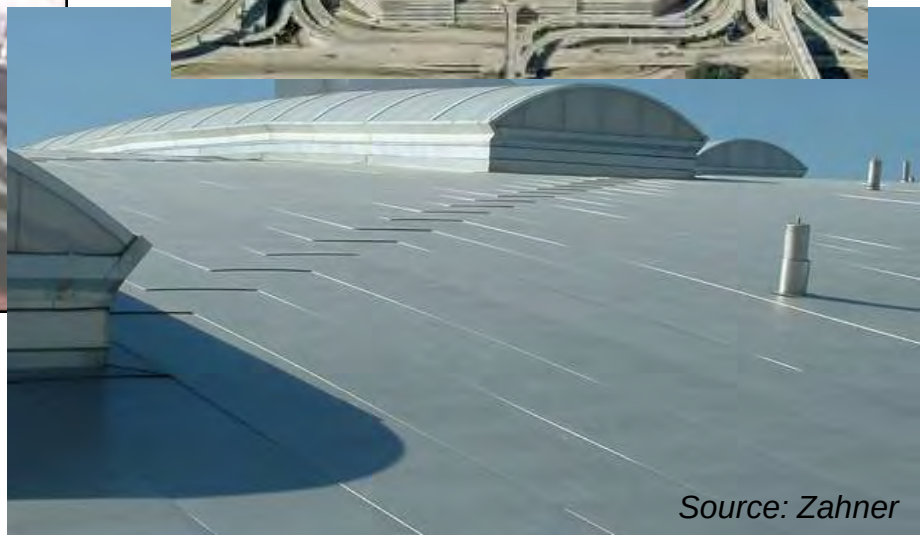
# New Bangkok International Airport

- Type 316 sun screens over skylights
- One the world's largest low profile stainless steel and glass curtain walls - 37 m high, 441 m long



# Dallas/Fort Worth Airport Terminal





Source: Zahner

- Type 304 stainless steel, Architex® finish
- Spring 2005 completion
- Standing seam roof
- Hurricane force wind uplift requirements

# *Arriving in the Arms of a Rainbow*

## New Haneda Airport, Tokyo


Designer: Naoya Sakagami, Nisshin Steel Co Ltd

**Material: Type 304 stainless steel which has been:**

- **Embossed**
- **Electrochemically coloured**
- **Sputter coated with blue ceramic**

# Kuala Lumpur International Airport

Outokumpu Stainless
Chadwick Technology

**150,000 sq m (> 400 tonnes) of fluorocarbon PVf2 painted Type 316 stainless steel**

# Changi Airport Singapore

Green Facades

# Kuala Lumpur International Airport
# Stainless Steel Plant Support Sun Screens

## Innovative use of Stainless Steel

# International Projects

# Chrysler Building New York

## Constructed in 1929

## The roof, spire and gargoyles are fabricated from Type 302 stainless steel

# Stainless steel
# - structures which last

## Empire State Building
## constructed 1931

# Jin Mao Tower, Shanghai - in the gathering dusk

Wang Da-Gang

# Petronas Twin Towers
# Kuala Lumpur

**Built 1996**
**Architect: Cesar Pelli**

**90 floors, 452 m**
**2400 tonnes of 2.5 mm Type 316 stainless steel**

# Parliament House, Canberra, Australia

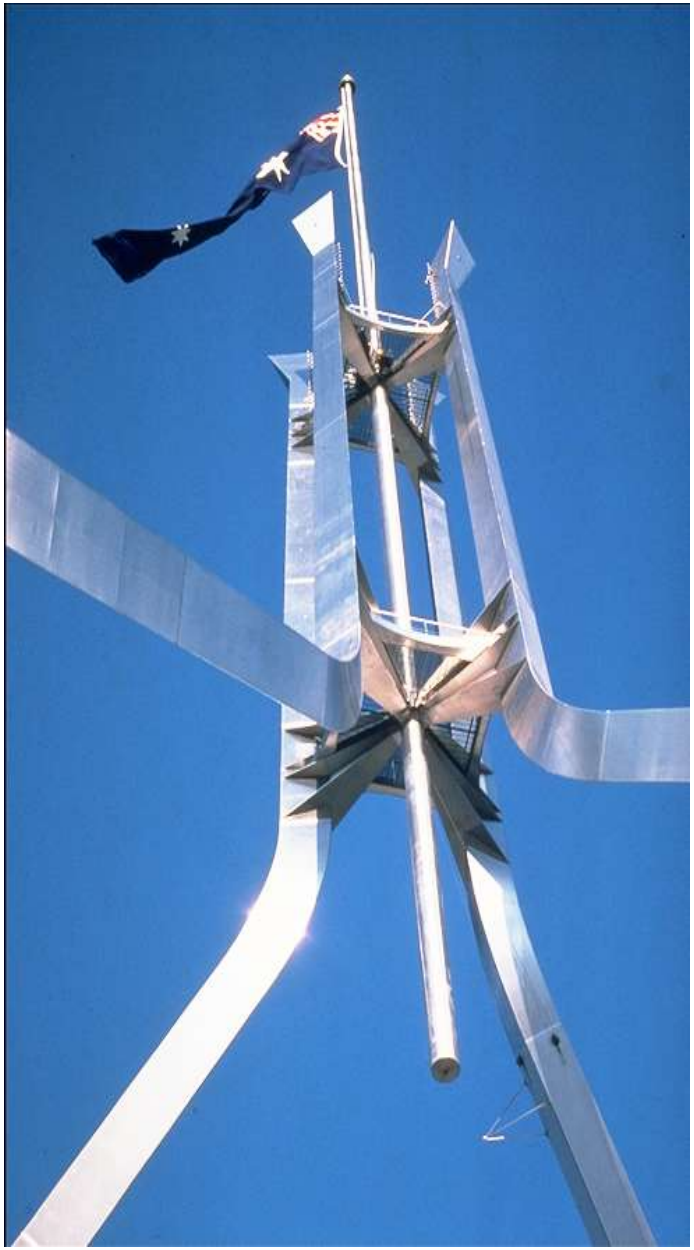
**200 tonne Type 304 stainless steel flagpole supporting the national flag**

**Believed to be the largest free standing stainless steel structure in the world**

# Federal Parliament
# Canberra
# Australia

**BHP guaranteed the stainless steel for 200 years**

**The 'expected life' of the structure is > 200 years**



# *The Centre*

# Hong Kong Central

A Cheung Kong development
Façade engineers: Meinhardt Façade Technology (HK) Ltd

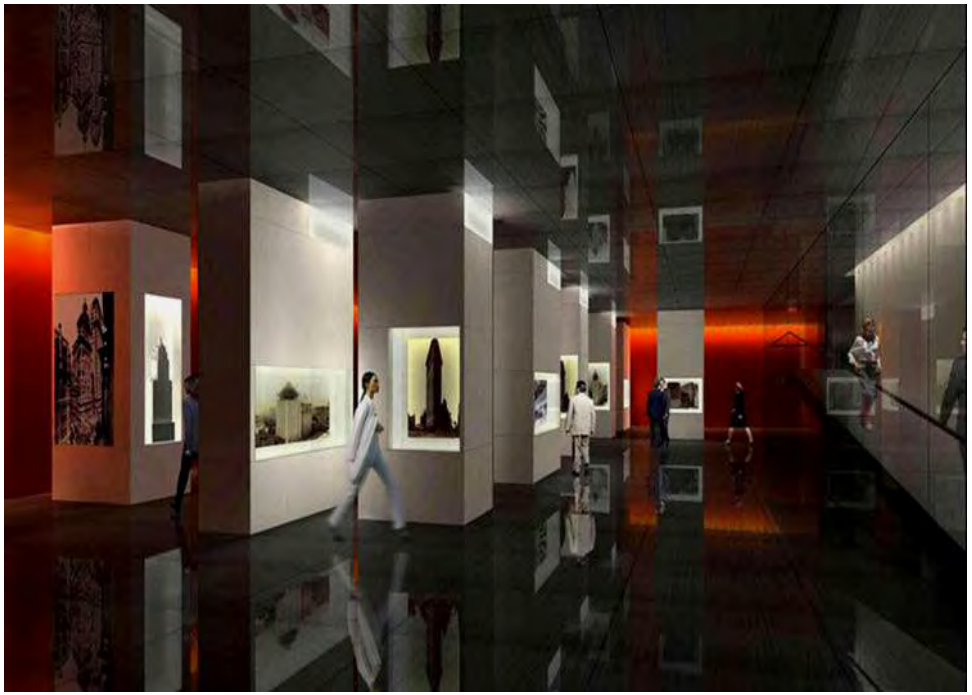
*The Centre*

## Hong Kong Central

**The foyer – brightly reflective stainless steel and glass above a polished stone floor**

# Skyscraper Museum
## Manhattan, New York

- Just opened
- Stainless steel is widely used for the floor, walls, ceiling, ramps and display cases because it is used in many of the world's tall buildings



Skidmore, Owings & Merrill

# Frederick R Weisman Art Museum

## Minneapolis, USA
## Opened November 1993

## 0.61 mm thick Type 316 stainless steel with a fine No.4 finish

Architect: Frank O.Gehry & Associates, Inc.

**"Constantly changing with the weather and time of day, the building is a living sculpture."**

# Iowa Laser Laboratory USA

Architect: Frank Gehry & Assoc.

# Iowa Laser Laboratory

**Flat walls have 2B finish**
**Curved walls have No.8 mirror polish**

# Walt Disney Concert Hall, Los Angeles

Architect: Frank Gehry & Associates

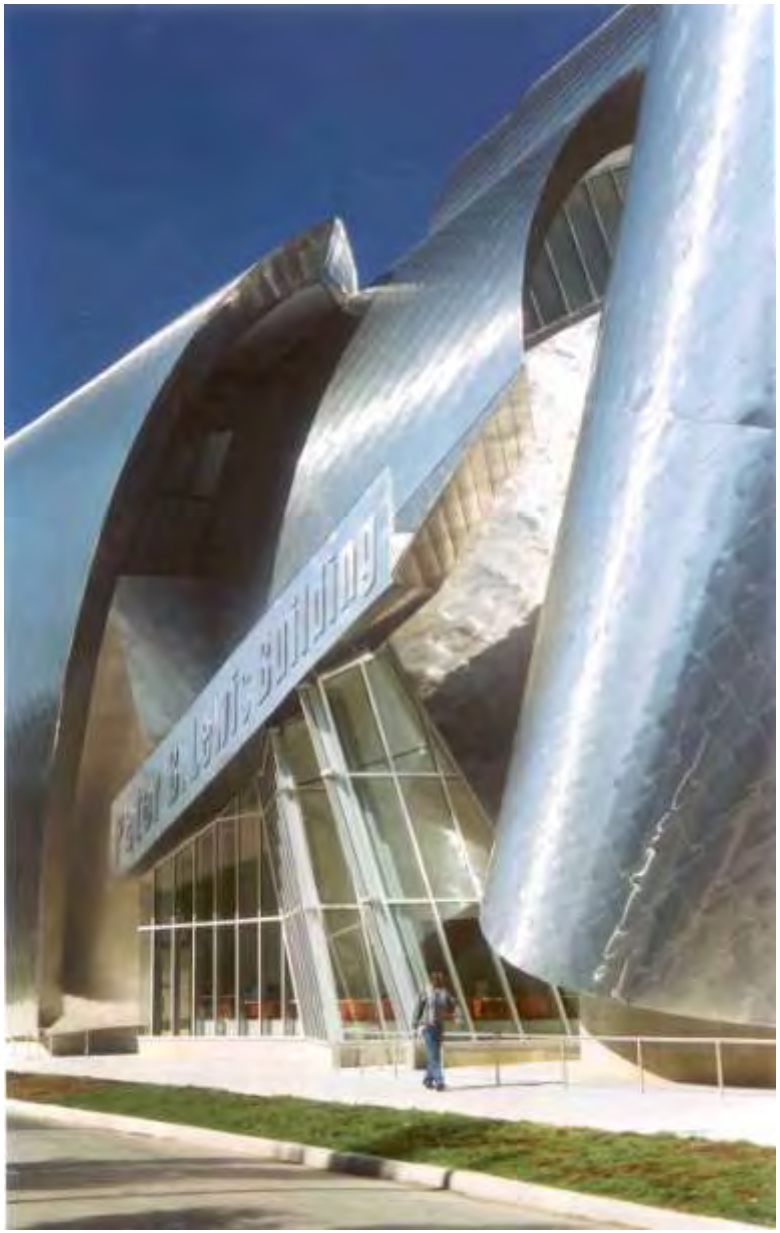
- Type 316 stainless steel
- Most exterior panels have vibration finish
- Mirror polish over VIP entrance caused problems - reflected sunlight into nearby apartments

# Peter B Lewis Building

## Weatherhead School of Management

## Case Western Reserve University, Cleveland

Architect: Frank Gehry & Assoc.



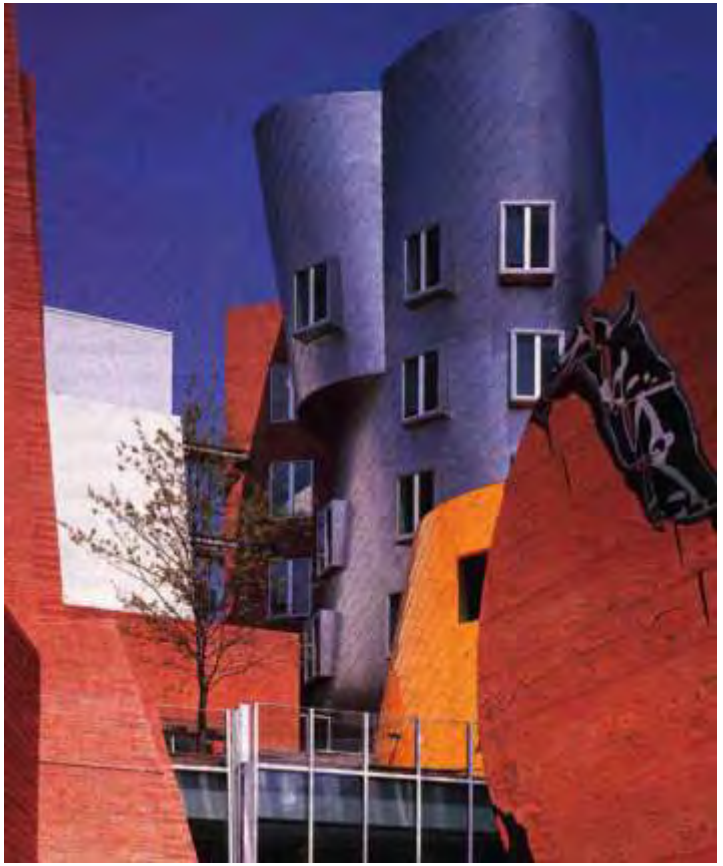
Completed in 2003

Clad in stainless steel shingles

# Ray and Maria Stata Center for Computer, Information and Intelligence Sciences

## Massachusetts Institute of Technology, Boston

Architect: Frank Gehry & Assoc.



**Brick, stainless steel and painted aluminium**
**Overlapping stainless steel shingles**

# Ray and Maria Stata Center for Computer, Information and Intelligence Sciences

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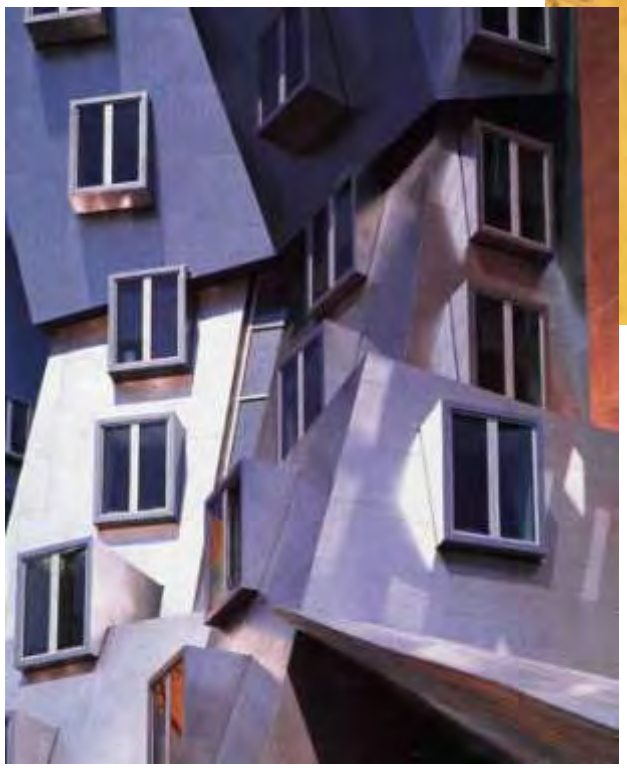
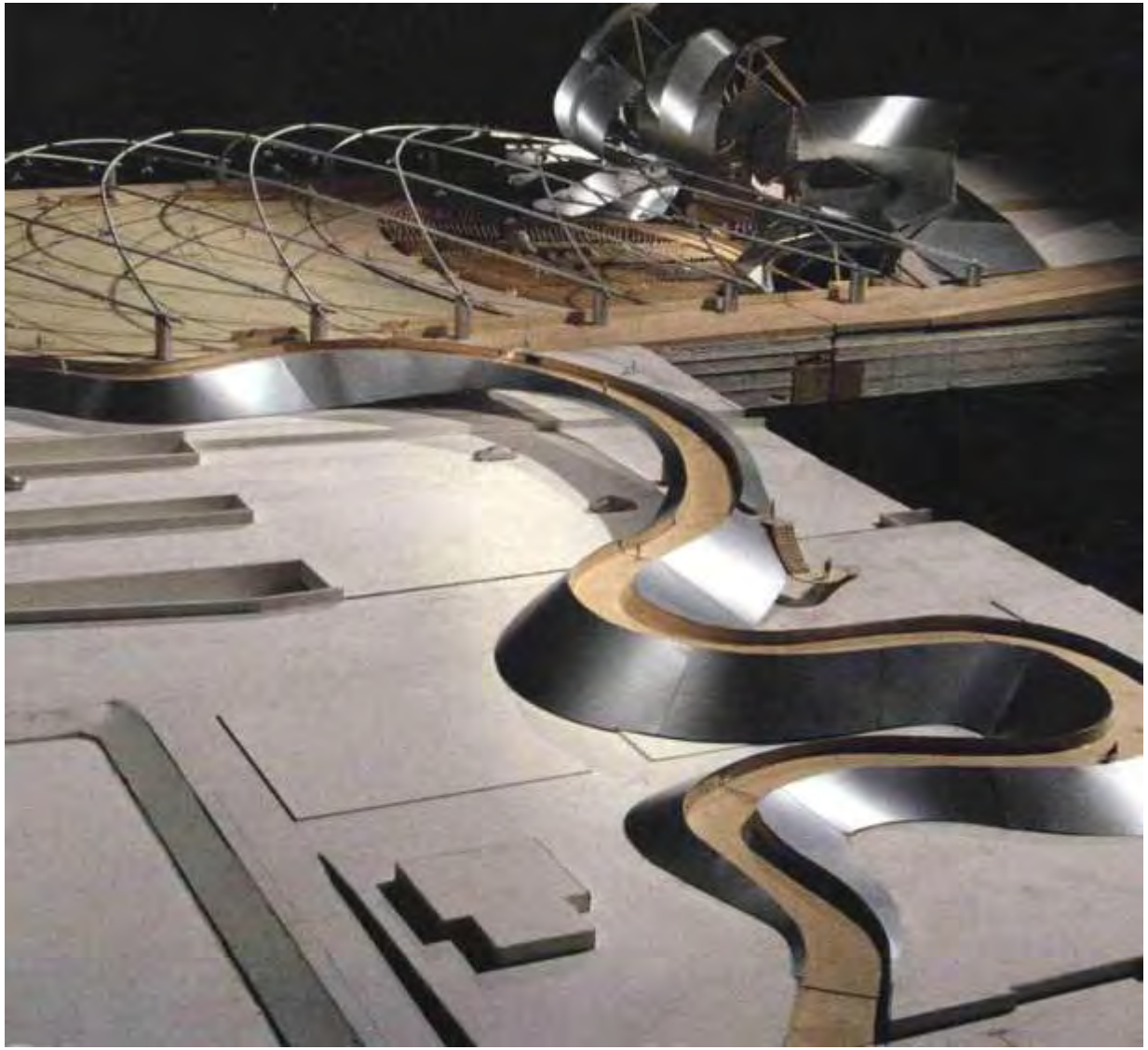


# Millennium Park, Chicago



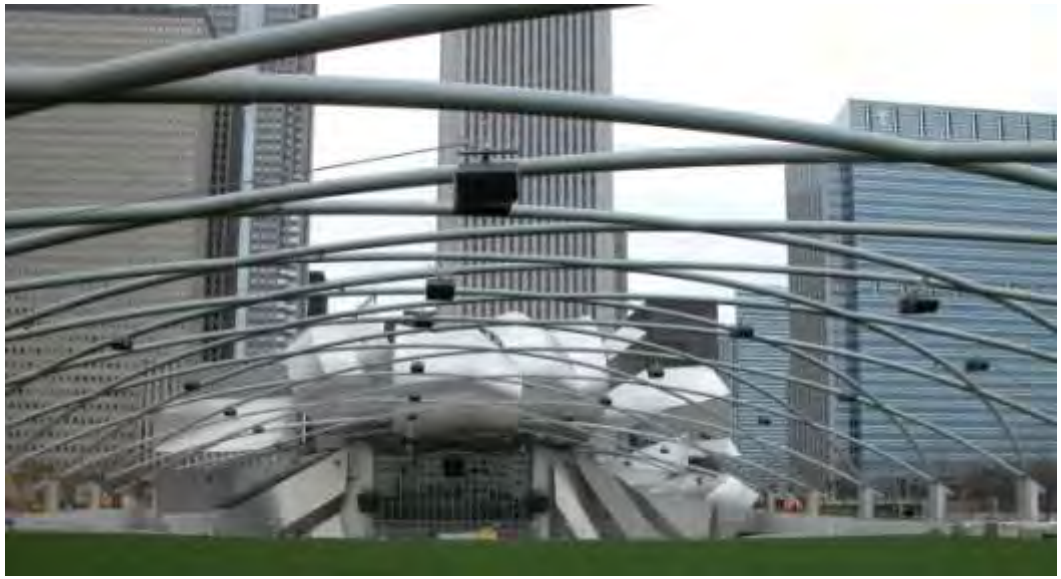
Architect: Frank Gehry & Assoc.

Amphitheater and bridge

# Millennium Park
## Chicago

**Amphitheater**

**stainless steel with a vibration finish**



**Architect: Frank Gehry & Assoc.**

# Millennium Park
## Chicago

**Bridge**

**stainless steel with a vibration finish**

**Architect: Frank Gehry & Assoc.**

# Stainless Steel Sculpture

## Millennium Park
## Chicago

Artist: Anish Kapoor

***Cloud Gate*** **sculpture ("The Bean")**

**20 m long, 10 m high, 4 m clearance underneath**

**168 polished Type 316 stainless steel plates, joined seamlessly together**

# Samsung Museum of Modern Art
# Seoul, Korea

Architect: Frank Gehry & Assoc.

**A cascading waterfall of stainless steel**

# Experience Music Project
# Seattle, USA

Architect: Frank Gehry & Assoc.

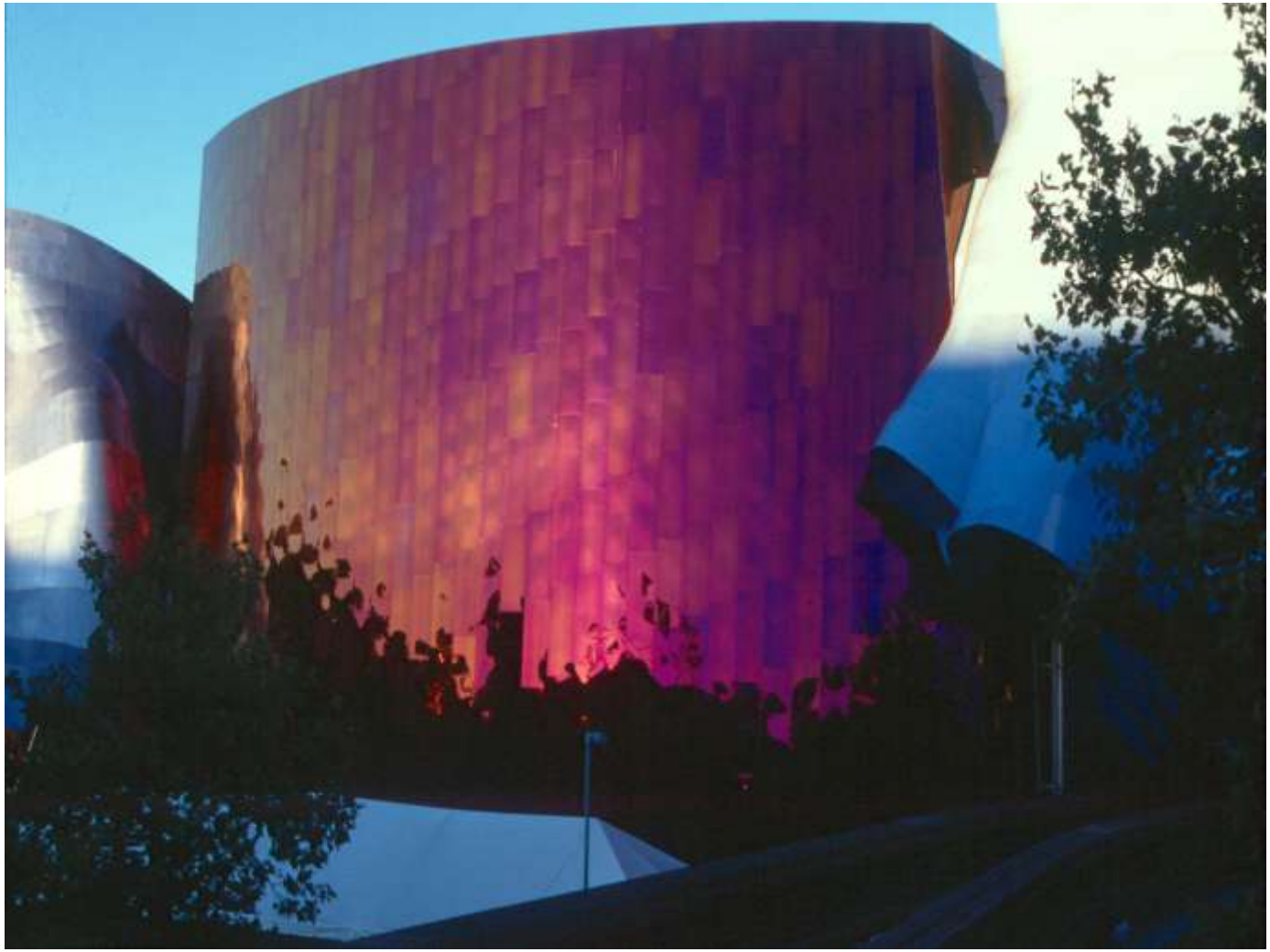
**Stainless steel structure – electrochemical gold colour**

# Experience Music Project

Architect: Frank Gehry & Assoc.

**Stainless steel roofing – electrochemical gold colour**

# Experience Music Project



Architect: Frank Gehry & Assoc.

**Stainless steel wall – electrochemical purple colour**

# Experience Music Project

Architect: Frank Gehry & Assoc.

**Foyer**
**Mirror polished Type 304 stainless steel**
**Natural and electrochemical purple colour**

# Team Disney administration building
## California

Architect: Frank Gehry & Assoc.

**Façade is with a 2B finish which has been electrochemically coloured in many hues then quilted to enhance the colour variation**

# dB Soft building -Japan

**Stainless steel panels have been electrochemically blackened then vibration finished to give 'living' colour**

# ‘Drum’ and ‘cone’ shaped glass structures Star City Casino, Sydney

Ronstan International Pty Ltd

**High strength 2205 duplex stainless steel rods and cast connectors were used extensively in the glass support structures to reduce the visual footprint**

# Star City Casino, Sydney

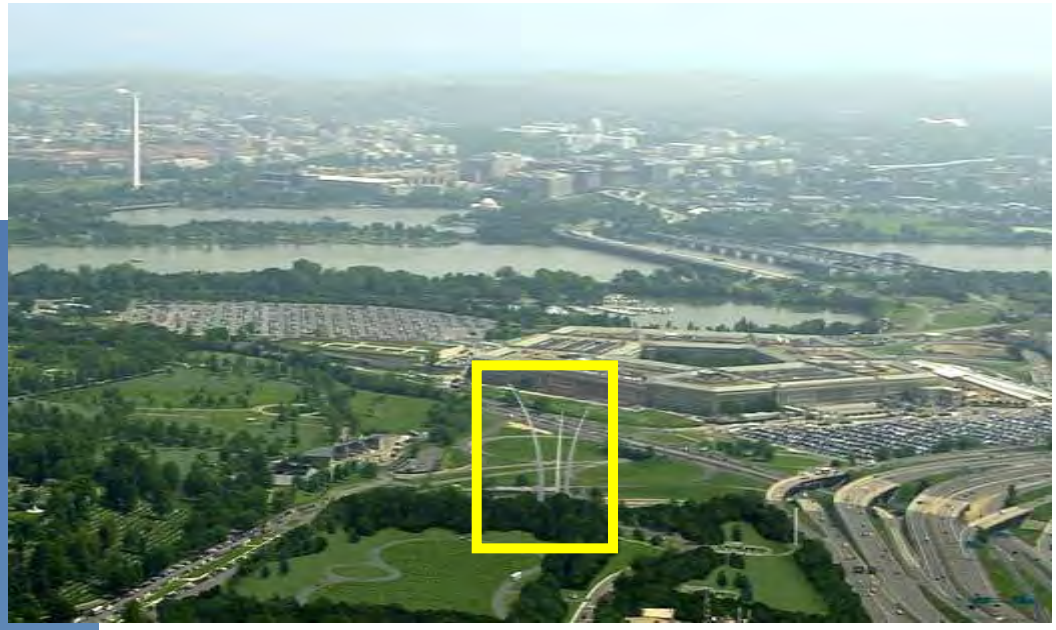
Ronstan International Pty Ltd

**The use of high strength 2205 duplex stainless steel makes the glass structure more transparent – it appears lighter**

# Paris

## Stainless steel tension structure supporting a glass dome

# USA Airforce Memorial
## Washington



Architects: Pei Cobb Freed
Structural engineers: Arup

**Height: 218 - 284 feet (90m)**

**Type 316 stainless steel plate**

**Challenging structural design – dampers in each spire control resonance caused by wind**

**Extensive wind tunnel tests**

# Kranji Racecourse, Singapore

Chadwick Technology

**Roofing is 5 mm and 1 mm stainless steel sheet with 2D finish**

# D. L. Lawrence Convention Center
## Pittsburgh

**Stainless Steel Batten Roof**

**Completed 2002**

**Proprietary Architex finish – dull, rolled through abrasive blasted rolls**

**Architect: Rafael Viñoly Associates**

**Roof water runs off into river – stainless steel will not pollute the water**

# Singapore Expo Station

Chadwick Technology
Townsend Group
Architects: Foster & Partners, London (station)
Phillip Cox Richardson & Partners, Australia (Expo)

**Stainless steel and titanium**

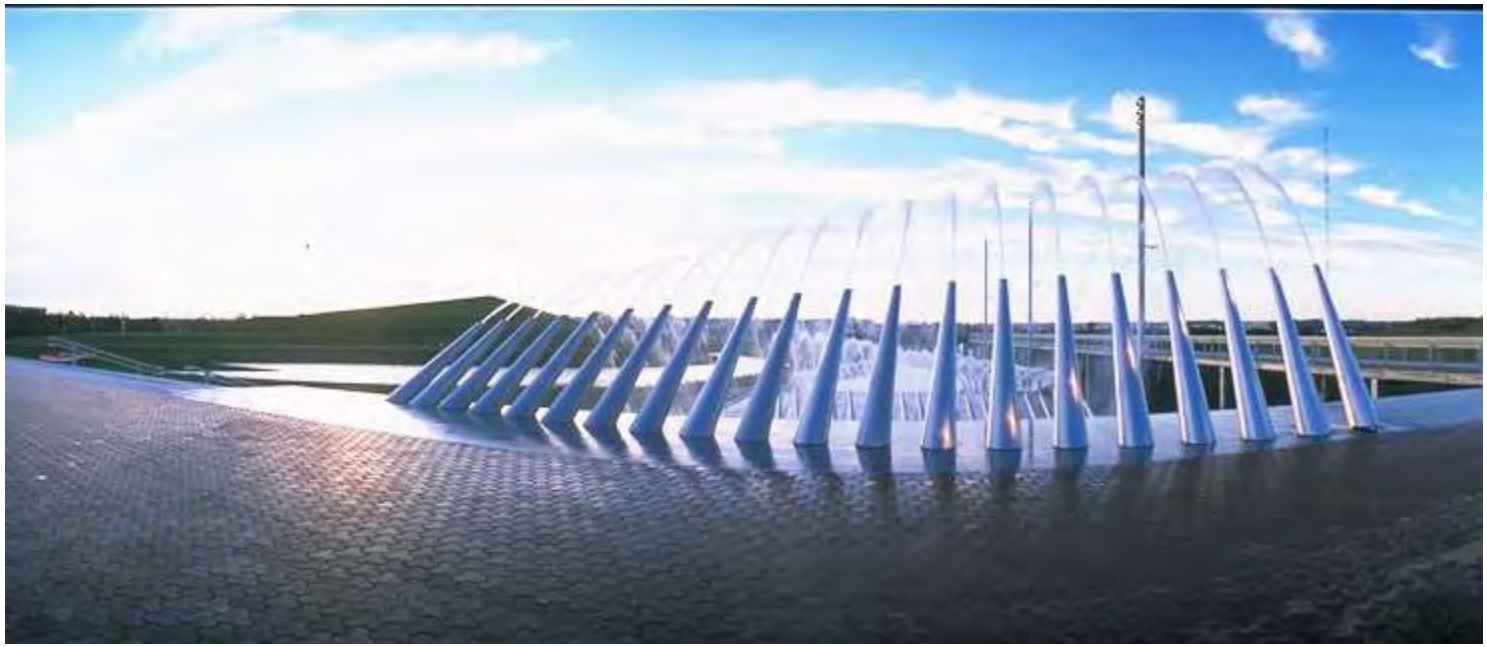
# Singapore Expo Station

….. a statement about Singapore
its values
its future

# Spencer Street to Colonial Stadium footbridge Melbourne, Australia

**Stainless steel cladding**

# Northern water feature, Sydney Olympic site



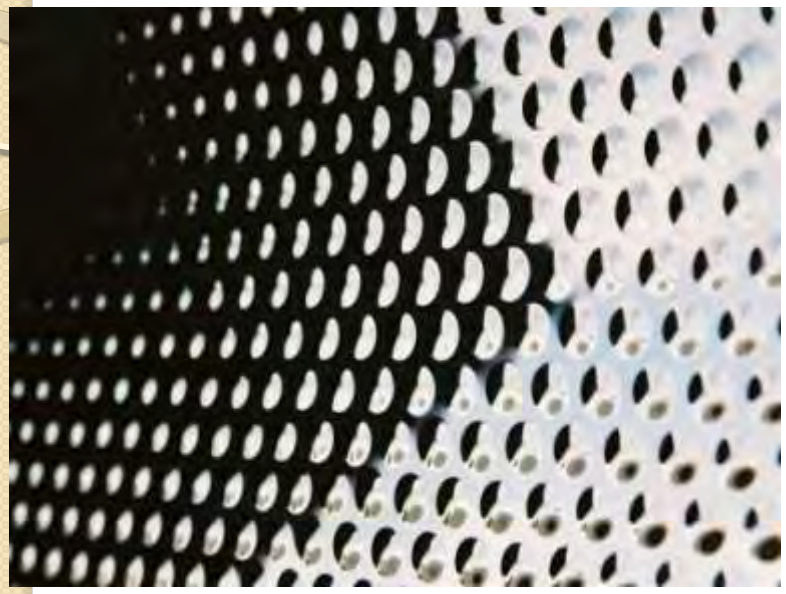
**Stainless steel inner jets and 3 mm tapered cladding with a No.4 finish**

**Type 316 handrails and safety wires are electrically insulated from galvanised steel uprights**

# Victorian College of Arts
## Melbourne

Architects: Minifie Nixon

# Victorian College of Arts
## Melbourne



Architects: Minifie Nixon

# Britomart Transport Centre
## Auckland, New Zealand

**Historic Central Post Office was restored and an underground rail station installed, connecting with bus transport**

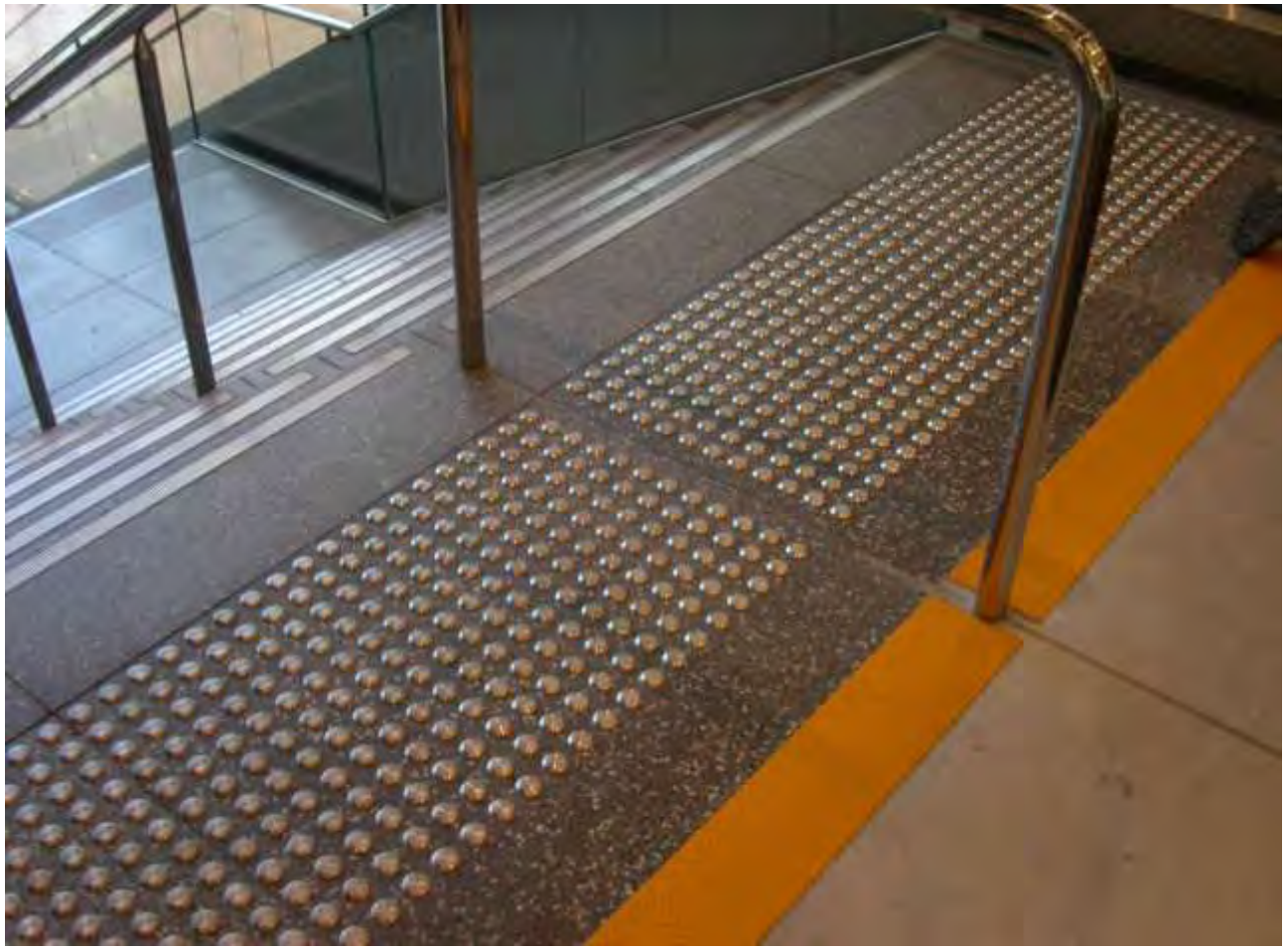
# Britomart Transport Centre
## Auckland, New Zealand

Interior of the restored Central Post Office

# Britomart Transport Centre
## Auckland, New Zealand

**Electropolished stainless steel internal seating**

# Britomart Transport Centre
## Auckland, New Zealand



**stainless steel indicators and hand railings**

# Britomart Transport Centre
## Auckland, New Zealand

**Internal bridge in glass and stainless steel**

# Britomart Transport Centre
## Auckland, New Zealand

**Stainless steel hand railing on bridge**
**Heavy schedule pipe was mirror polished**

# Britomart Transport Centre
## Auckland, New Zealand

**Michael Parekowhai's poles**
**sheet rolled with the texture of native trees then formed into tree trunks - a stainless steel forest**

# Britomart Transport Centre
## Auckland, New Zealand

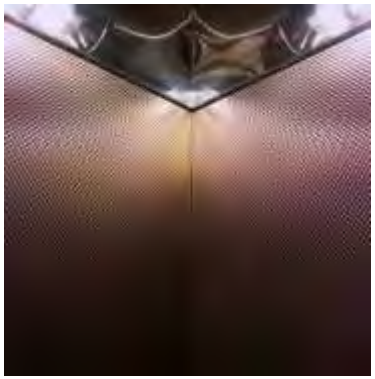
**Michael Parekowhai's stainless steel tree trunks – large and small**

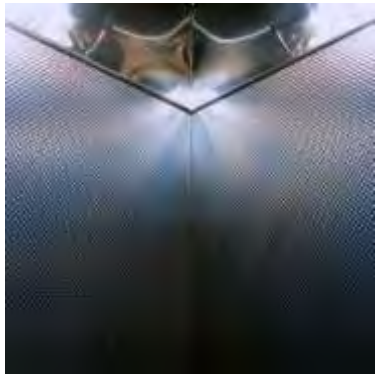
# Britomart Transport Centre
## Auckland, New Zealand

Lift tower covered in Type 316 stainless steel mesh

Lift doors and entrance in mirror polished Type 316

# Britomart Transport Centre
## Auckland, New Zealand





**Textured and coloured Type 316 interiors of lifts**

# Britomart Transport Centre
## Auckland, New Zealand

**Britomart underground rail station**

**Air conditions are corrosive – diesel fumes contain sulphur and salt-laden sea air is pumped in to remove diesel exhaust fumes**

# Britomart Transport Centre
## Auckland, New Zealand

**View back to escalators from station platform**
**Note the “volcano” skylights allowing entry of natural light**

# Britomart Transport Centre
## Auckland, New Zealand

**Stainless steel mesh ceiling**

**Mesh has 70% open area to allow fire sprinklers to spray through**

# Britomart Transport Centre
## Auckland, New Zealand

- Skylights designed to look like volcanoes
- (Auckland is built around 9 extinct volcanoes)
- Stainless steel spheres reflect natural light onto the ceiling

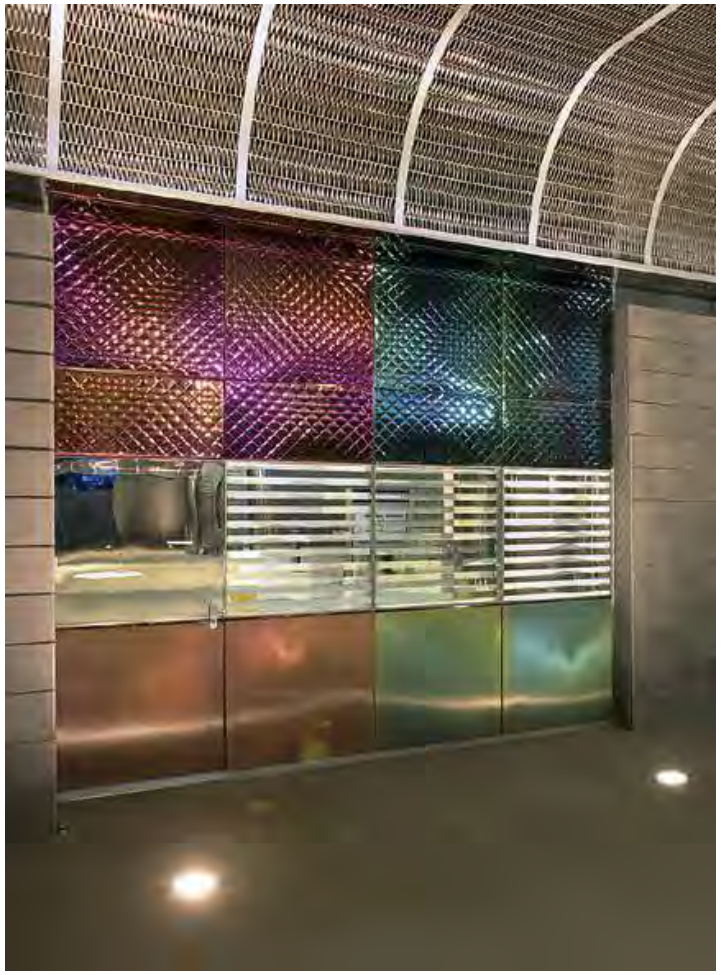
# Britomart Transport Centre
## Auckland, New Zealand

**Perforated stainless steel air diffusers provide fresh air to remove diesel exhaust fumes**

# Britomart Transport Centre
## Auckland, New Zealand

**Stainless steel air diffusers along platform edge - mirror polished then perforated**

# Britomart Transport Centre
## Auckland, New Zealand



**Coloured textured stainless steel wall cladding**

# Britomart Transport Centre
## Auckland, New Zealand


**Textured stainless steel column and wall cladding**

# Britomart Transport Centre
## Auckland, New Zealand

**Textured stainless steel toilet partitions and door cladding**

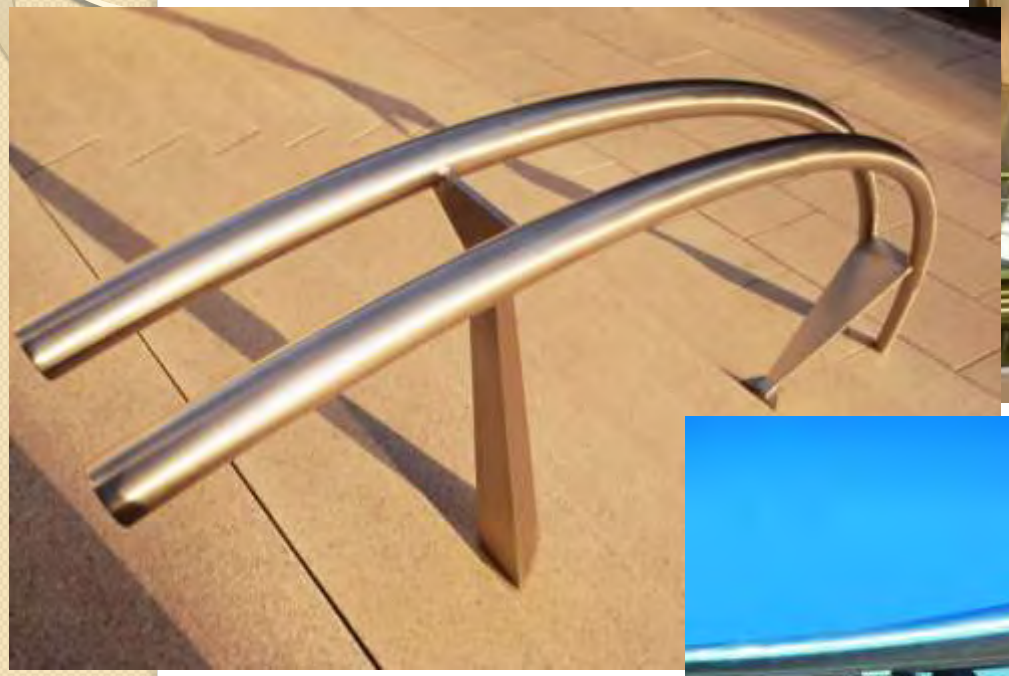
# Britomart Transport Centre
## Auckland, New Zealand

**stainless steel grating**
**used as tree surrounds**

# Britomart Transport Centre
## Auckland, New Zealand

**Electropolished stainless steel tubing formed into framework above “volcano” skylights**

# Stainless steel handrails




# Stainless steel railings Presumably Type 316

**Along the seawall in Ushuaia, Argentina - the world's southern most city**

**Located along the Beagle Channel in Tierra del Fuego – Atlantic Ocean to east, Pacific Ocean to west**

## Innovative use of Stainless Steel

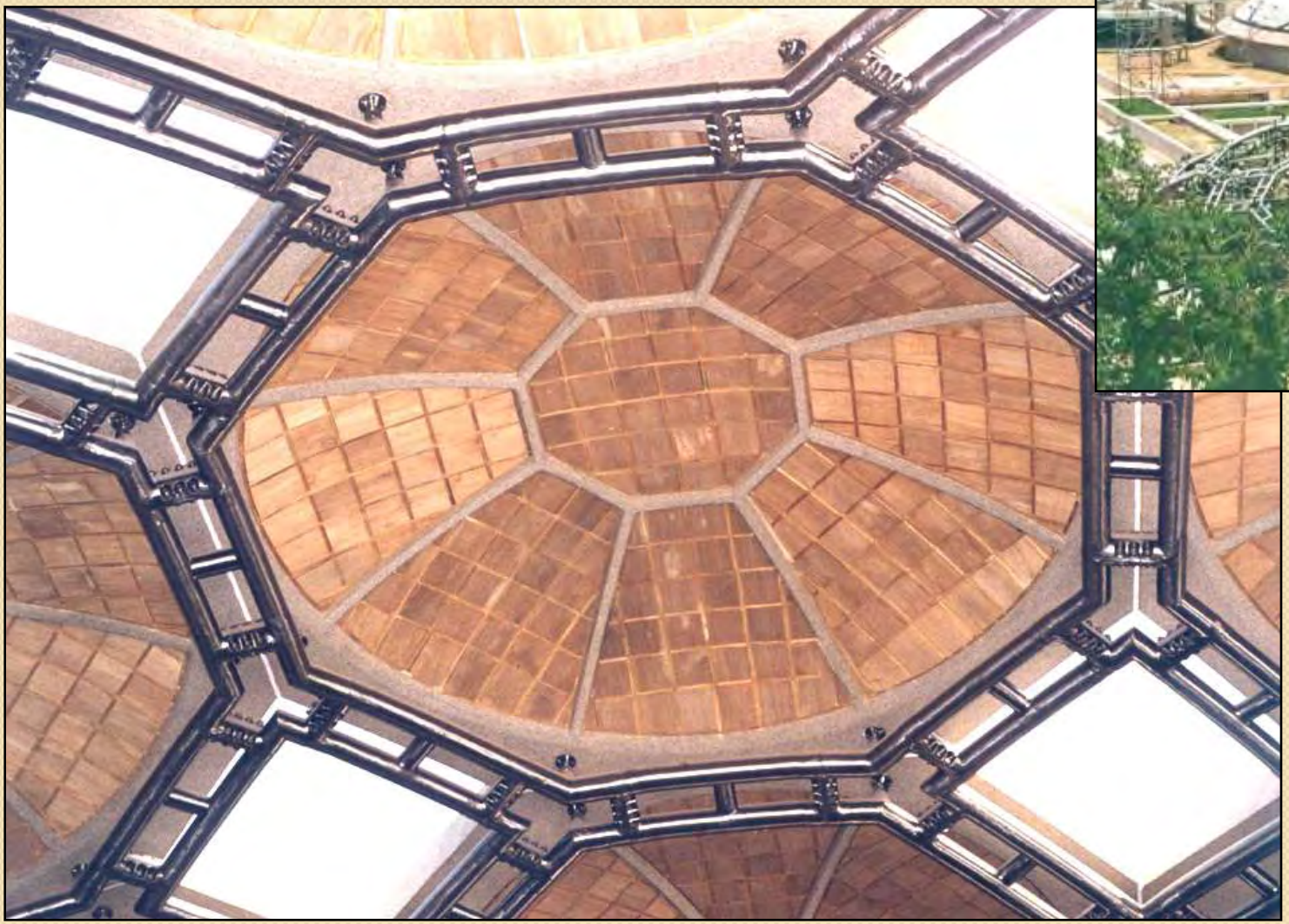
# National Projects

- Resin-coated profiled SS roof (10,000 sqm)
- Koperkhairane railway station, Navi Mumbai
- Salem Steel-SAIL guarantees 60 years life
- Two more stations also clad in SS

# Thurbe Rly Stn. (10,000 Sq M)

# Khalsa Heritage, Punjab (5,000 Sq M)

# Parliament Library building in Delhi



**VIP dome;** dome span dia 16 metres; 38 tonnes used

# Parliament Library building in Delhi

**Focal dome;** dome span dia 25 metres; 31 tonnes used


Space frame at the factory gate of Jindal Stainless Ltd, Hisar; 18 m long and 11 m wide; 10 tonnes used

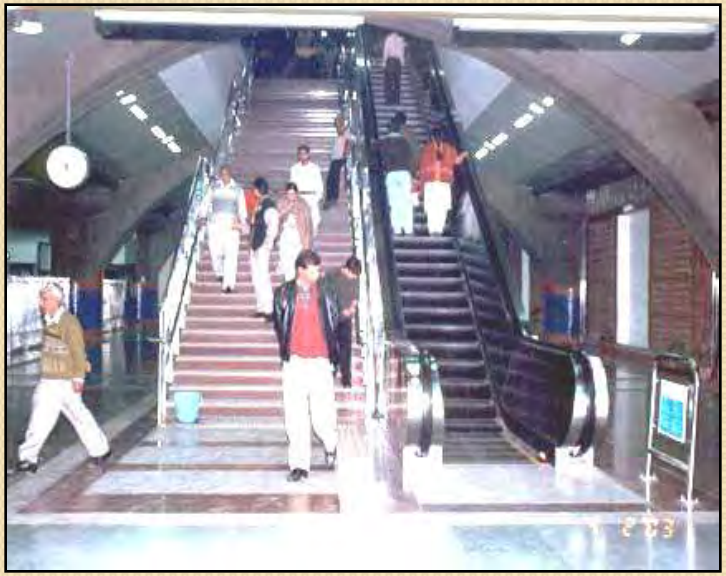
30 metre high Gateway at Jindal Power Ltd, Raigarh

Internal glass staircase with front wall cladding, in stainless steel

# Apollo Tyres, Gurgaon


*Industrial Economist*
Building, Chennai

# DMRC station



Escalators & Handrails

Ticket entry points

**Dustbin**


# Street furniture at Walkeshwar, Mumbai

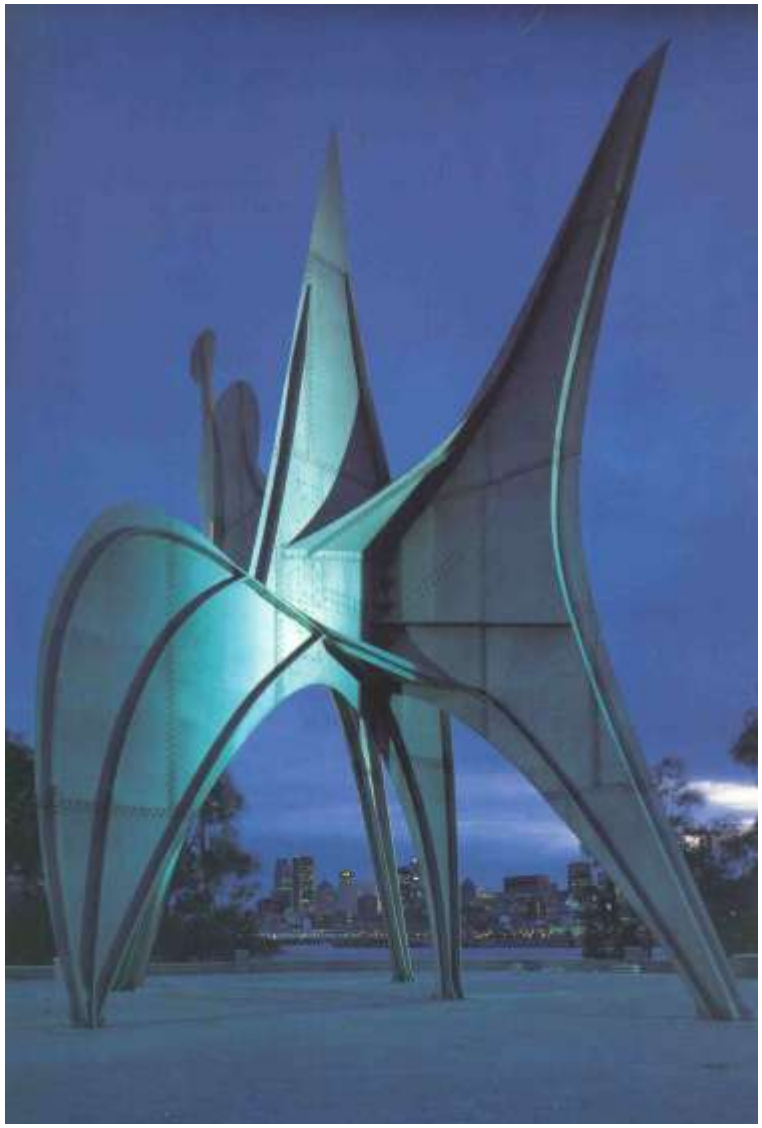

# Bus shelter, Delhi

Garbage bins, Garden of Five Senses, Delhi

# Stainless Steel Sculpture

Mural at the cargo terminal of Chennai Port

# Stainless Steel Sculpture in Canada (left) and India (right)



# The Globe at Akurdi Chowk, Pune


Signage at the Ramoji Film studio, Hyderabad

# Use SS roofs for

- Long life guarantee
- No maintenance
- Large span area – no limitation
- Dull and anti-glare finish sheets available

# Use SS Rebar for

can be used for ATC

- Long life – 120 years guarantee
- No repair and maintenance
- No disruption of services
- Essential for terminals in coastal and rain-fed
- SS rebar will be shortly available in India

A pier in Progreso, Mexico

Constructed b/w 1937 and 1941, the 2 km long pier with **SS rebar** –
**shows no sign of deterioration**

Foreground CS rebar pier constructed during late 1960s – **only the remains are seen !**

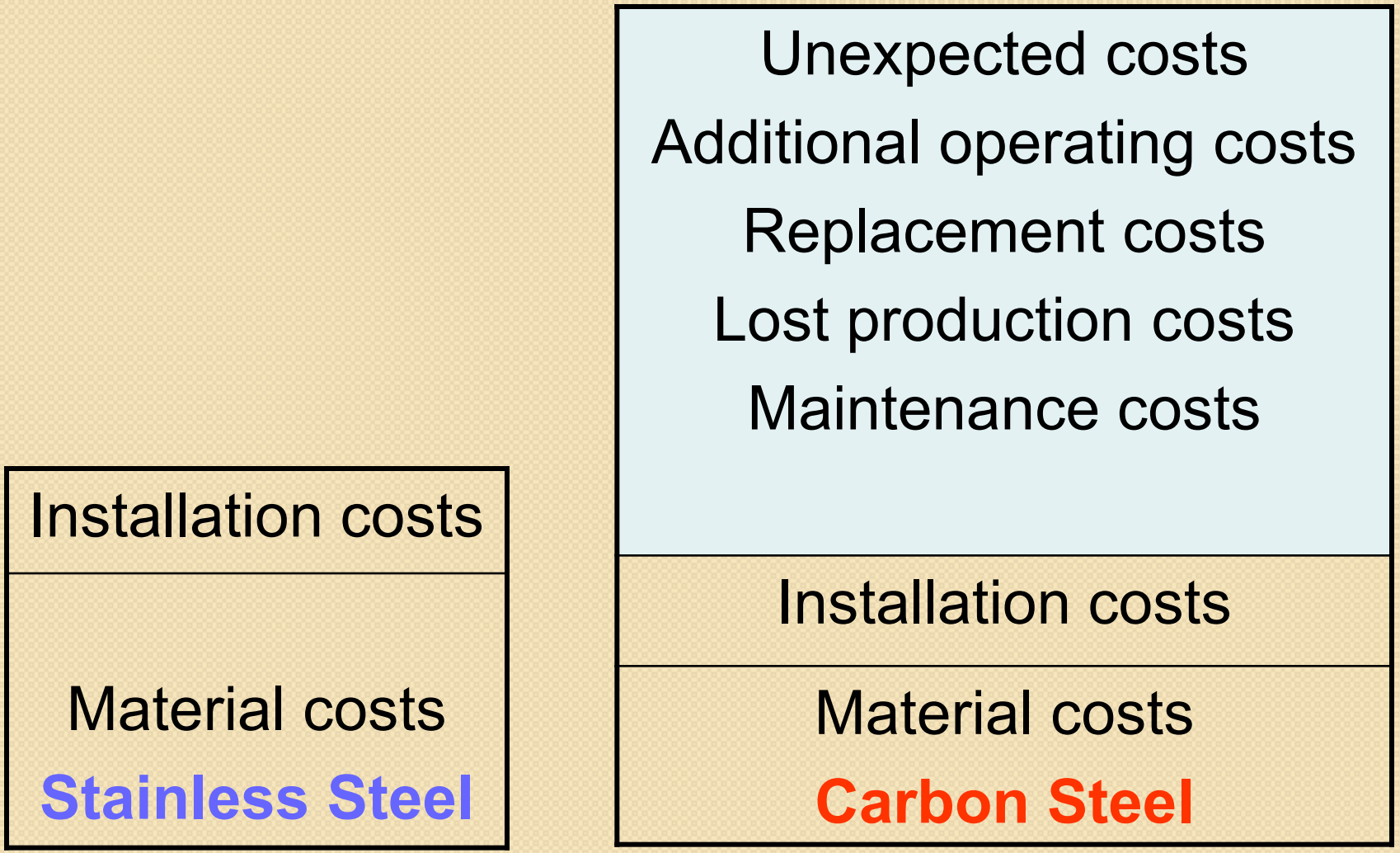
# Use SS plumbing for

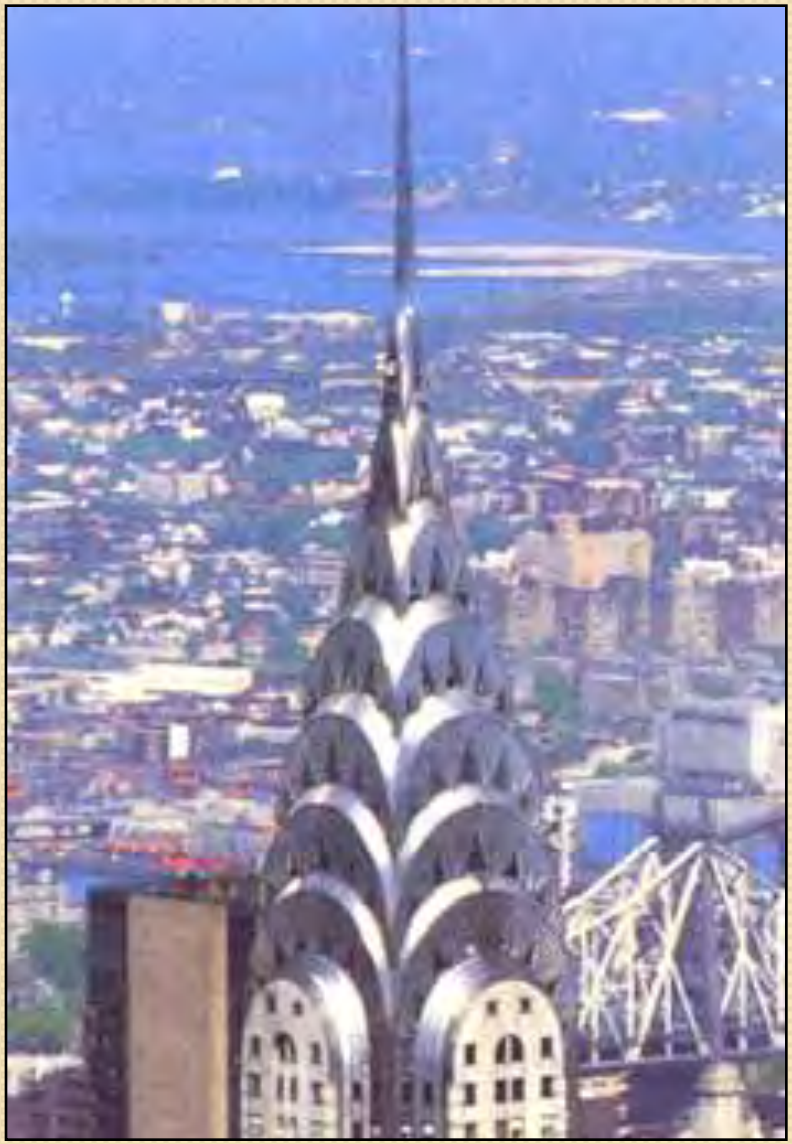
- Long leak-proof life – 50 years
- No more messy wash rooms
- Perfectly hygienic for all chemistries of potable water
- Thin walled “press fitting” technology  available in India

# Large capacity (up to 40,000 Litres) are also available

- Initial cost of stainless steel is higher.
- However, if the cost of ownership and usage over the design life is worked out, stainless steel will be a very cost-effective option.
- USE Life Cycle Cost (LCC) analysis.

# Life Cycle Cost (LCC)





Chrysler Building in New York City

The Art deco Top was clad with SS in 1930

Still looks gleaming in marine, urban and industrial environment

Manually cleaned only twice since installation

# Reusing Stainless Steel

525 William Penn Place
Pittsburgh, Pennsylvania
Completed in 1952

- Stainless entrance/lobby
- Exterior spandrel panels
- Lobby renovation in 2002
- Most of the stainless steel was refinished and reused
- Architect IKM

**Before**


**After**

# ISSDA member companies can provide

- Handrails, railings
- Facades, column and wall claddings
- Roofs (profiled sheets)
- Window and door frames
- Building entrances, canopies
- Interior decoration
- Street furniture

# ISSDA member companies can provide

- Rebar for concrete
- Structural members
- Plumbing and toilet fittings
- Builders' hardware
- Sculptures, murals, signage
- Sheets in plain, colour and rigidized finishes

# Some suggestions

- There is no scope for hiding fabrication faults
- Good fabrication skills is a must
- Trying to reduce costs by selecting inferior grade of SS or selecting an inexperienced fabricator or by not following proper guidelines will only lead to jeopardizing the entire job

- Cost of fabrication should not be an overriding factor
- Sometimes fancy designs can be difficult to fabricate and can lead to increase in project cost
- Hence it is essential to involve an experienced fabricator at the design stage itself
- Fabricator can help the designer to arrive at an optimum design which can be fabricated at a reasonable cost

- Many times the main civil contractor quotes his price for a project unaware of the intricacies of SS and its fabrication
- To keep the budget under control he is then forced to knock down the price of the SS fabricator
- The result is a shoddy job because quality of workmanship was compromised
- Hence it is advisable for AAI to ask for quotations separately for the SS portion of the project

# Conclusion

# Assistance from ISSDA - NI

www.stainlessindia.org www.nickelinstitute.org

- Free technical literature available to architects, designers for specifying stainless steel.
- Free technical literature to fabricators on stainless steel welding and fabrication.
- Free assistance in sourcing stainless steel products and services.
- In-house workshops at offices / factories; Would be glad to hold regional workshops for the benefit of AAI personnel in other cities.

Thank you for your time and support!