Applications

Roof & Wall Design

- All standard metal designs are possible in stainless steel
- There are differences in
  - Thermal expansion
  - Strength
  - Appropriate thickness
  - Weight/square foot

Chrysler Building

Completed 1930
First large architectural roof application

Type 302, 2B finish

Minor Stainless replacement

LEED Gold – Existing building category

Empire State Building, 1931, New York

World’s tallest building for 41 years, 382 m ((1,253 ft)
First spandrel and mullion panels, spire sheathing
LEED Gold – Existing building

Al Hamra Firdous Tower, Kuwait

- Skidmore Owings & Merrill, New York
- Completed 2011
- Kuwait's tallest building, 412 m (74 floors)
- 50 metric tons, Type 316 façade, doors, and other exterior details

Kingdom Tower, Saudi Arabia – Adrian Smith

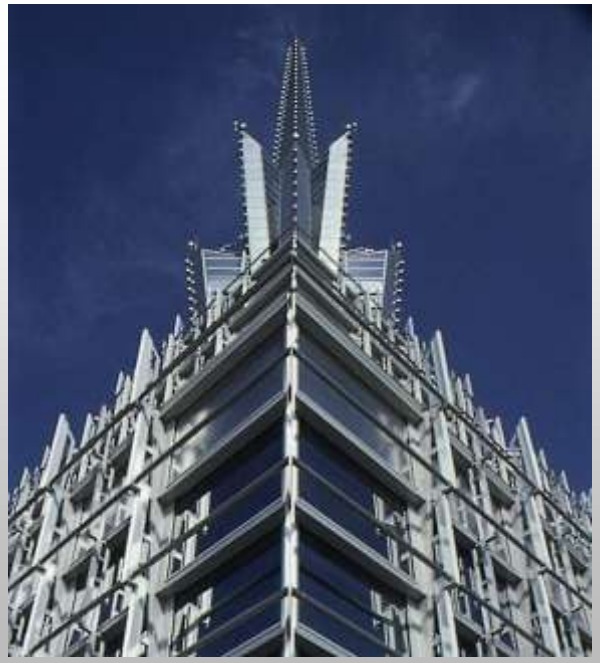
- Under construction - over 1 km in height
- 2205 & glass exterior

Pin An Finance Center, Shenzhen, China

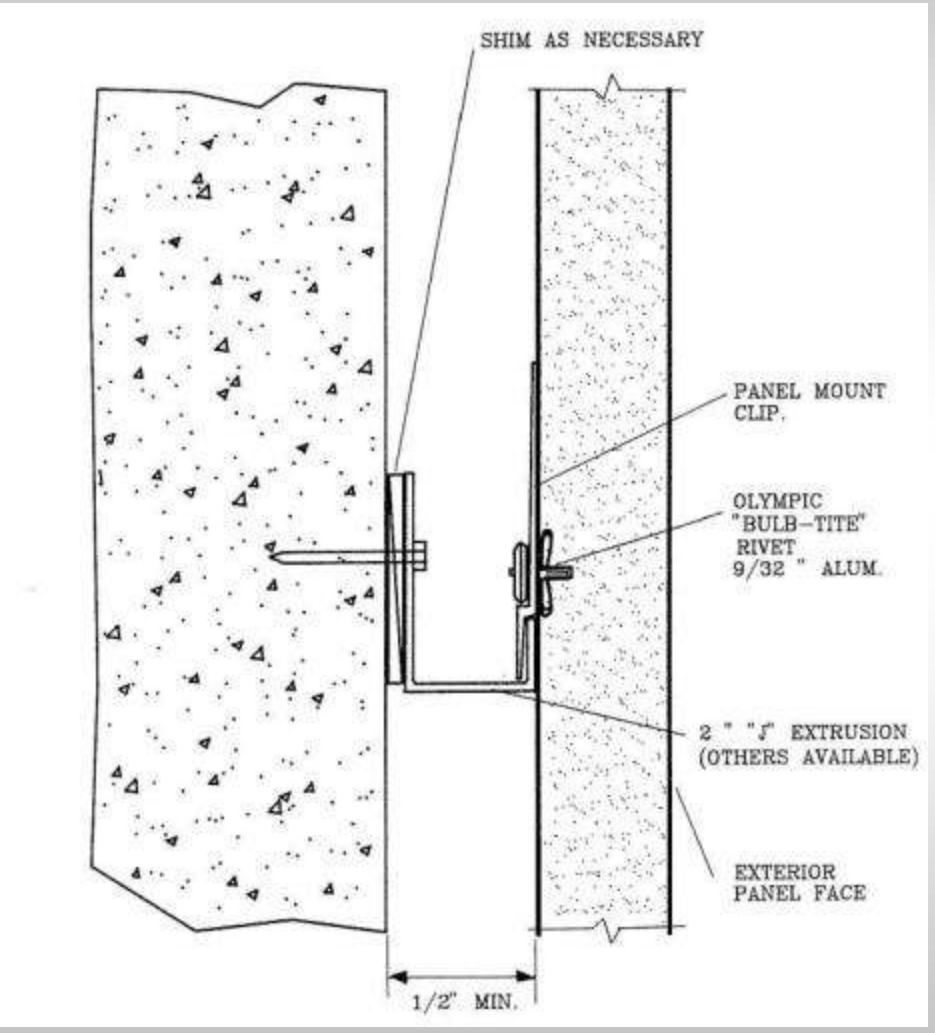
- China’s tallest and world’s second tallest skyscraper, 660 m
- 2016 completion
- Architect: Kohn Pederson Fox
- Type 316L, linen, 2 and 0.8 mm
- 2,500 m tons (1,700 m tons main tower façade and 800 m tons podium)
- LEED Gold Precertified

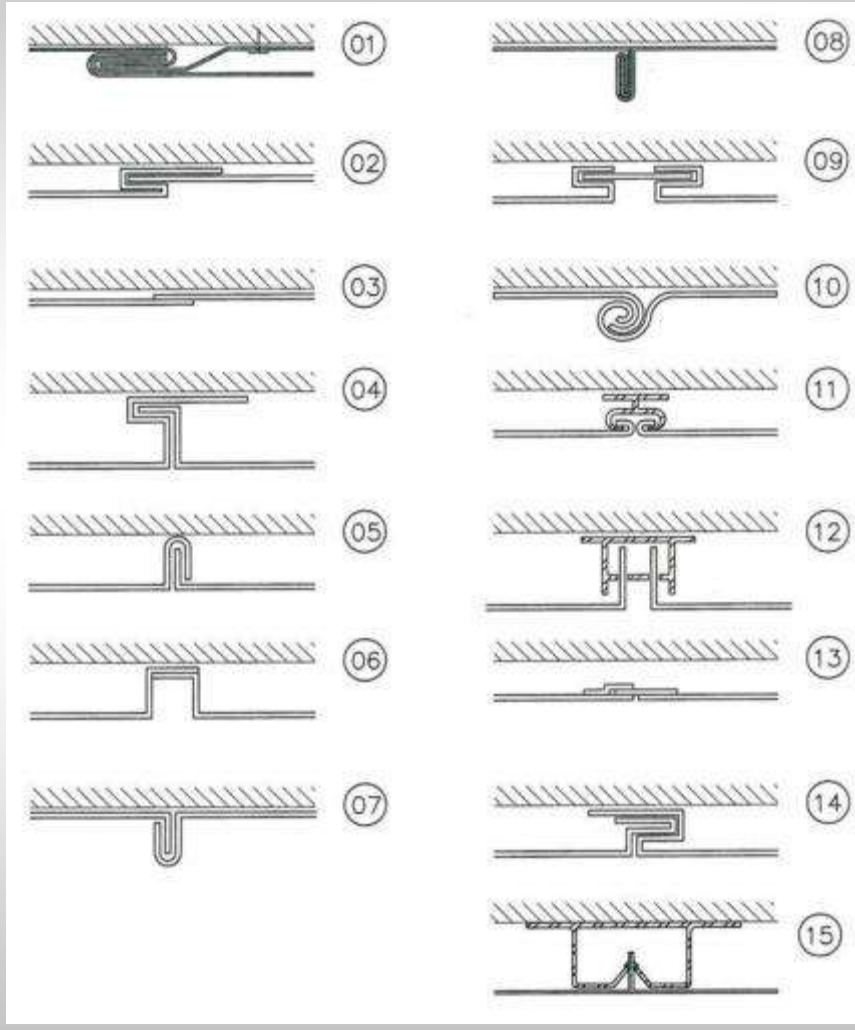
Jin Mao Tower, Shanghai, China

- Skidmore Owings & Merrill
- Type 316 stainless steel
- Cambric finish
- World’s fifth tallest building



Examples of Traditional Wall Panel Joints and Attachment to Concrete Wall





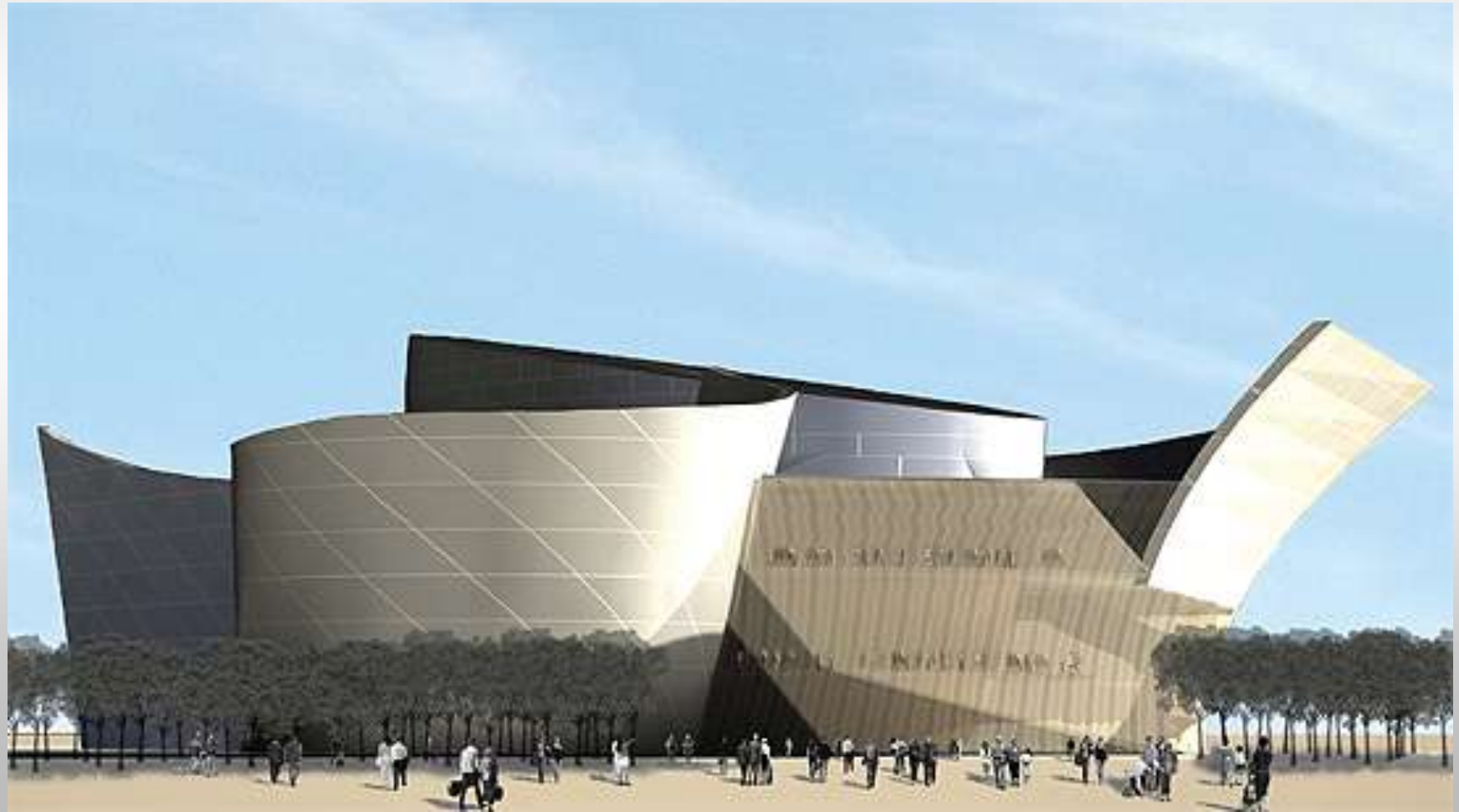
Walt Disney Concert Hall, Los Angeles

Gehry Partners

Type 316, vibration and mirror polished finishes

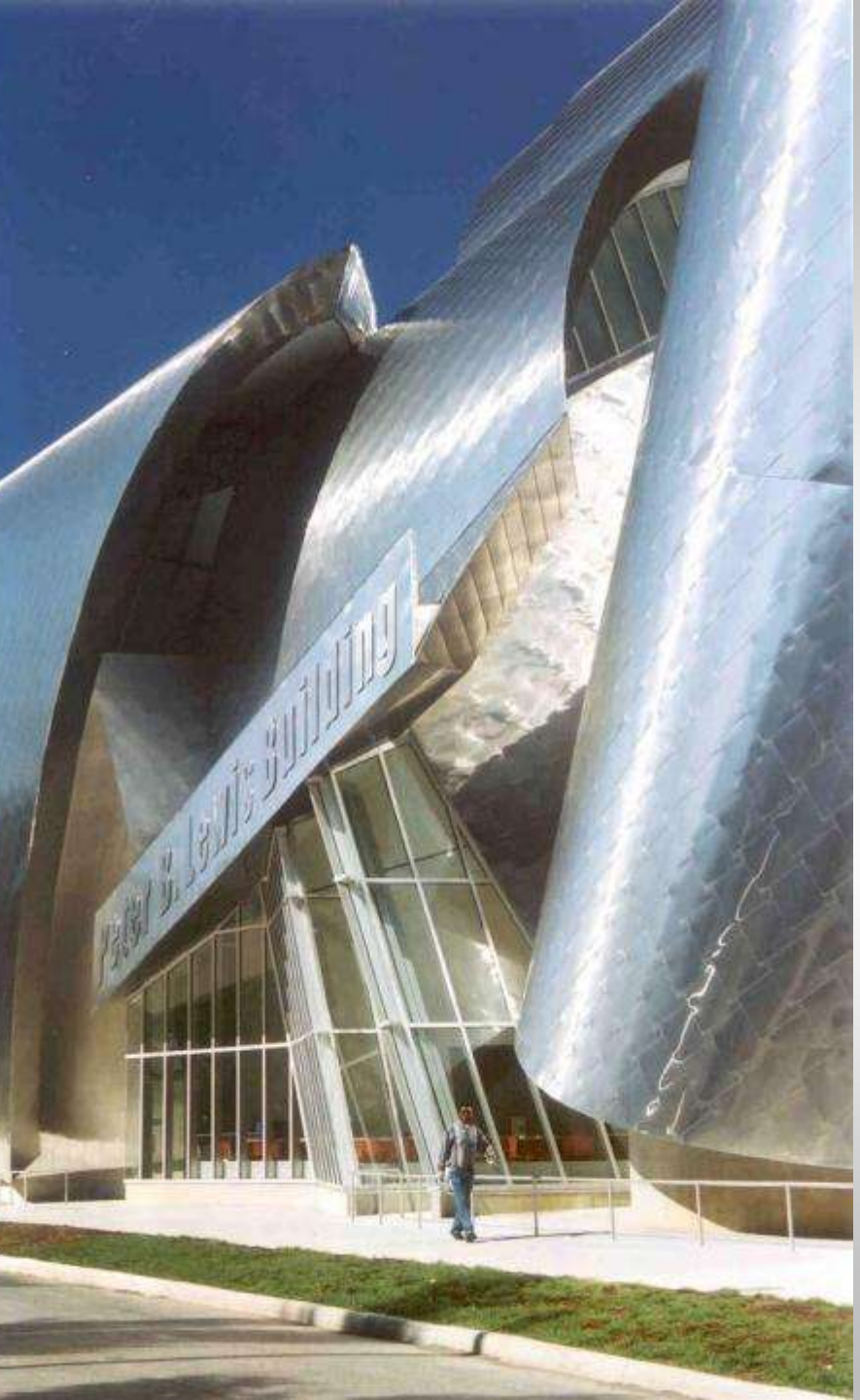
National Polish Symphony Concert Hall
Katowice, Poland (2008)

- Frederick Swartz Architects
- Glass and stainless steel



Shenzhen China
OCT Creative Exhibition Center

- Zhu Pai design
- Completed 2012
- Type 316, bead blasted finish

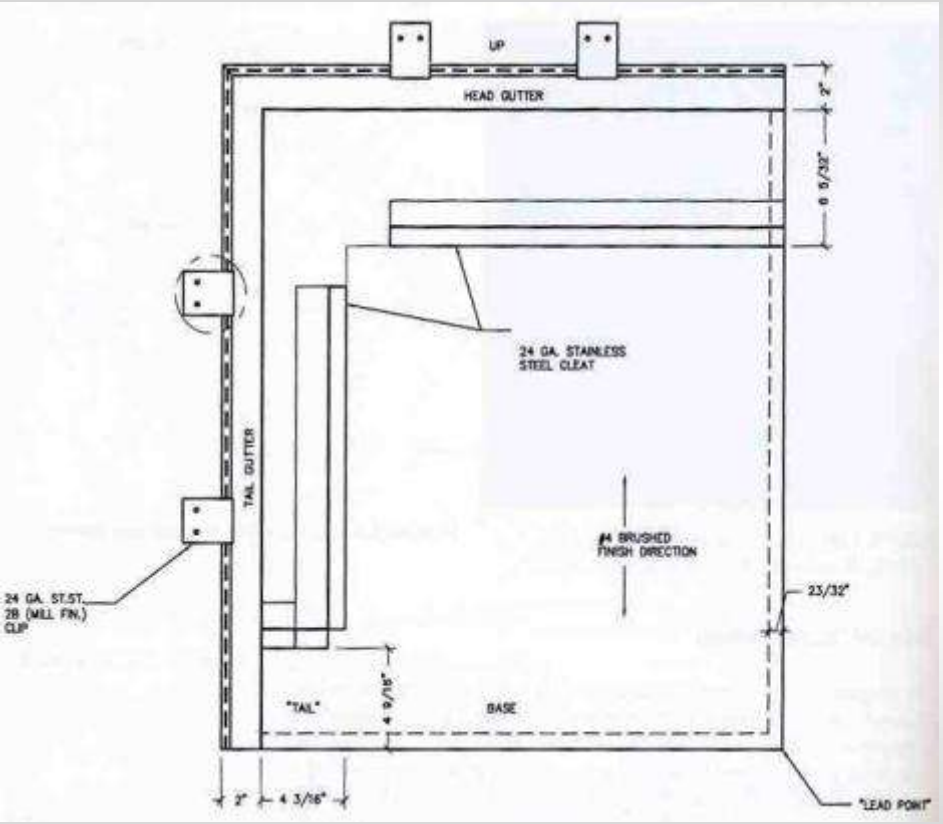


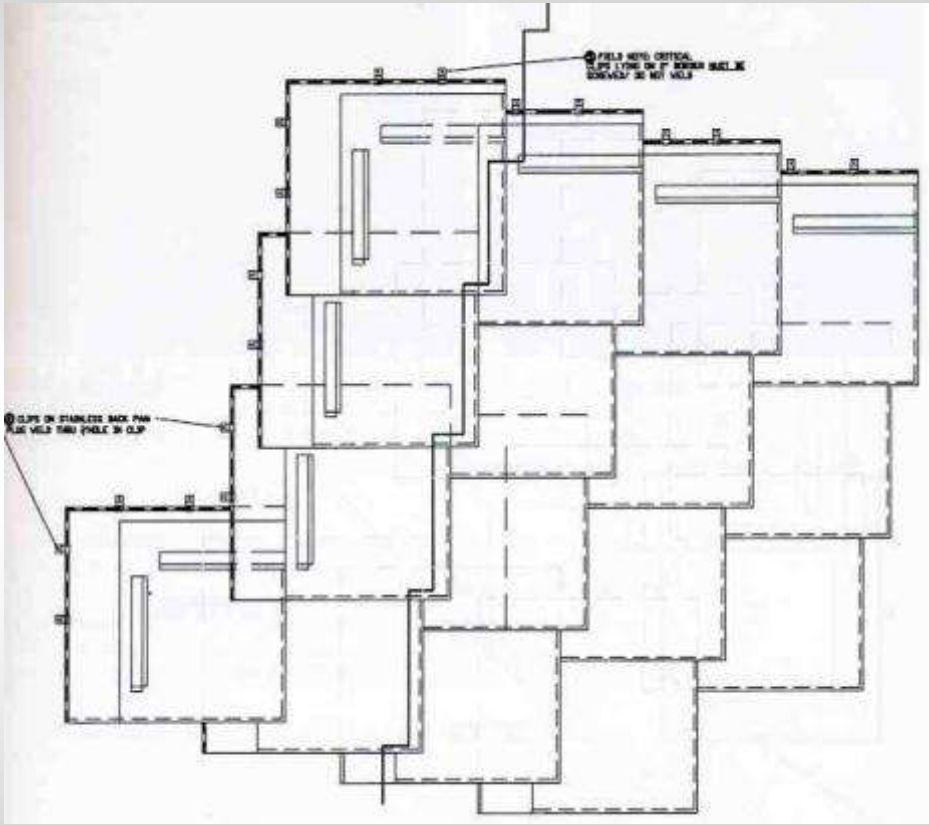
Peter B Lewis Building

Case Western Reserve University, Cleveland

Peter B Lewis Building Details

Overlapping, interlocking shingles in a predetermined design

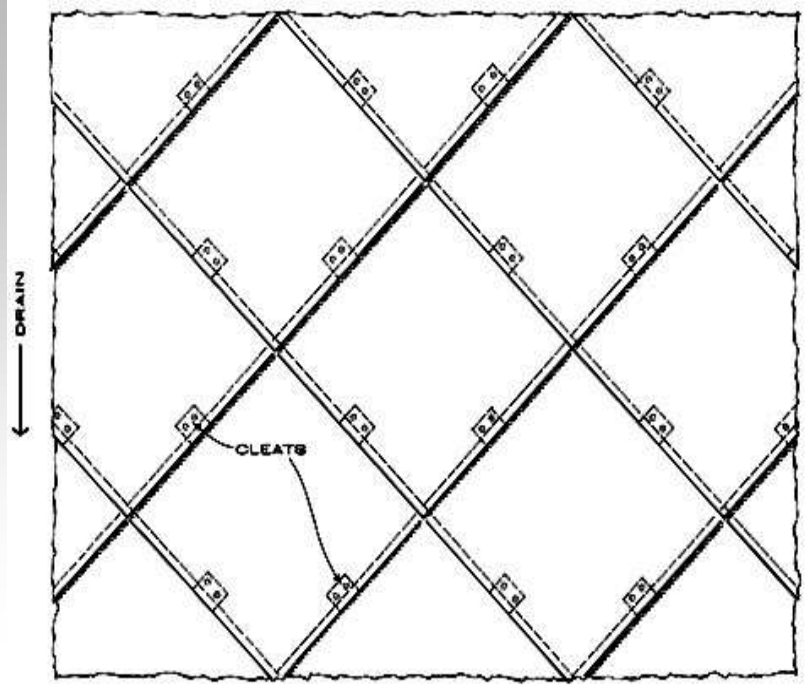




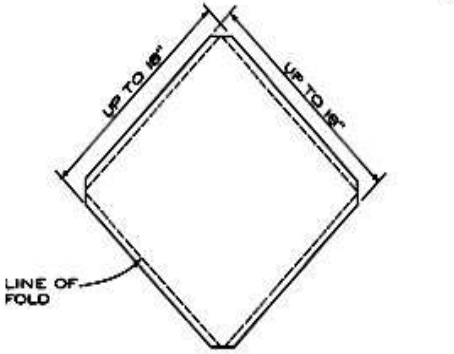
University of Texas, Natural Science & Engineering Research Building

Type 304, electrochemically colored stainless shingles

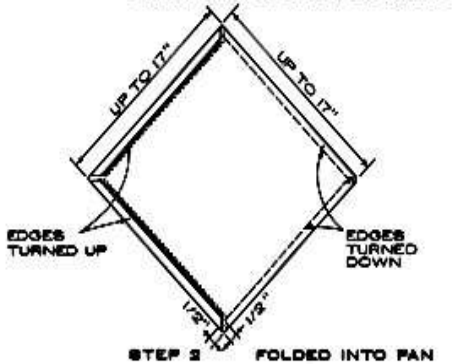
Design for 50+ year life to sustainable design standards



PARTIAL PLAN OF LAYOUT



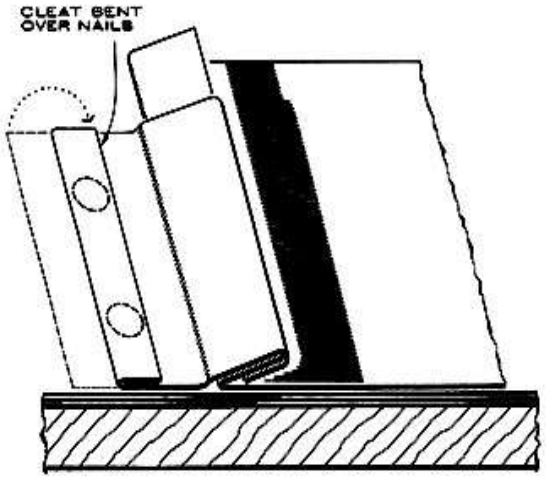
STEP 1 NOTCHED & TINNED



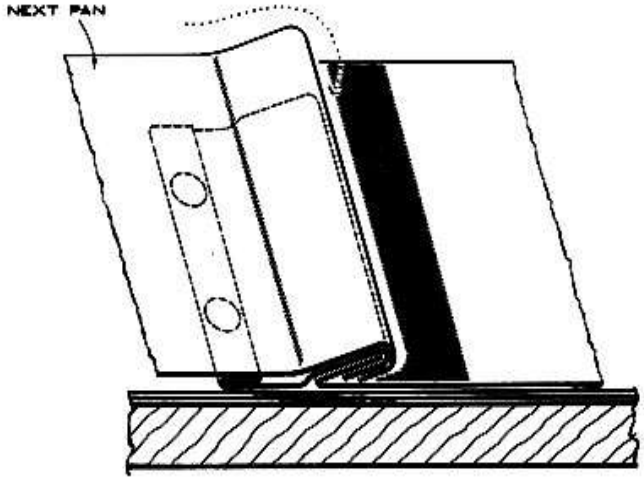
STEP 2 FOLDED INTO PAN

DIAMOND PATTERN

SHEETS MAY BE NOTCHED AND FOLDED IN SHOP
DIMENSIONS : 15"X 15" OR 16"X 16"



STEP 3



STEP 4

Singapore Residence

Electrochemically colored stainless steel shingles simulate aging copper

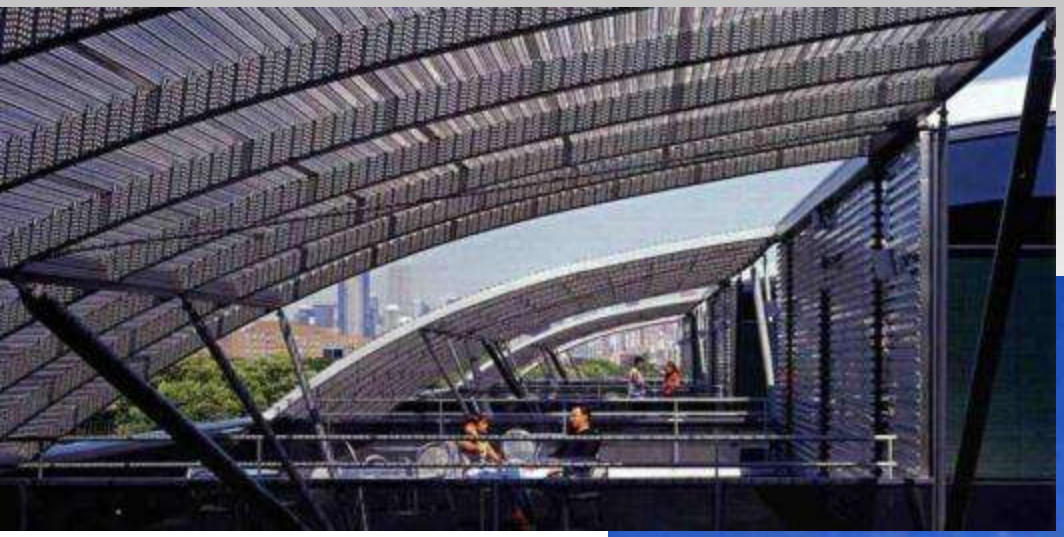
Zaha Hadid's Broad Museum of Art, Lansing Michigan (2013)

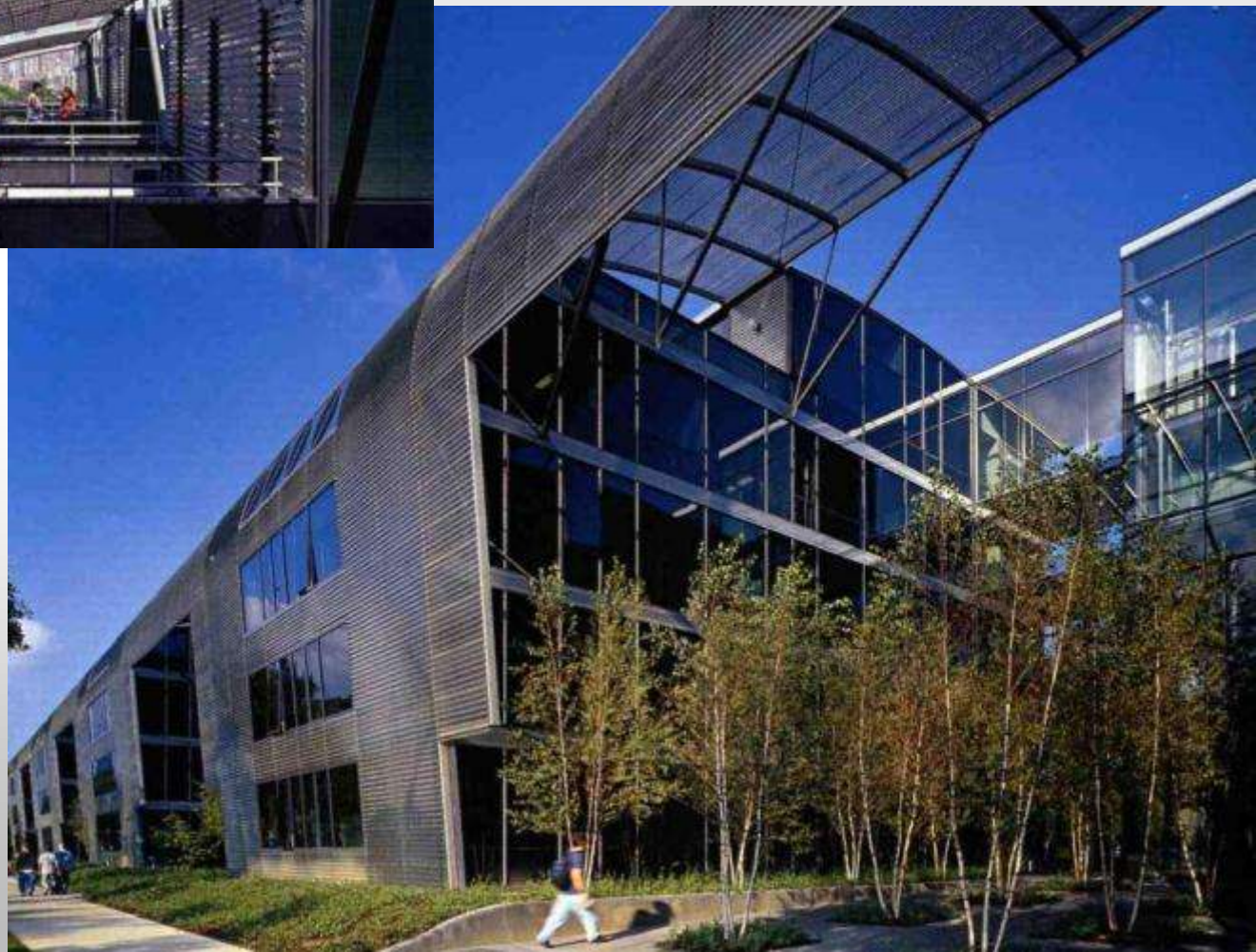
- Type 316, vibration finish on corrugated panels

Contemporary Jewish Museum

- San Francisco California USA, 2008
- Blue electrochemically colored stainless steel
- Studio Daniel Libeskind

Illinois Institute of Technology, Chicago





Architect:
Rem Koolhaas

Corrugated wall panels and perforated patio screens

Millennium Park Concert Hall, Bridge, Sculptures – All Type 316

September 11 Museum Building, New York

- Situated between the sites of the two towers
  - Perforated Type 316 roof and wall sunscreen cladding
  - Two finishes to create texture
    - Glass bead blasted and mirror polished
- Other park applications
  - Type 316 park benches, water feature components, lighting, subway station canopy
  - 2205 walkway gratings

Just Announced KPF – New Exterior Petersen Automotive Museum, Los Angeles

Ribbons of vibration polished stainless steel will wrap the existing building in light

Council House 2, Australia, Green Star 6

World Trade Center New York Buildings

- All will have Type 316 exterior façades
- Buildings 1 - 5 (under construction)
- Building 1 stainless steel
  - 250 metric tons, Type 316 façade
    - “Laser” textured finish
  - Structural supports for glass curtain wall covering bottom 200 ft
  - 6 ton, Type 316, 0.25” plate spire Lobby and other applications

If You Build A Residence in Stainless, It Will Sell - Even During a Recession

Trump Tower
Chicago
SOM
2009 completion
Type 316
1389 ft, 423 m

8 Spruce Street
2011 completion
Frank Gehry
New York
Type 316
870 ft, 265 m

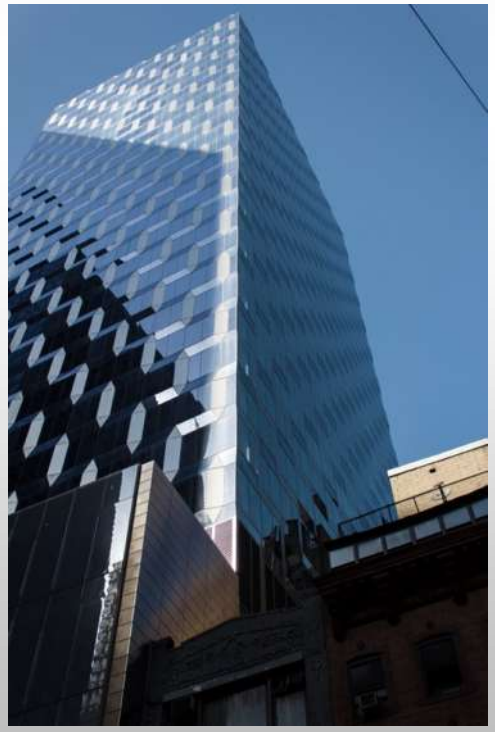
250 West 55th St, 316

West 57th St, 316

7 Bryant Park, 316

f

Javits Ctr, 316

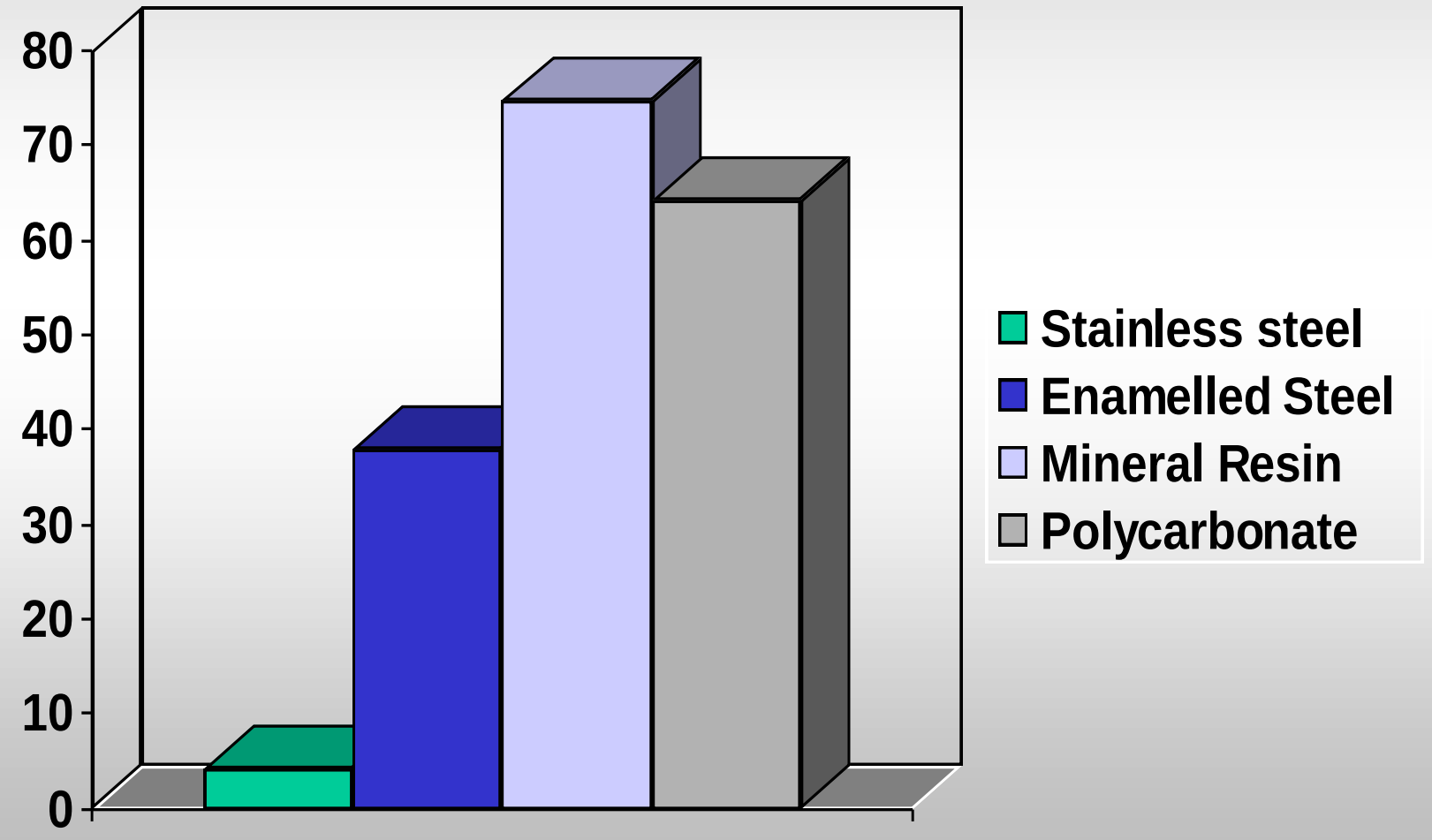


Gem Tower, 316

FDR Memorial,

Mean Bacteria Count After Cleaning

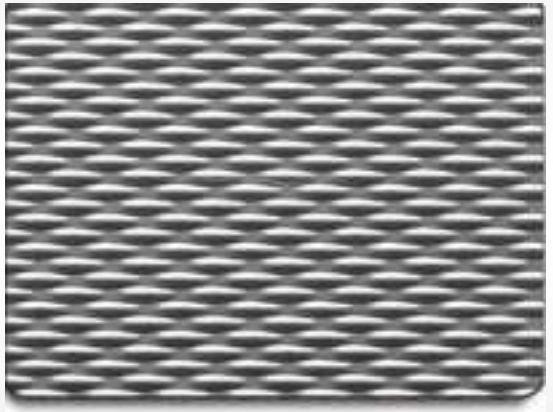
10 Seconds - Abraded Sink Surfaces (x 10^4 cfu/cm^2)

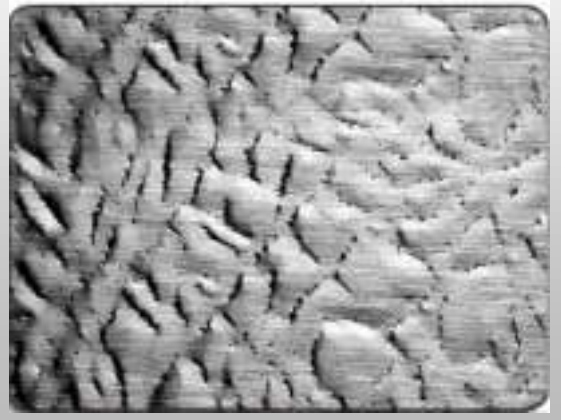


Stainless Steel Kitchen Cabinets & Custom Table Base

Stainless Steel Bathroom Partitions

- Durable
- Sanitize with steam cleaning to avoid chemicals





Corrosive Indoor Public Transit

- Corrosiveness increased by
  - Exposure to coastal or deicing salt
  - Urine exposure
- Type 316 and smooth finishes for locations with salt or urine exposure
- Fire safety also important

Southwark Station, London

Architectural Record magazine, March 2000

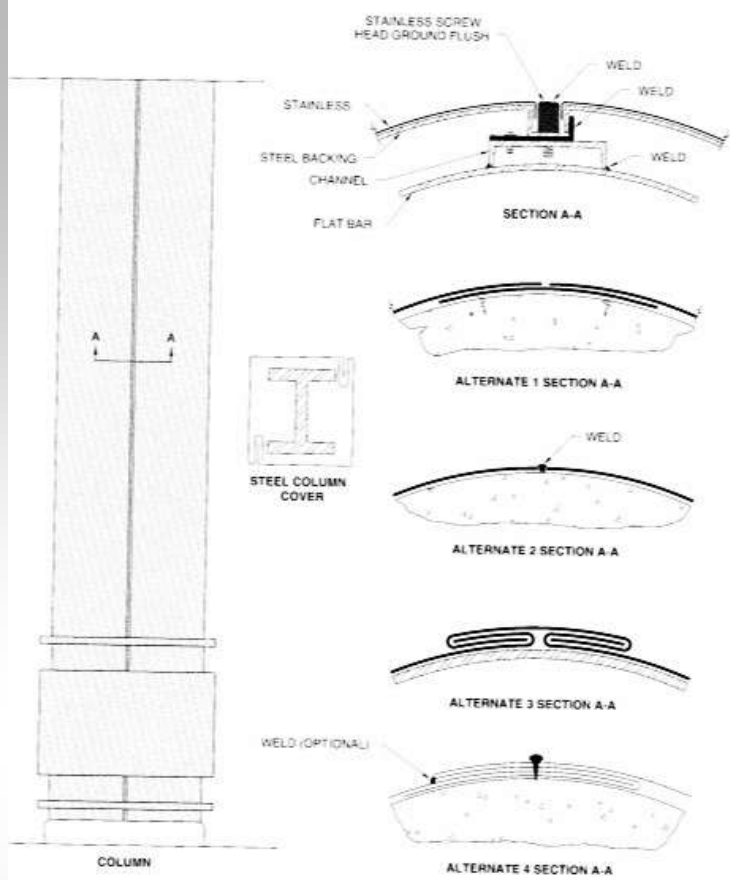
Stainless Steel Floor Tiles

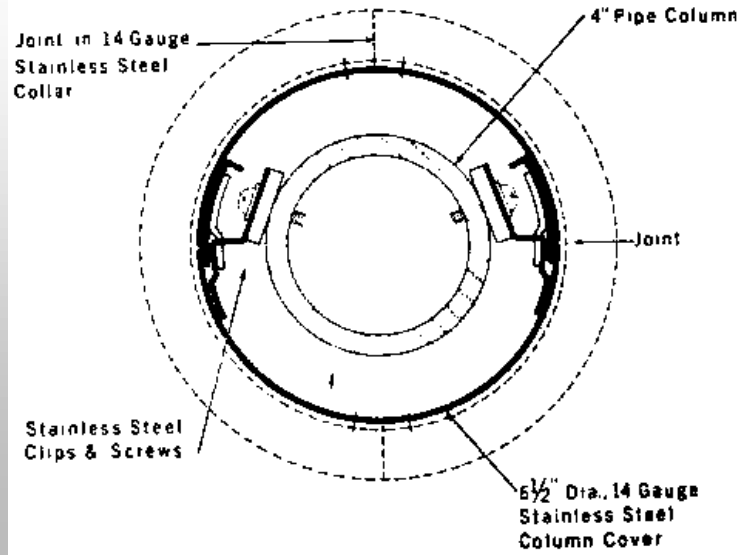
Various slip and wear resistant finishes
Installed like floor tiles

Bangkok International

Glass Curtain Wall Supports & Built-in Furniture

Embossed and polished column cover Miami International Airport

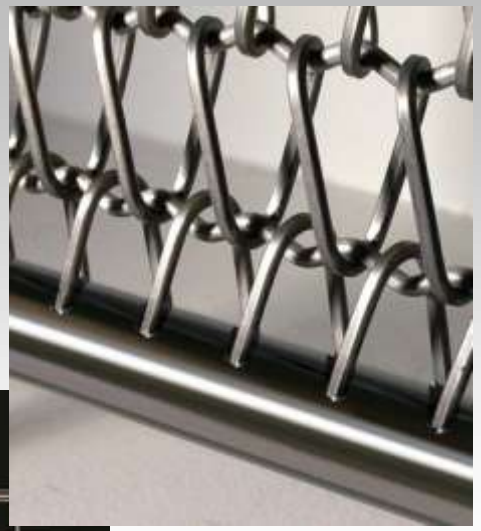




Louis Vuitton

Woven mesh walls held in place with simple clips

Auto Showrooms

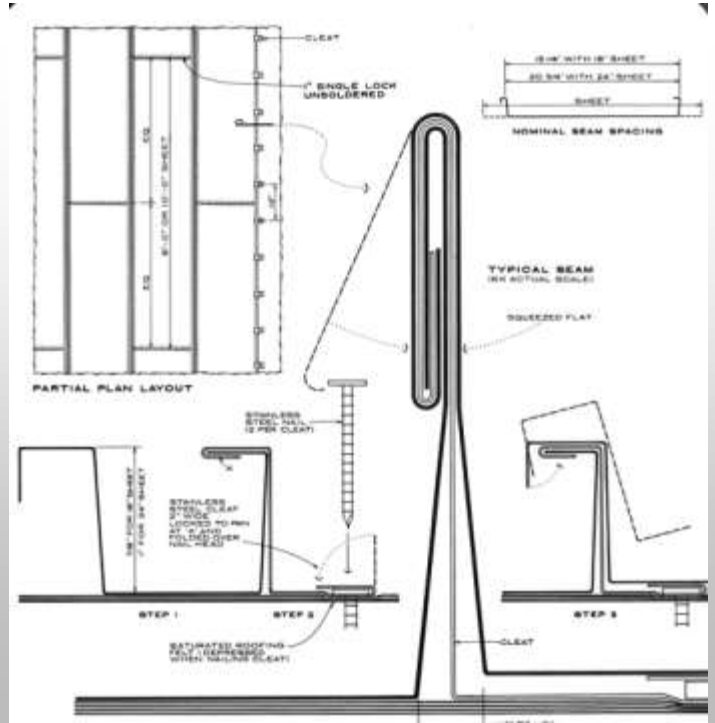


Bending Characteristics Annealed Stainless Steel

R = bend radius, T= metal thickness

Type	Free Bend	V-Block
Austenitics	180°R = 1/2 T	135°R = 1/2 T
Ferritics	180°R = T	135°R = T

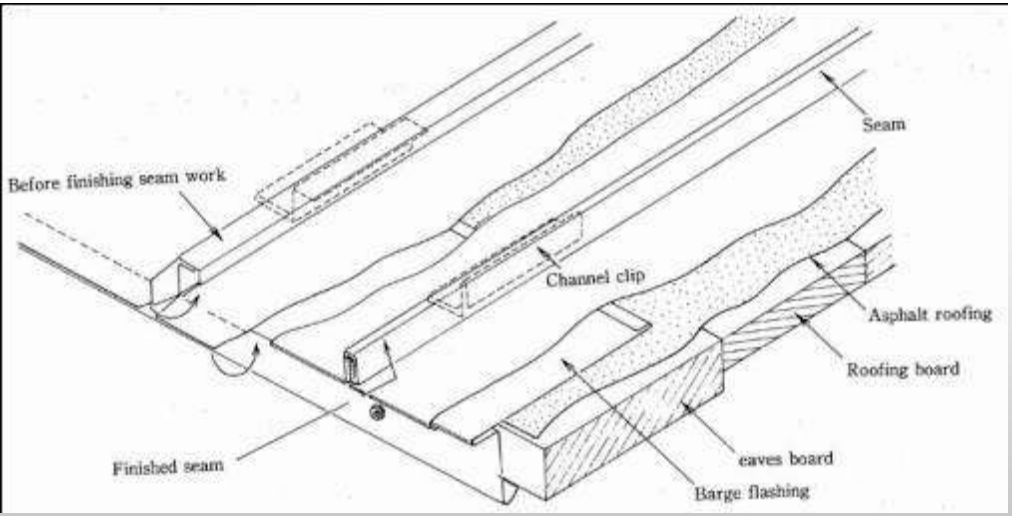
Standing seam roof detail with very tight bends

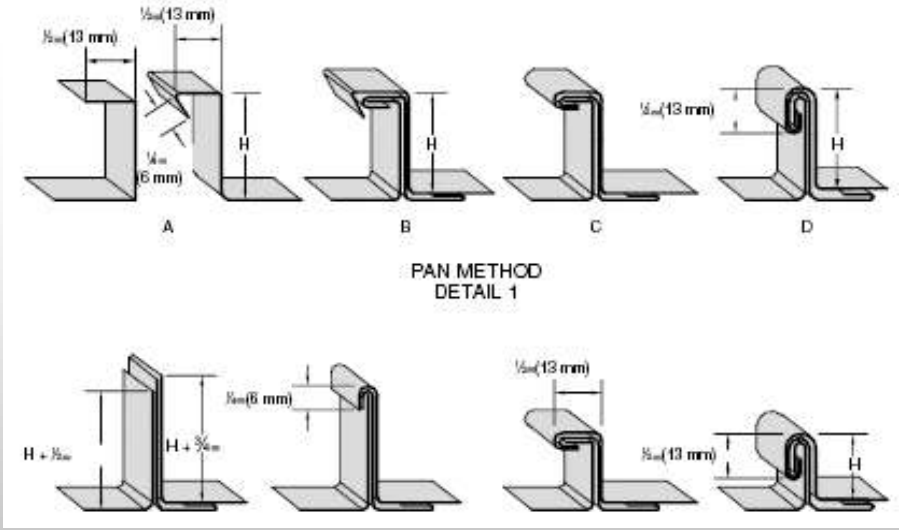


Standing Seam Roofs

Thickness and pan width comparison (mm) and profiles

Pan Width	Stainless Steel	Galvanized Steel	Copper	Aluminum
430	0.38	0.61	0.55	0.81
580	0.46	0.61	0.69	1.02

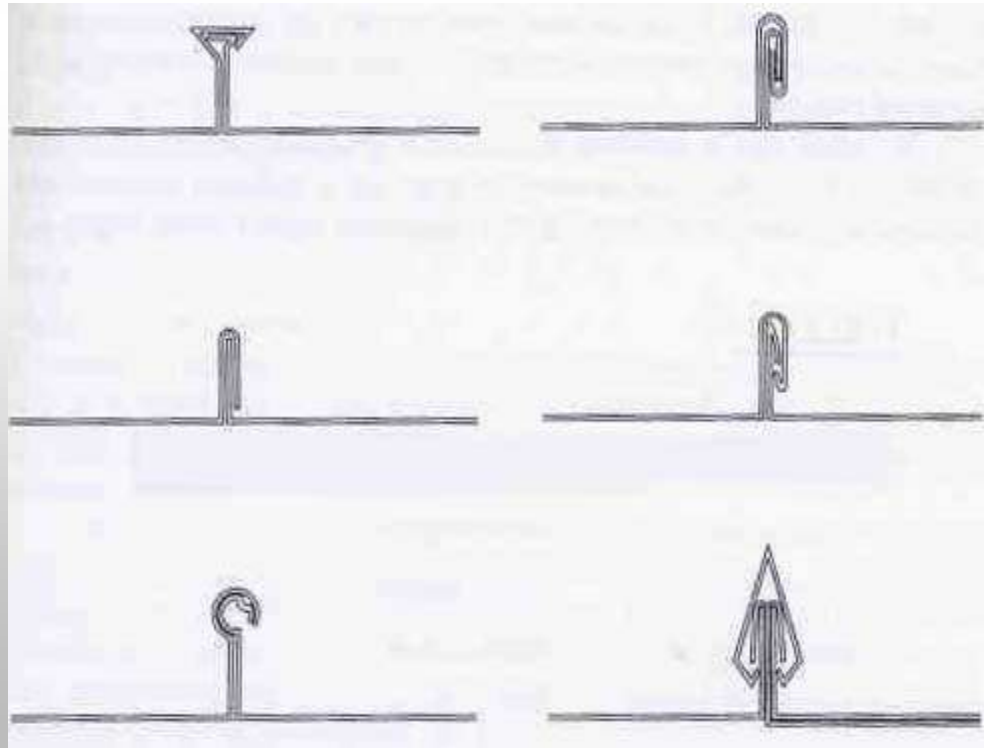




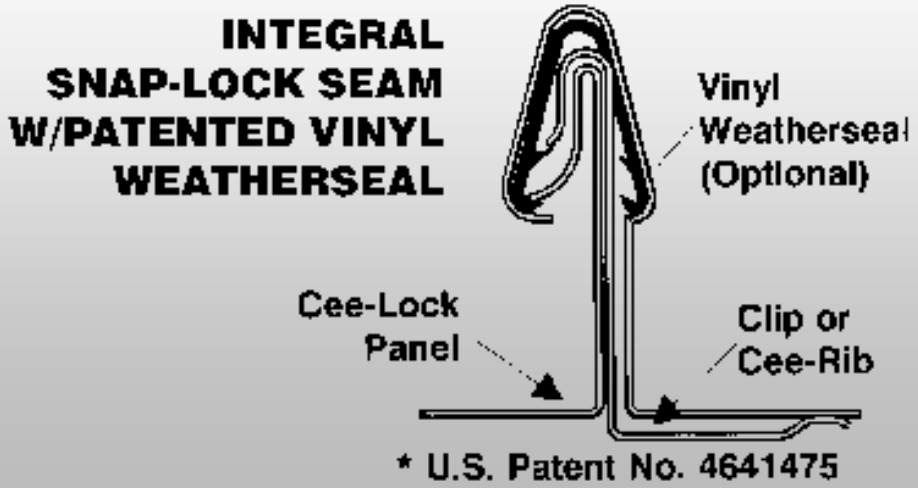
Reform Later Day Saints Temple Complex

Hellmuth Obata Kassabaum Architects

Standing seam roof, 4,500 roof panels, Type 304, 2D finish



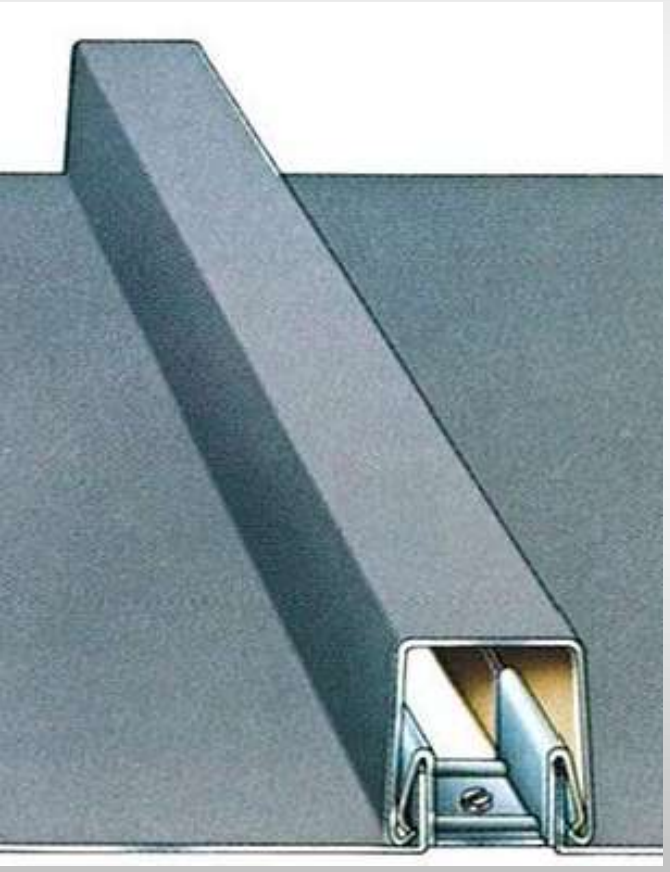
Doha International Airport



Roof: Duplex AL2003 and 2205
Interior: Type 304

Kowloon Station, Hong Kong

Batten cap design, Type 316, proprietary dull rolled finish resembling abrasive blasting



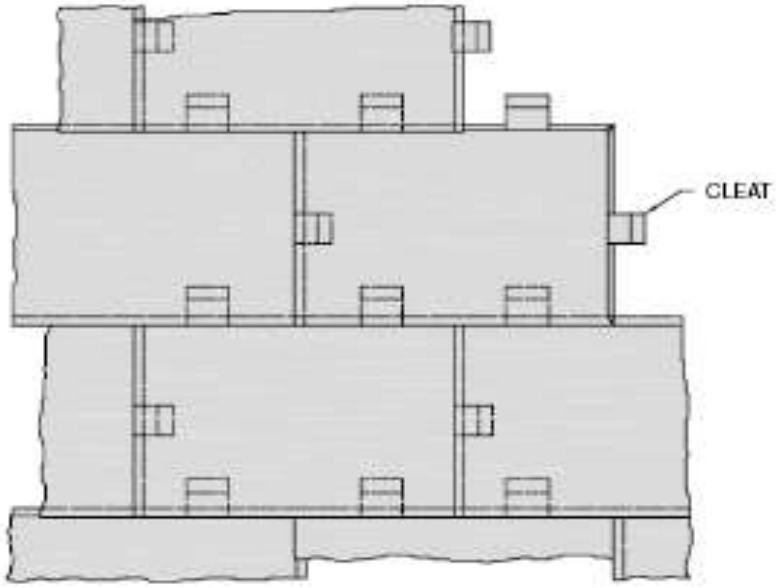
Shakaden Temple, Japan

Completed 1975

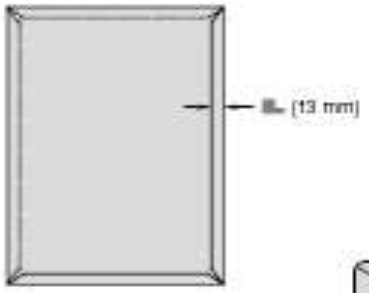
Electrochemically colored

Black roof with gold dots and clips

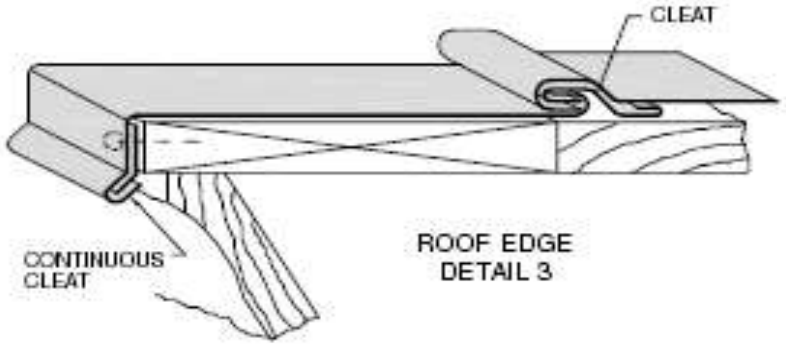
No color change



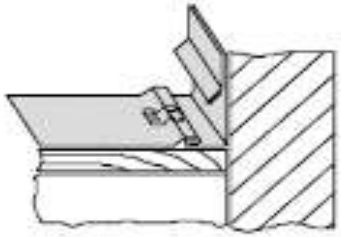
FLAT SEAM ROOF



ROOFING SHEET
DETAIL 1



ROOF EDGE
DETAIL 3



JUNCTION PARAPET WALL
DETAIL 2

Wind Uplift Resistance

- Design
- Material strength
- Strength retention over time
  - Minimal corrosion

Stainless roof, private residence, Florida

Both roofs exposed to 257 km/hr gusts

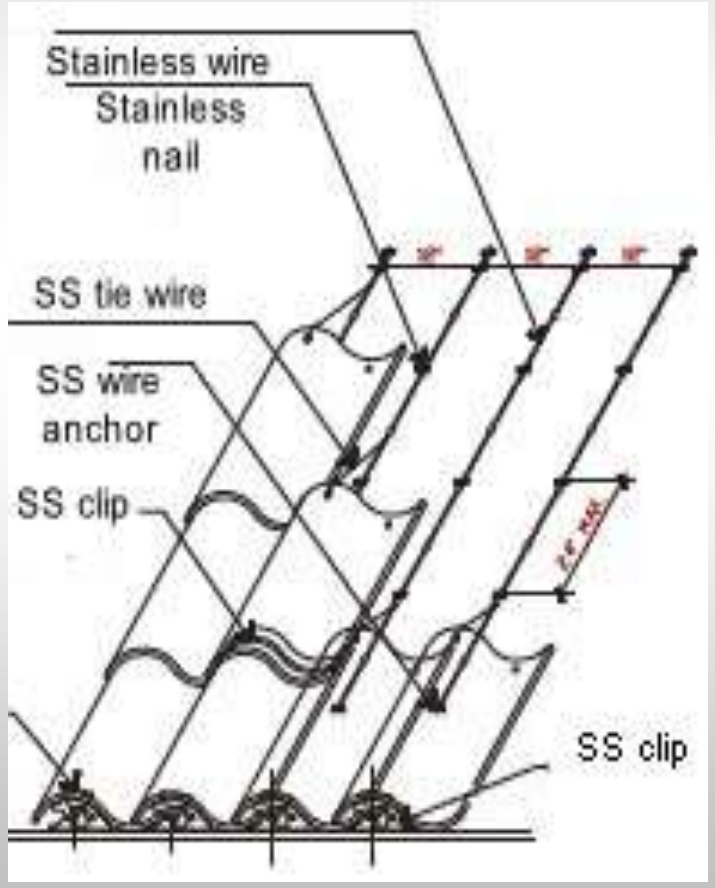
New York University website

Hurricane Katrina
New Orleans Mint

Stainless Steel Wire Ties for Tile or Slate

Recommended by US Federal Emergency Management Agency (FEMA) in coastal areas

Should be considered for any corrosive high wind area



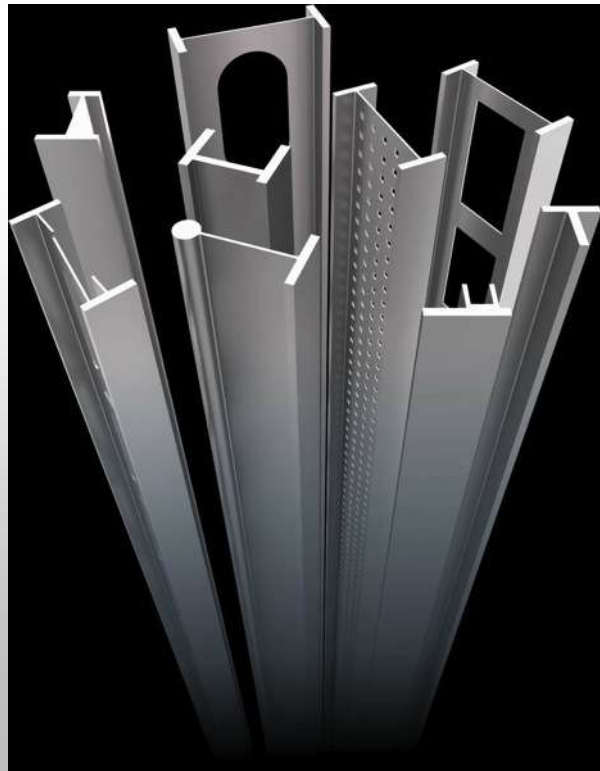
Hurricane (typhoon) damage

Stainless Steel's Structural Advantages

- Corrosion resistance
  - Sustainability/long term performance
  - Avoid coatings and see structural detail
  - Reduce maintenance
  - Long term security
- Seismic performance
- Impact resistance
- High temperature strength & stiffness retention
- High strength stainless steels
  - Reduce section sizes & minimize visibility

Structural Design Standards and Design Guides

- Material specifications define strength
- SEI/ASCE 8 Cold Formed Structural Section Standard
- EuroCode 3 covers all structural shapes
- AISC Stainless Steel Structural DG 27
  - Issued September 2013
  - AISC carbon steel standard format
  - Adapted from EuroCode
  - Larger hot rolled structural shapes
    - 3 mm (0.125 inch) or greater
  - Austenitic, duplex, and precipitation hardened stainless steels
- China is developing a structural design standard for stainless steel



Gateway Arch

First large stainless steel structural application

Architect: Eero Saarinen

Completed: 1965

192 m (630 ft.) high

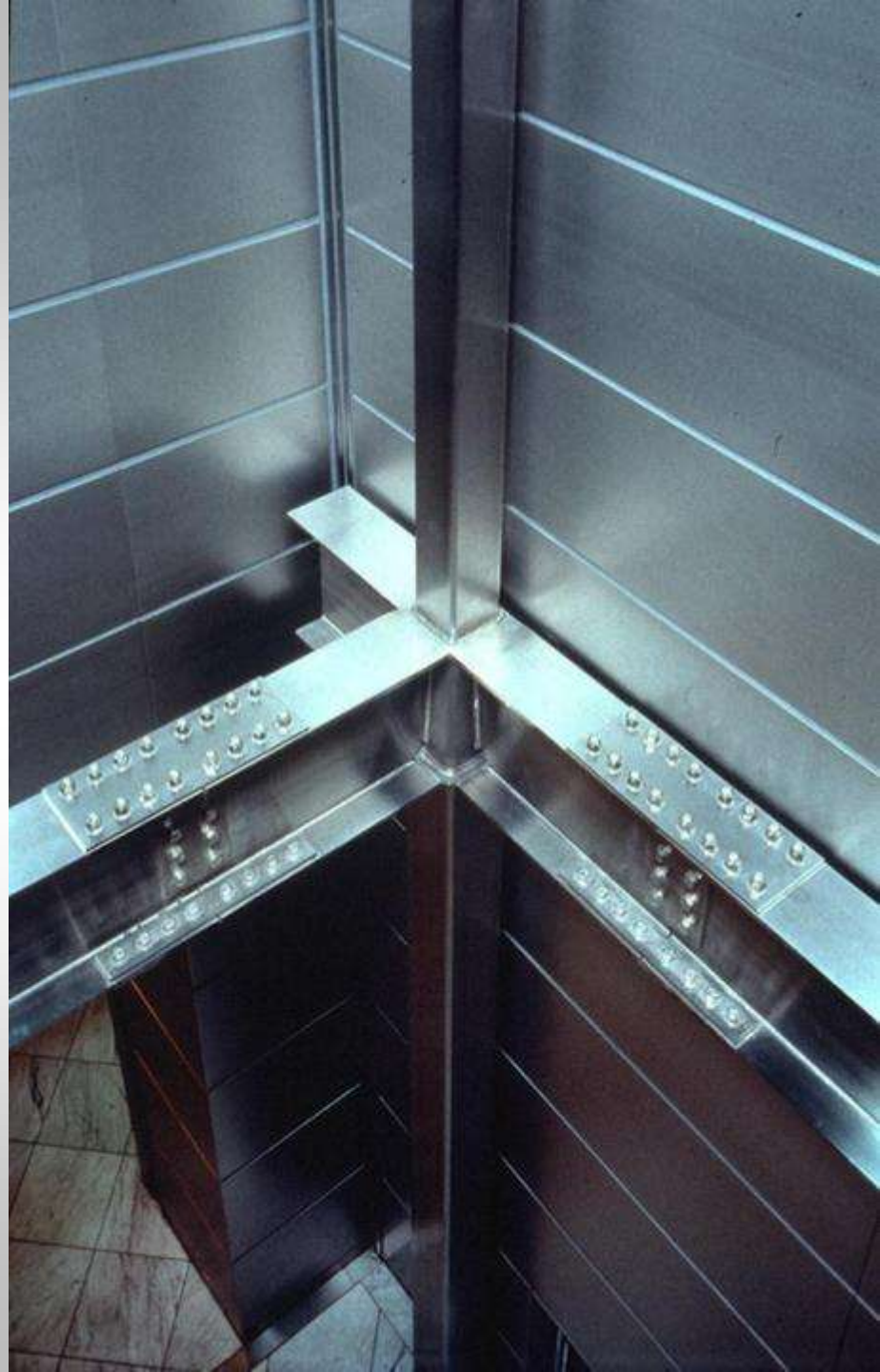
Exterior: Type 304, 6.3 mm (0.25 inch) plate, No. 3 polish

Interior: Carbon steel, 9.5 mm (0.375 inch) plate

Japanese Research Lab Demonstration Building

Osaka, Japan

Photo taken after major 1995 earthquake - No damage



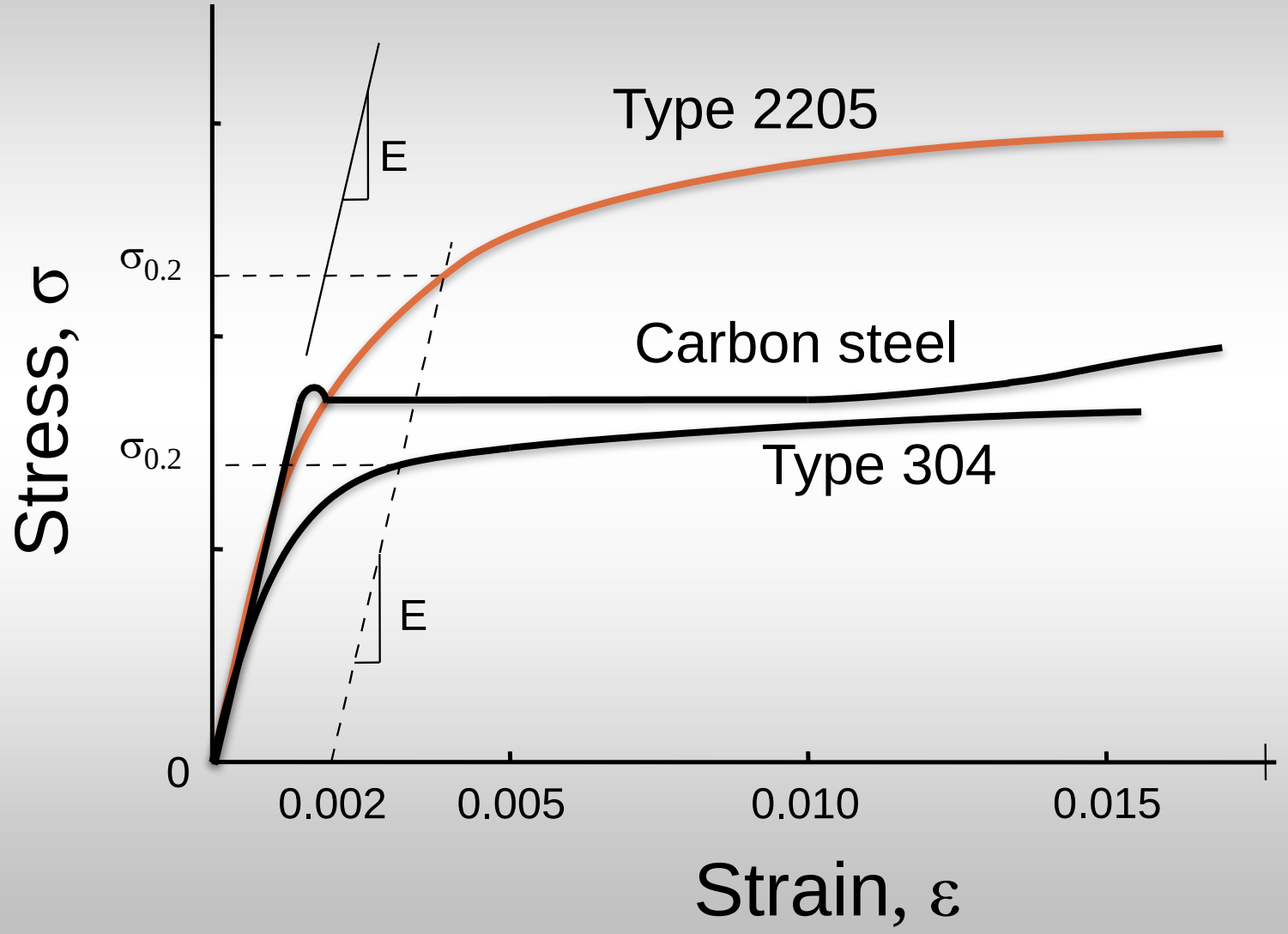
Pio of Pietrelcina Church, Italy

Type 316
used in seismic design

Stainless mesh ties stones in arches together to allow movement during earthquakes

Roof supports above arches are stainless steel

Stress-Strain Behavior

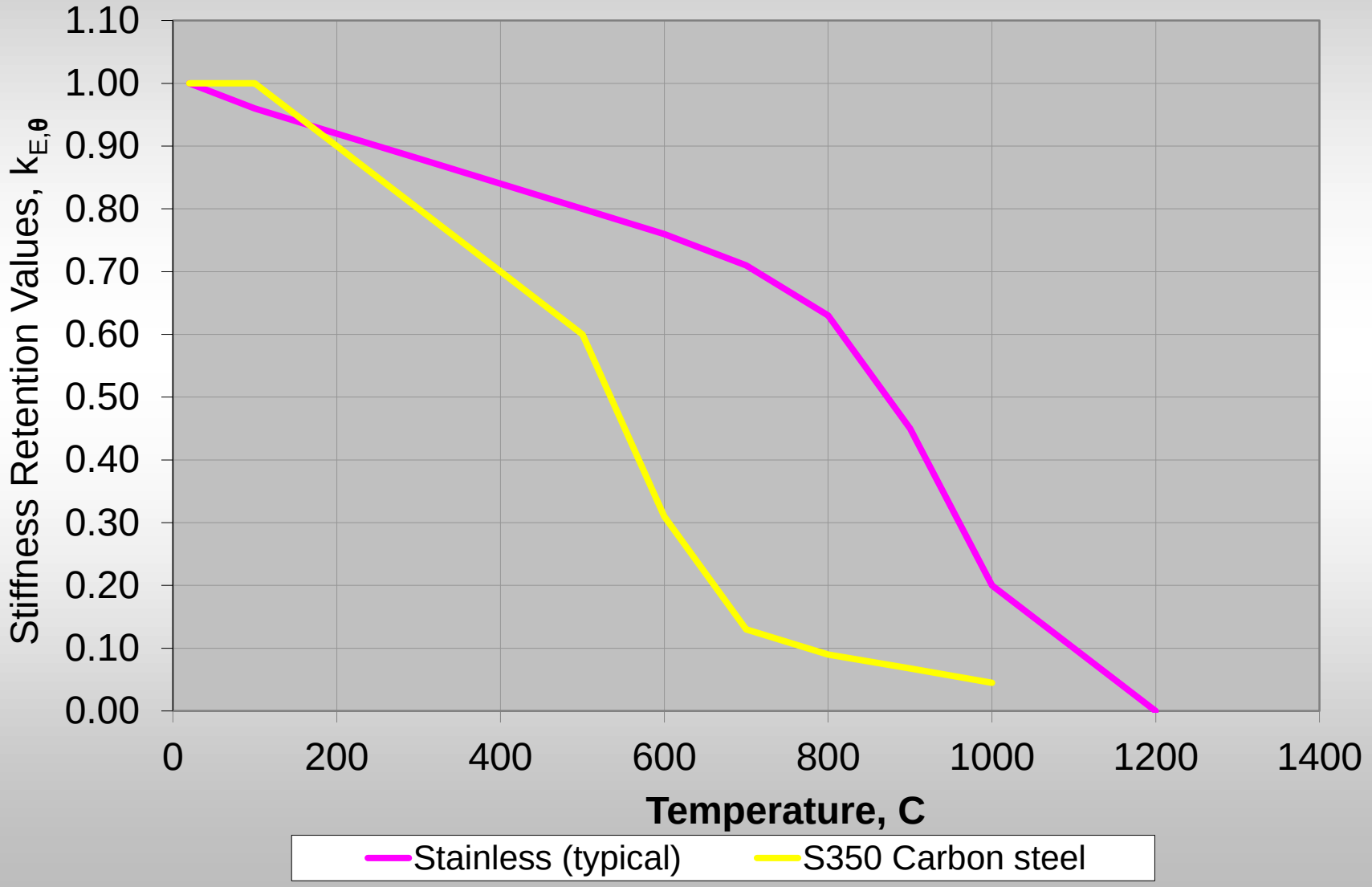


Fire and Thermal Radiation Resistance

- Aluminum is least resistant
  - Aluminum's strength decreases above 100ºC
  - 6061-T6 tensile strength decreases 60% at 200ºC
- Carbon & weathering steel are normally fire proofed
  - Carbon steel limited to 370ºC under continuous loading
  - Carbon steel tensile strength drops 30% at 500ºC
  - Weathering steel tensile strength drops 50% >540ºC
- Stainless steel has better strength and stiffness retention
  - Stainless steel used for heat treating furnaces for other metals

Stiffness Retention at Elevated Temperature

7 times the stiffness retention of carbon steel at 800 C (1472 F)



Space Frame Roofing Finite Element Analysis

- Tubular structure (1.9” diameter/0.19” wall to 3.5 “ diameter/0.24” wall)
- Various structural knots (intermediate, edge, support) at lattice apexes
- Free span: 35.4 ft
- Module side: 5.9 ft
- Structure width: 11.8 ft
- Roofing load: 184 lbs/ft^2
- Structure weight: 6.9 lbs/ft^2

Critical Times and Temperatures for Space Frame Roof Failure

Steel	Critical time to failure (minutes)	Critical temperature for failure (˚F)
Carbon Steel	10:32	892
Type 304	15:19	1117
Type 316	28:53	1465

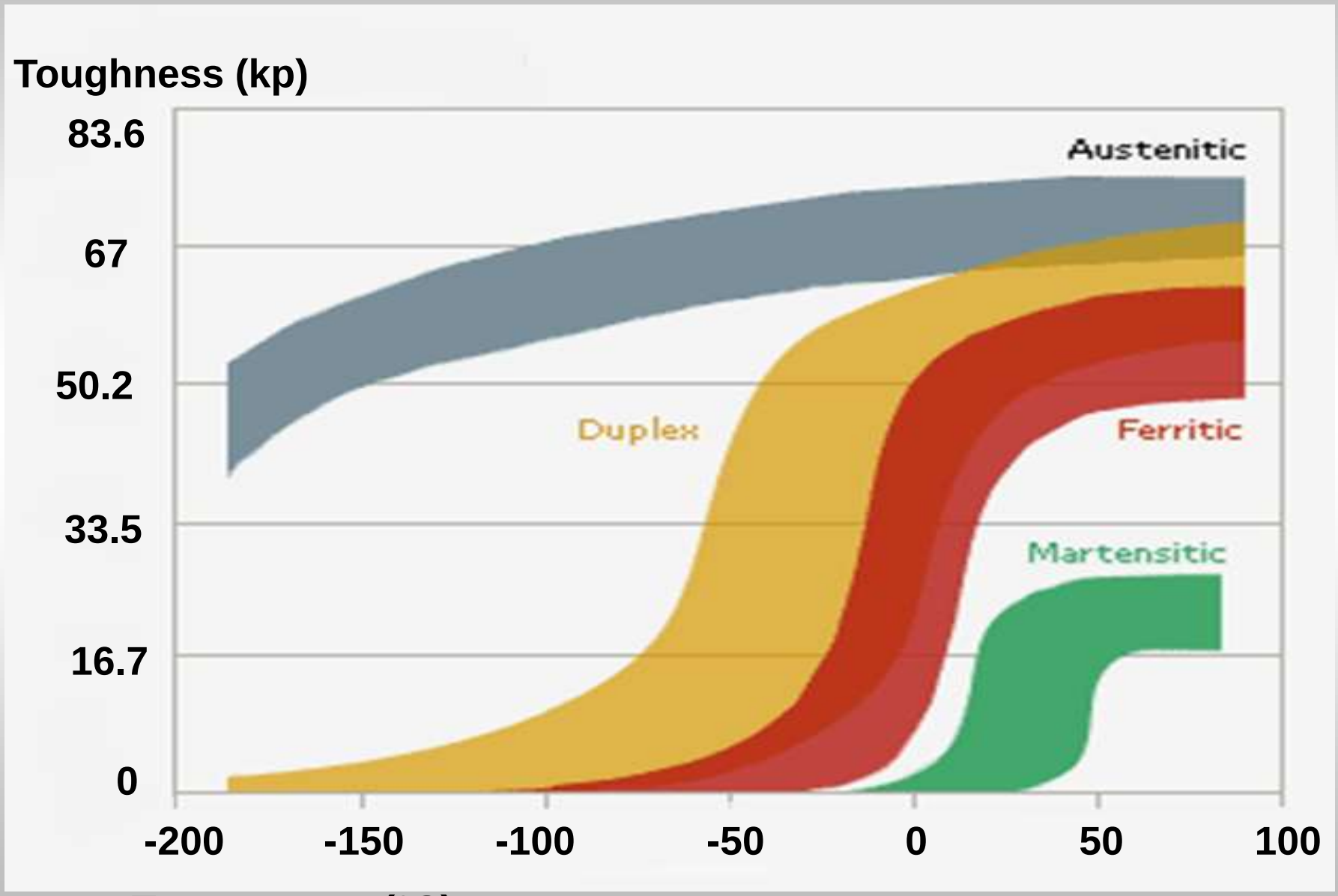
Relative to carbon steel

- Type 304 increases the critical time to failure by 45%
- Type 316 increases the critical time to failure by 174%

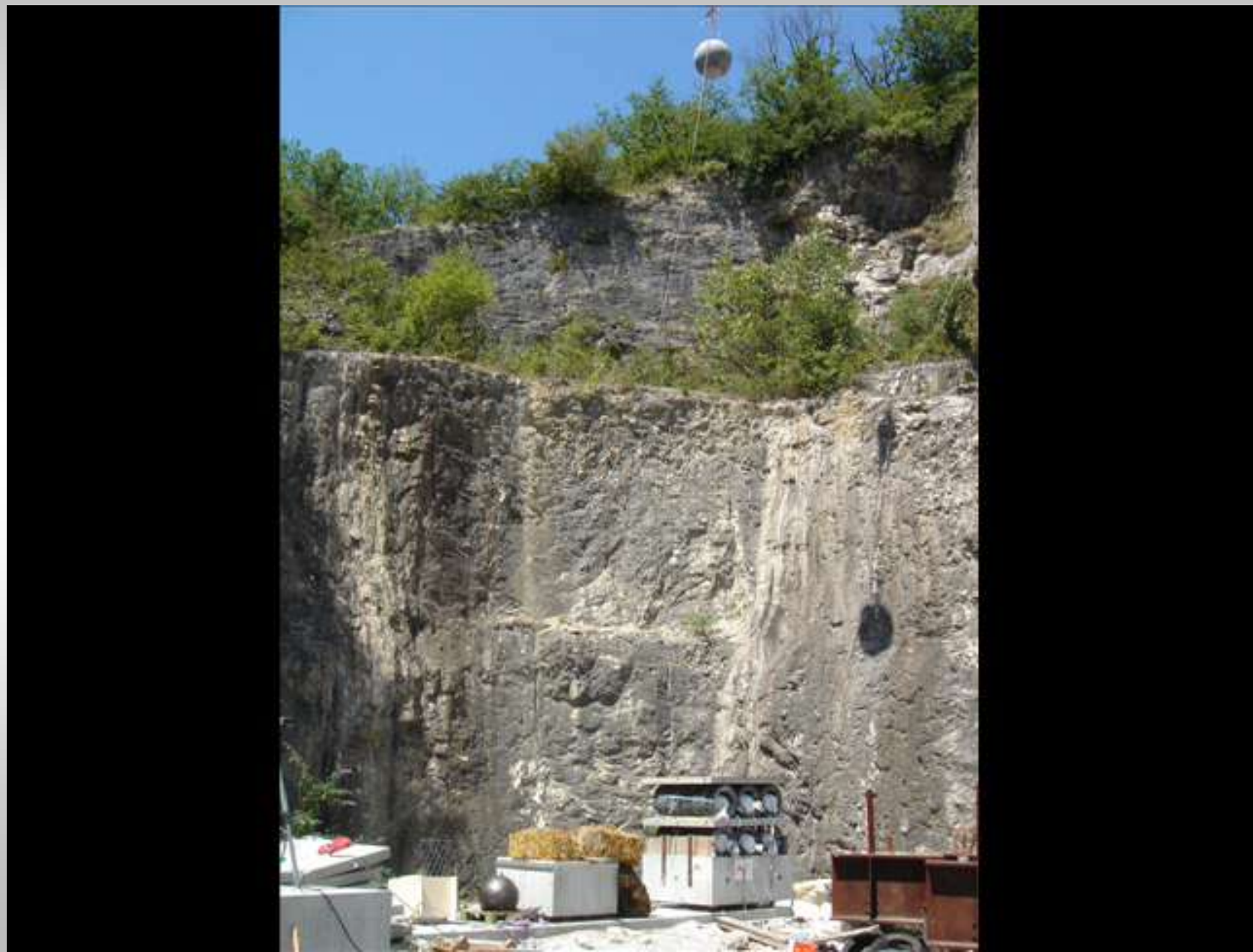
Relative to Type 304

- Type 316 increases the critical time to failure by 89%

Impact Toughness



700 KG Ball Impact
Carbon Steel Reinforced Concrete



700 KG Ball Impact
Type 304 Stainless Reinforced

7 World Trade Center, New York

2205 below the canopy, Type 316 elsewhere

Doha, Qatar, Convention Center & Tower (2015), Jahn

- 2205 stainless
- Convention center column covers, bollards
- Wall panels bottom 18 m of 550 m tall tower

Private Gates, Durban

Where Should Stainless Concrete Reinforcement Be Used?

- Sensitive electronic equipment
  - MRIs, automated highway toll booths
  - Government facilities
- Coastal or deicing salt
  - Bridges, pavement, seawalls, piers, parking garages
  - Salt exposure levels
    - Immersion, spray, splashing
    - Coastal zone with high chloride deposition rates
- Seismic design (bridge piers, slab connections)
- High impact resistance - security, avalanche walls
- Fire resistance/containment

Stainless Steel Reinforced Concrete

- UK government Building

Benefits of Long Life
Pier Progresso Mexico

- Reduced environmental impact
- No disruption and replacement cost
- Much lower long term operational costs
- Numerous reports including NACE 07240

Functioning pier
- Completed 1941
- Type 304 rebar

Non-functioning pier
- After 30 years
- Carbon steel rebar

Sea Walls & Pier Concrete Corrosion

Sidney Opera House
Carbon steel reinforced concrete retaining wall corrosion
Replaced with Type 316 rebar

Coastal Chloride Deposition/ Chloride Penetration Relationship Brazil, Cuba, Yucatan Peninsula

- Chloride penetration into various types of concrete and relationship to chloride deposition
  - 200 meters (656 ft) or less from shore had highest levels
  - Not limited to shore
- Locations with ~ 10 kg/ha (8.93 lbs/acre) of chloride deposition or greater
  - Wide range of concrete types tested
  - Only horizontal surfaces tested – simulating road applications
  - Measureable chloride penetration

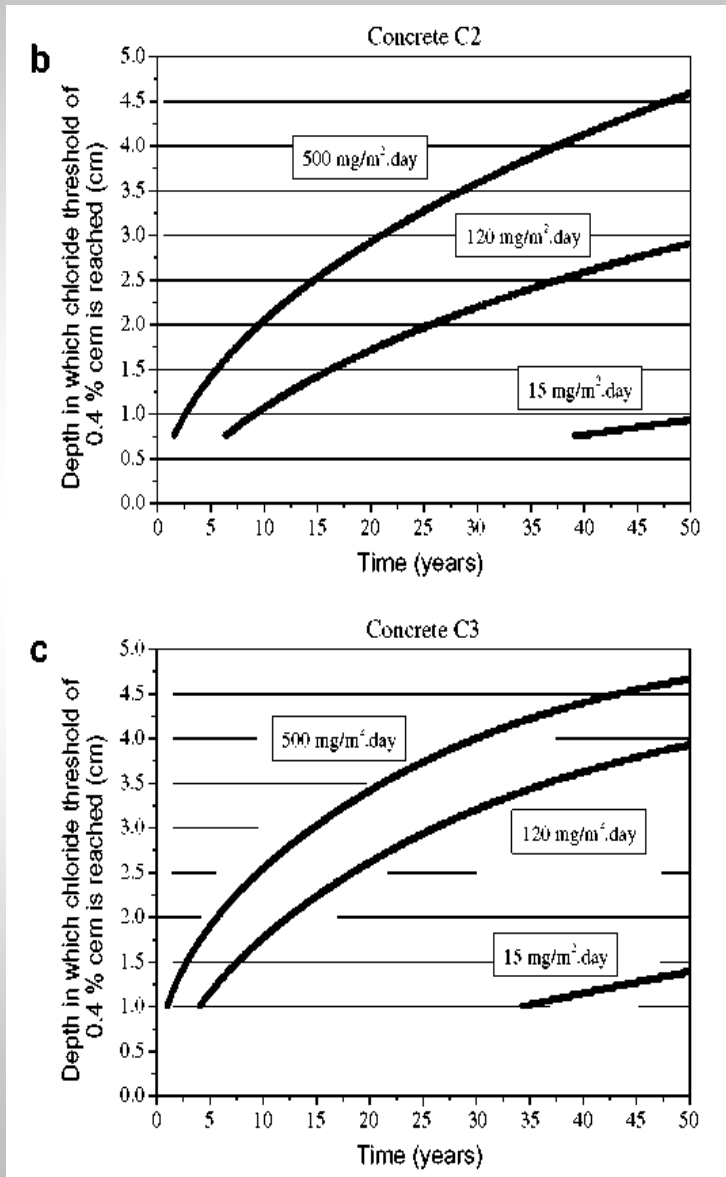
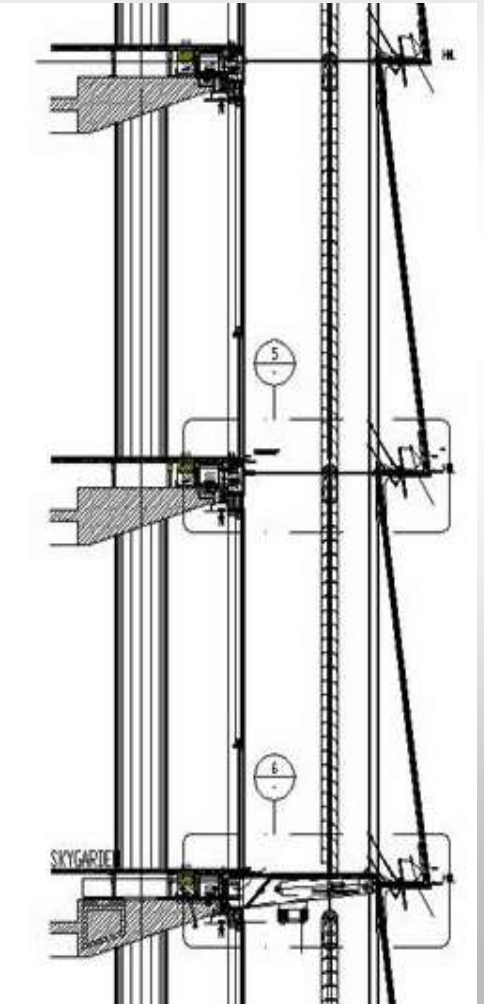
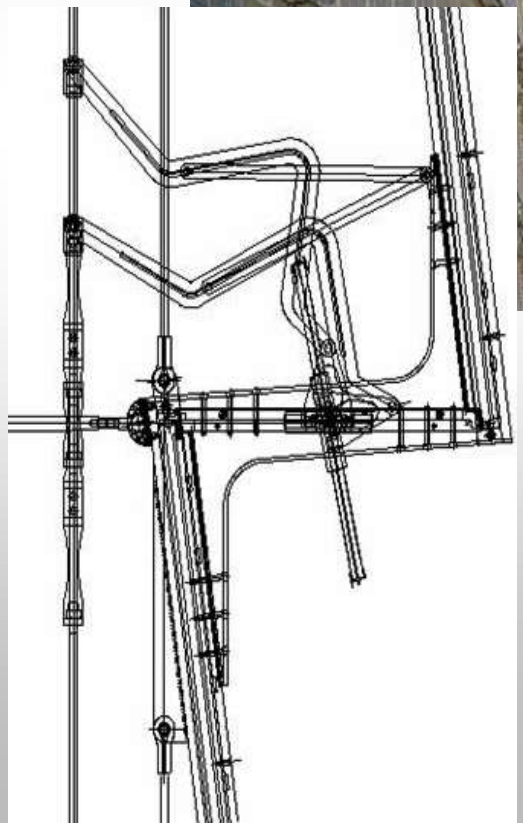
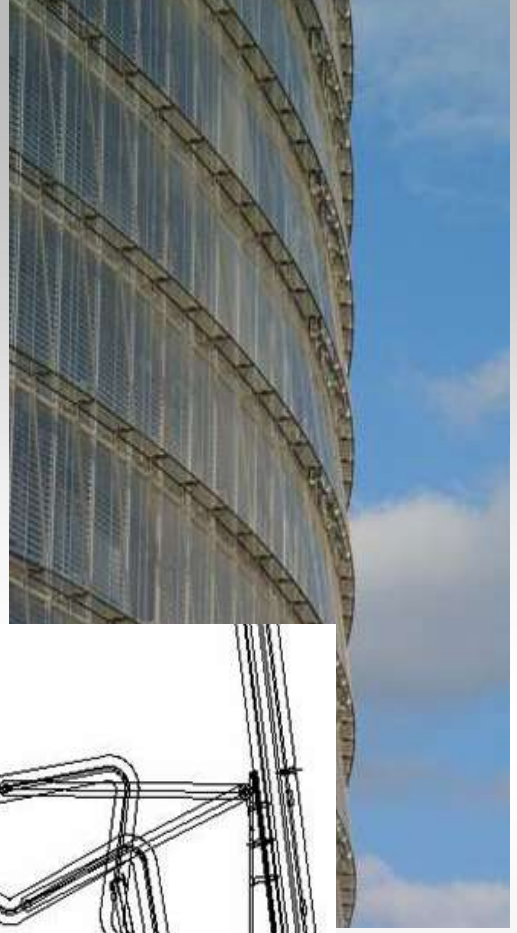


Fig. 8. Simulations of chloride threshold advance in concretes C1 (a), C2 (b) and C3 (c) for different chloride deposition levels.

Post Tower
Bonn, Germany
Helmut Jahn





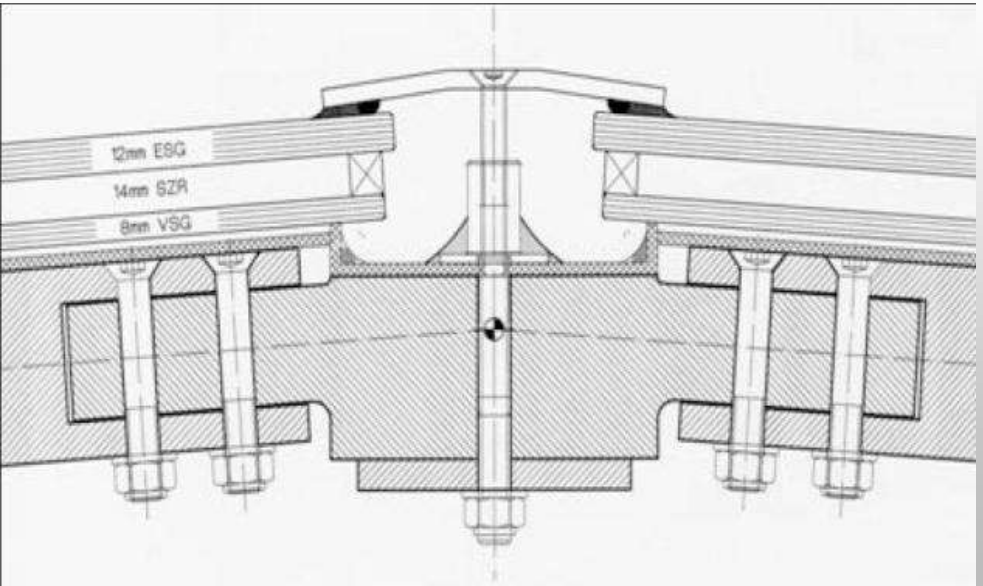


Exterior glass wall in double façade systems are typically supported by stainless structural sections

New Poly Plaza, Beijing

Skidmore Owings & Merrill

Type 316 cable
2205 tension
bars and spiders

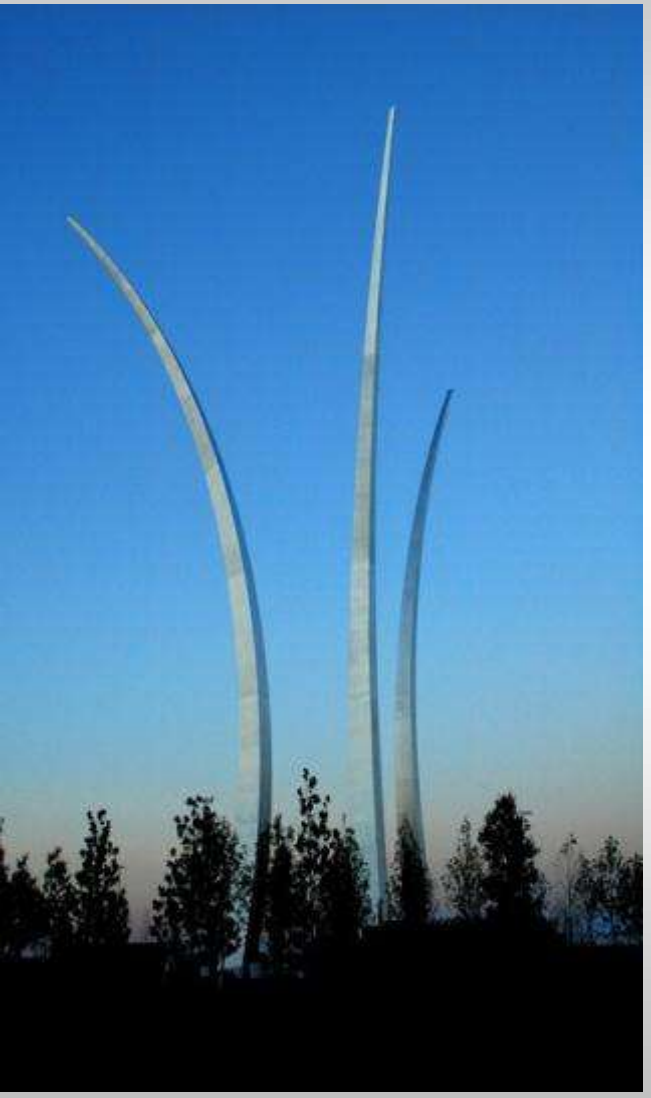


DG Bank Skylights

Apple Cube, Manhattan

Glass supported by high strength 2205 duplex,
Points of light created with highly polished Type 316

US Air Force Memorial



Pei Cobb Freed

Structural: Arup

Type 316 plate
0.75 in (19 mm)

3- step dull finish

66 - 87 meters
(218 to 284 feet)

Harbor Dr Bridge, San Diego

- Completed 2011, 168 m (550 ft)
- One of world's longest self-anchored, suspension bridges
- 62 tons structural 2205 plate & pipe and 1.5 tons 17-4 PH support deck
- 2.5 tons cable stays (2205 connections, 316 cable)

Conclusions – Stainless Steel

- Very sustainable construction material, particularly for
  - Long building service lives
  - Corrosive locations
  - High traffic/low maintenance
- High level of design and finish flexibility
- Contact ISSDA for free literature and technical assistance
- Questions?

- Design detail source:
  - SMACNA Architectural Sheet Metal Manual