Achieving International Stainless Steel Design Success

Speaker: Catherine Houska

Sponsors:

Nickel Institute

Indian Stainless Steel Development Association

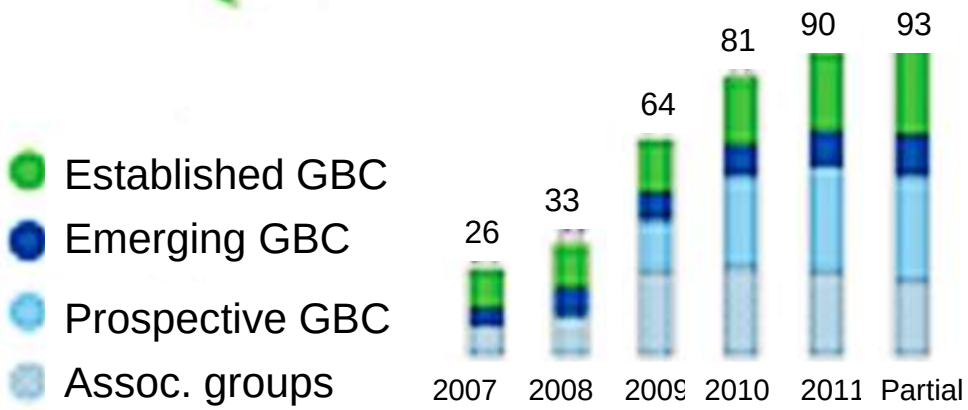
Why Should You Consider Stainless Steel?

- Sustainable
  - Longevity, energy savings, no VOCs
- Attractive & provides design flexibility
  - Wide range of finishes on sheet and strip
  - Any metal design is possible
- Structural benefits include
  - Enhances safety & security
  - High strength
  - Reduces section sizes
  - Seismic performance

1 World Trade Center
Type 316 Linen & spire
Gold LEED expected

World Green Building Council

Countries & Associated Groups



A rapidly growing international mega trend

WGBC founded by 9 countries in 2002

Now 97 countries and affiliated groups

Environmental & Economic Benefits

- Significant opportunity for decreased energy, water, & material resource use
  - Strategic & environmental advantages
- US statistics for buildings
  - 36% energy use
  - 30% of greenhouse gas emissions
  - 12% of potable water consumption
  - 30% raw material production
  - International averages are higher (>40% greenhouse gases)

Empire State Building, 1931, LEED Gold
Stainless spandrel panels, window frames and spire

Stainless Steel Provides Long Life

Chrysler 1930

Savoy Hotel Canopy 1929

Shakaden Temple 1975

Empire State 1931

Thyssenhaus 1956

Gateway Arch, 1965

Other Metals Have Shorter Service Life & Require More Maintenance

Peeling painted carbon steel

Peeling painted aluminum roof, 25 years

Peeling painted Aluminum Florida, <10 yrs

Important Trends

- Whole Building Life Cycle Assessment
  - Minimum project life requirements
    - IgCC and ASHRAE using 75 years
    - LEED & BREEAM = 60 years min.
  - Material environmental impact x # replacements

- Long term owners requiring 75, 100 or even 150 year design life

- More corrosive urban environments
  - Population growth/redevelopment
    - High pollution & coastal areas
  - Increased & more aggressive deicing salt

US Federal Courthouse
Eugene, Oregon, USA
US Gold LEED, 100 year life

Average Rates (%)

	Recycled Content	Recapture Rate
Carbon Steel		
Sheet/strip	25-35 **	70
Structural	≤95 **	97
Stainless Steel	70 - 92**	92*
Zinc	23 **	33
Copper		
Electrical wire	0 *	>90
Other products	70 – 95 *	>90
Aluminum		
Sheet	0 *	70
Extrusions	Varies *	70
Castings	≤100 *	70

* ABC Industry ** All Applications

Reducing Energy Use & Heat Islands

- Material and finish choice affects energy performance
- Solar Reflective Index (SRI)
  - Calculated based on ASTM E1980
  - Solar Reflectance & Emittance
    - Varies with material & finish
  - Roof slope (1:6) & exterior walls ≥ 39
  - Low slope roofs ≥ 82
- In 3 years, SRI values can not deteriorate below 32 and 64
  - Unlike other materials, stainless steel SRI values do not decrease over time

Pittsburgh Convention Center (2003)
Was Gold LEED after construction
Now LEED Platinum Existing Building
2/3% less water, 29%less energy
50+ year life requirement

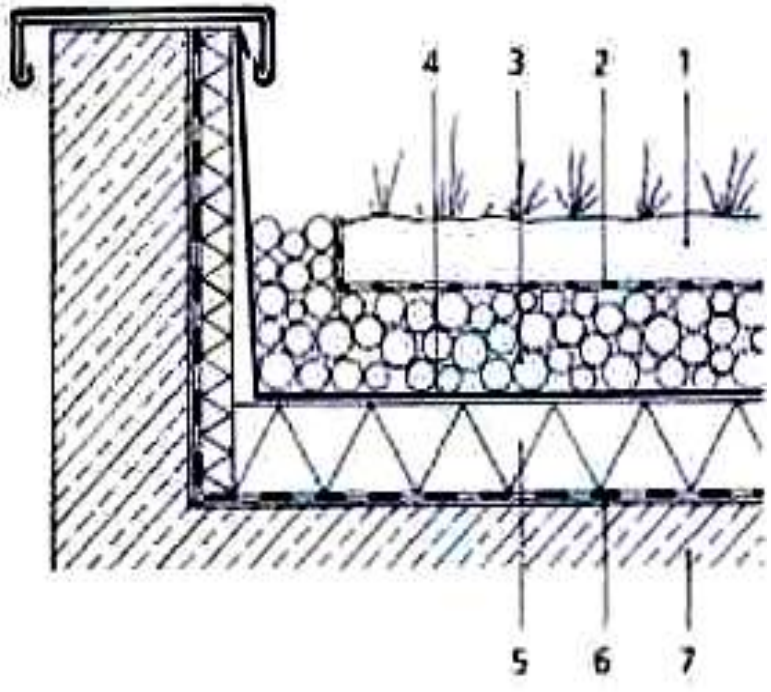
Product	Temperature Rise, at C (F)	Solar Reflective Index
Stainless Steel, bare	27 (48 F)	39-60
Galvanized steel, new bare	30 (55 F)	46
Aluminum, new bare	27 (48 F)	56
Any metal, white coating	9 (16 F)	107
Clay tile, red	32 (5 8F)	36
Concrete tile, red	39 (71 F)	17
Concrete, white dirty	37 (67 F)	22
Concrete, new white	12 (21 F)	90
Asphalt, generic white	36 (64 F)	26
Asphalt, generic black	46 (82 F)	1
Wood shingle, brown	37 (67 F)	22
Wood shingle, white	6 (10 F)	106

Sources: LBNL Cool Roofing Materials Database
and finish producers

US Gold LEED, Pacific Lutheran University

Renovation & expansion of existing masonry student activities center
Type 304 roofing and wall panels
100 year design life
Zimmer Gunsul Frasca Architects

Welded Stainless Green Roof Liners



1 Plants in soil
2 Filter membrane
3 Drainage layer
4 Welded molybdenum-containing stainless steel
5 Thermal insulation
6 Vapor barrier
7 Roof deck

Paul Klee Center, Berne

- Renzo Piano Building Workshop
- Undulating shape mimics the hills
- Type 316 roof trays are used to create vegetated roof

Building Energy Modeling

- National governments requiring significant energy use reductions for their buildings
  - Usually at least 30% below typical
- Building energy modeling software leaps forward - fenestrations
  - **US DOE FREE COMFEN 5 software**
    - Large number of buildings analyzed
    - Calculates energy use/cost, CO_2
    - Full range of variables
    - Multi-room – not a cube approach
  - Exterior sunscreen impact determined
    - More relevant than % of open area
    - Sheltered locations are more corrosive application = stainless steel

San Francisco

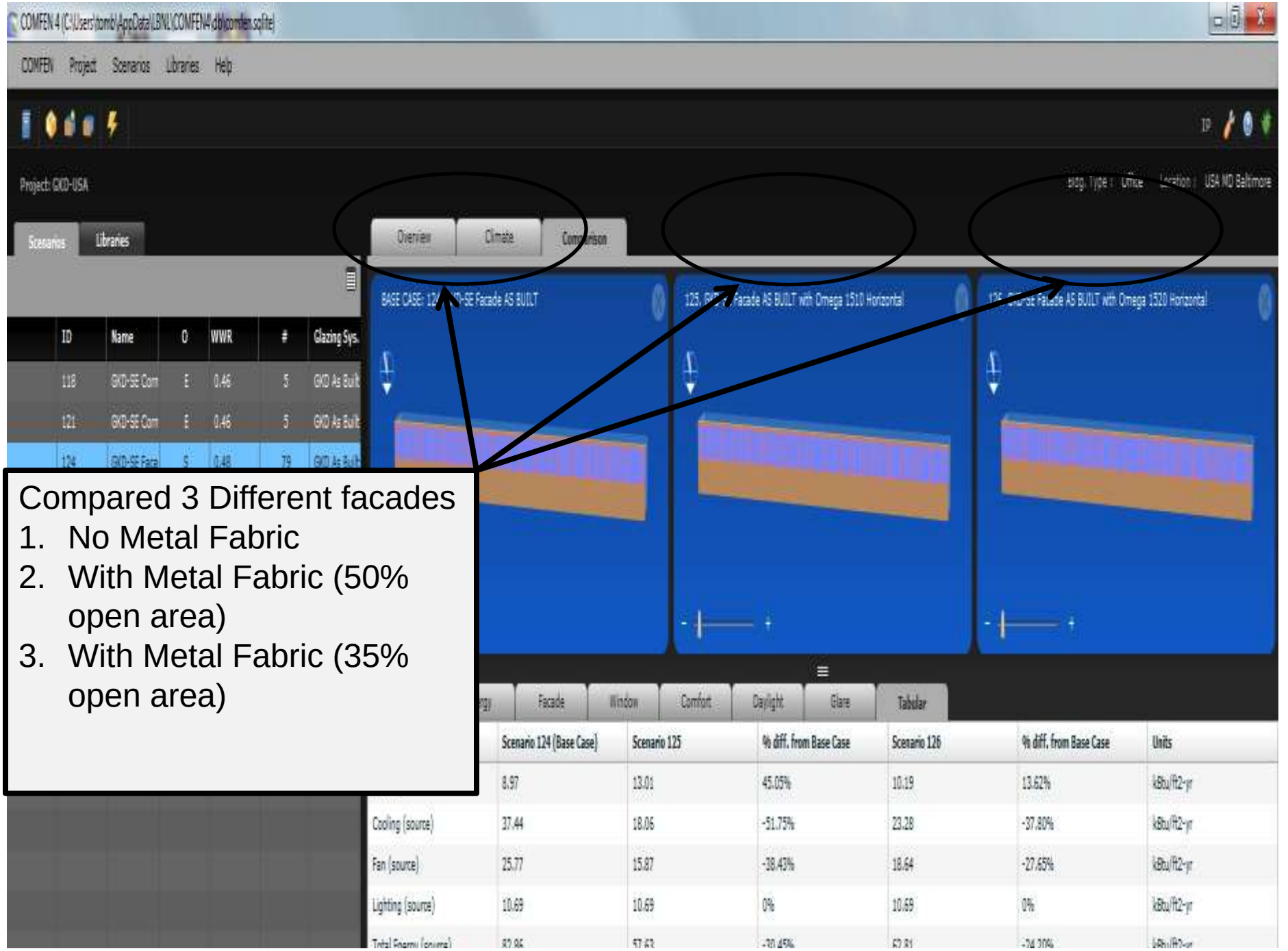
Federal Building

Type 316 sunscreens

Surpassed government energy performance criteria by 50%

COMFEN 5 Building Example
Eastern Michigan University, USA

- Woven mesh sunscreens, 35% open area
- US Department of Energy free COMFEN software predicted energy reduction
- Northern climate, air temperature 24 C
  - Building exterior temperature
    - 34.4 C no shading
    - 27.8 C with shading



Compared 3 Different facades

1. No Metal Fabric
2. With Metal Fabric (50% open area)
3. With Metal Fabric (35% open area)

Summary | Energy | Facade | Window | Comfort | Daylight | Glare | **Tabular**

Annual Values	Scenario 124 (Base Case)	Scenario 125	% diff. from Base Case	Scenario 126	% diff. from Base Case	Units
Heating	8.97	13.01	45.05%	10.19	13.62%	kBtu/ft2-yr
Cooling (source)	37.44	18.06	-51.75%	23.28	-37.80%	kBtu/ft2-yr
Fan (source)	25.77	15.87	-38.43%	18.64	-27.65%	kBtu/ft2-yr
Lighting (source)	10.69	10.69	0%	10.69	0%	kBtu/ft2-yr
Total Energy (source)	82.86	57.63	-30.45%	62.81	-24.20%	kBtu/ft2-yr
Peak Demand Electricity	10.60	7.25	-31.62%	8.10	-23.52%	W/ft2
Peak Demand Electricity Date	AUG 17 02:30 PM	AUG 14 01:00 PM	--	AUG 14 01:00 PM	--	
Peak De			-10.57%	20.52	-9.27%	W/ft2
Peak De			--	MAR 1 06:15 AM	--	
Avg. Day			-76.83%	85.85	-69.40%	fc
Avg. Disc			1.12%	10.57	8.45%	Index
Avg. The			0.09%	83.52	1.44%	PPS
CO2 emi			-36.65%	22.34	-27.31%	lb/ft2

% diff. from Base Case compares the total energy savings 35% open area (30.45%) or 50% open area (24.20%) GKD Metal fabric would save versus using no fabric at all.

Recent Stainless Sunscreen Examples

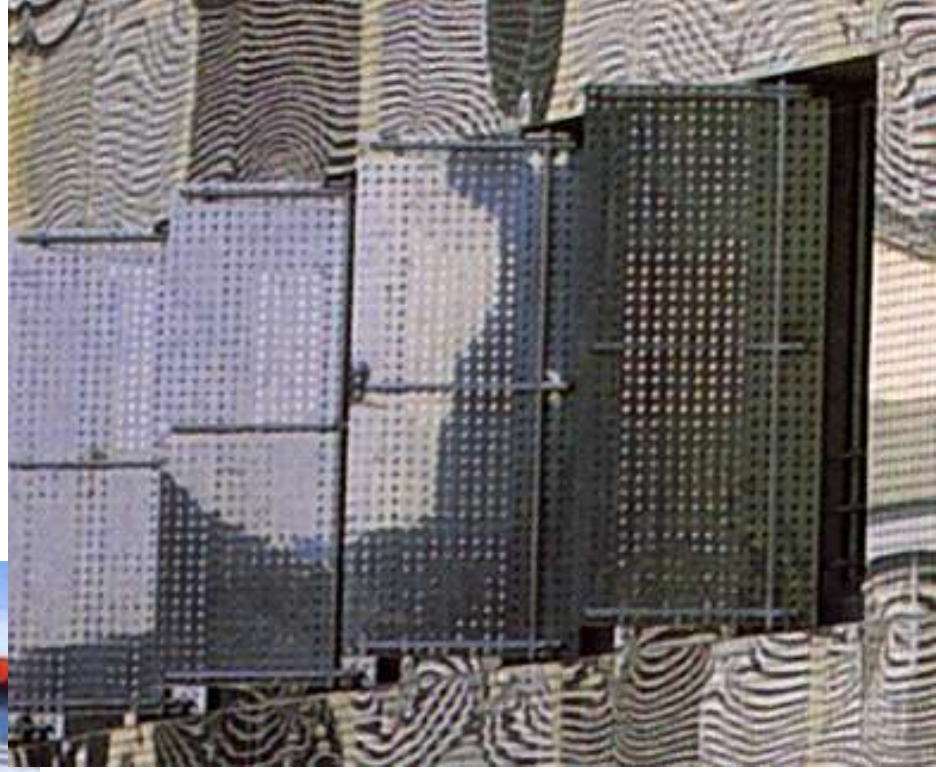
Guangzhou China
2nd Children's Activity Center
Woven mesh

Cooper Union, NYC
Perforated screens
LEED Platinum
40% energy savings

Stainless Steel Green (Plant) Sun Screens

Sun Screens

University of Chemistry, Physics, and Electrical Engineering (CPE), Lyon



Installation of perforated sunscreens over an existing glass wall dramatically reduced heat gain

Scottish Parliament

- Many common building materials release emissions
  - Reducing these creates a healthier environment
  - Bare uncoated metal has no emissions
- Stainless, wood and concrete
  - Interior stainless structural supports, wall and ceiling panels

Success Requires Picking The Correct Material
What Factors Influence Corrosion?

- Pollution
  - Acid rain
  - Sulfur Dioxide & particulate
- Coastal or deicing salt exposure
- Weather conditions
  - Rain type (rare, light, heavy)
  - Temperature
- Maintenance
- Design/specification
  - Crevices
  - Finish topography, roughness & application method

Select Type 304

- Rural/suburban
- Low to moderate pollution

Select Type 316

- Pollution
  - Moderate to high urban
  - Low to moderate industrial
- Coastal and deicing salt
  - Low to moderate exposure

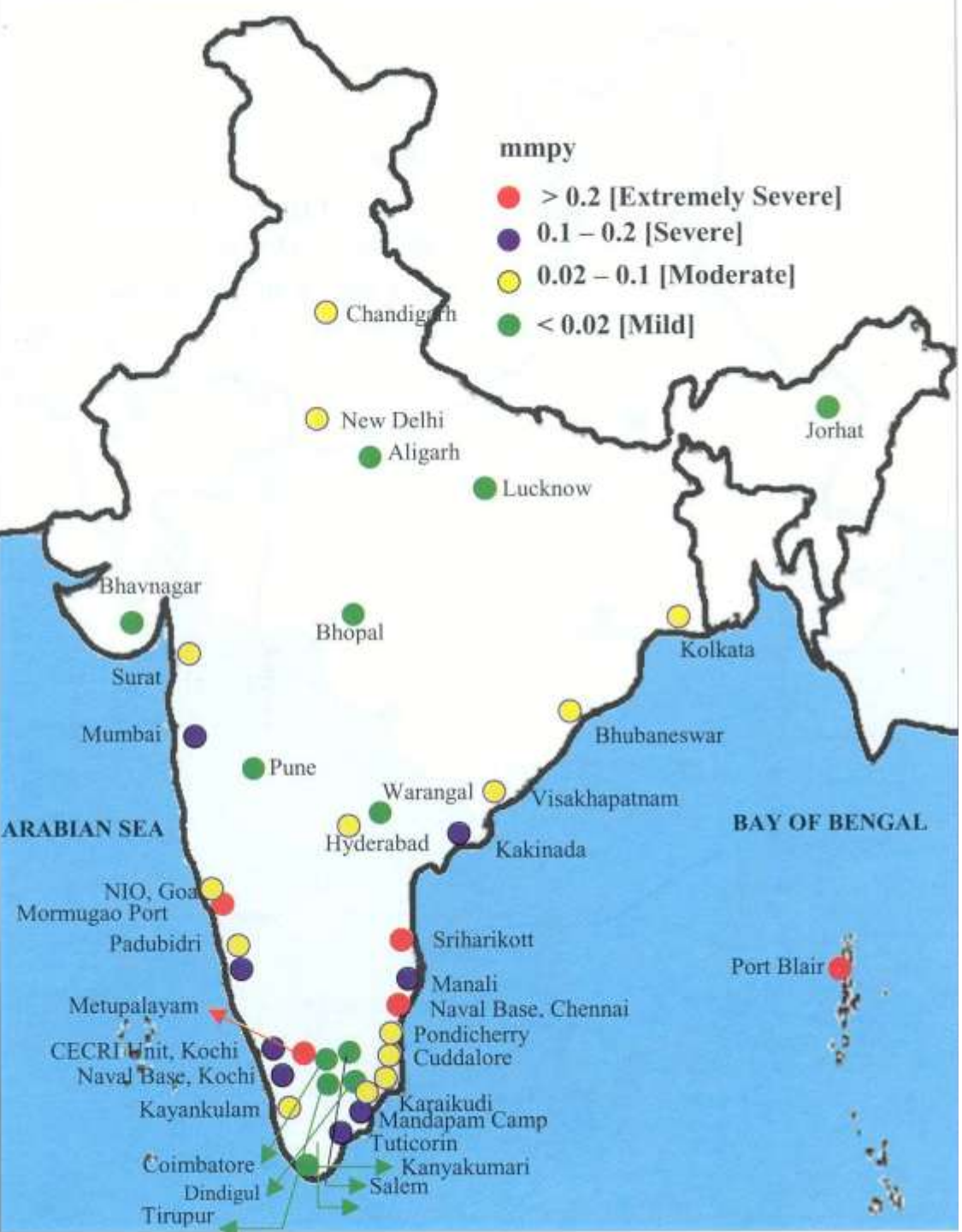
Higher Alloys Like 2205

- High pollution or salt exposure
- High particulate
- No rain washing

Other More Corrosive Locations

2205 Railings, Canary Island 30 years – salt spray

Stockholm Congress Ctr 2205 Sunscreen
Area behind the screen is not washed & highly visible



New Corrosion Corrosion Map for India

Dubai Beach Site Corrosion Rates Predict Perforation - Standing Seam Roof Example

Metal	Corrosion Rate Dubai Coastal Inch/year	SMACNA Thickness Inch	Time To Perforation, Yrs
2205 Duplex*	0	0.015	50+
Galvanized steel**	0.02	0.024	2.2
Aluminum	0.002	0.032	16
Zinc***	0.035	0.028	Less than 1
Copper	0.004	0.022	5.5

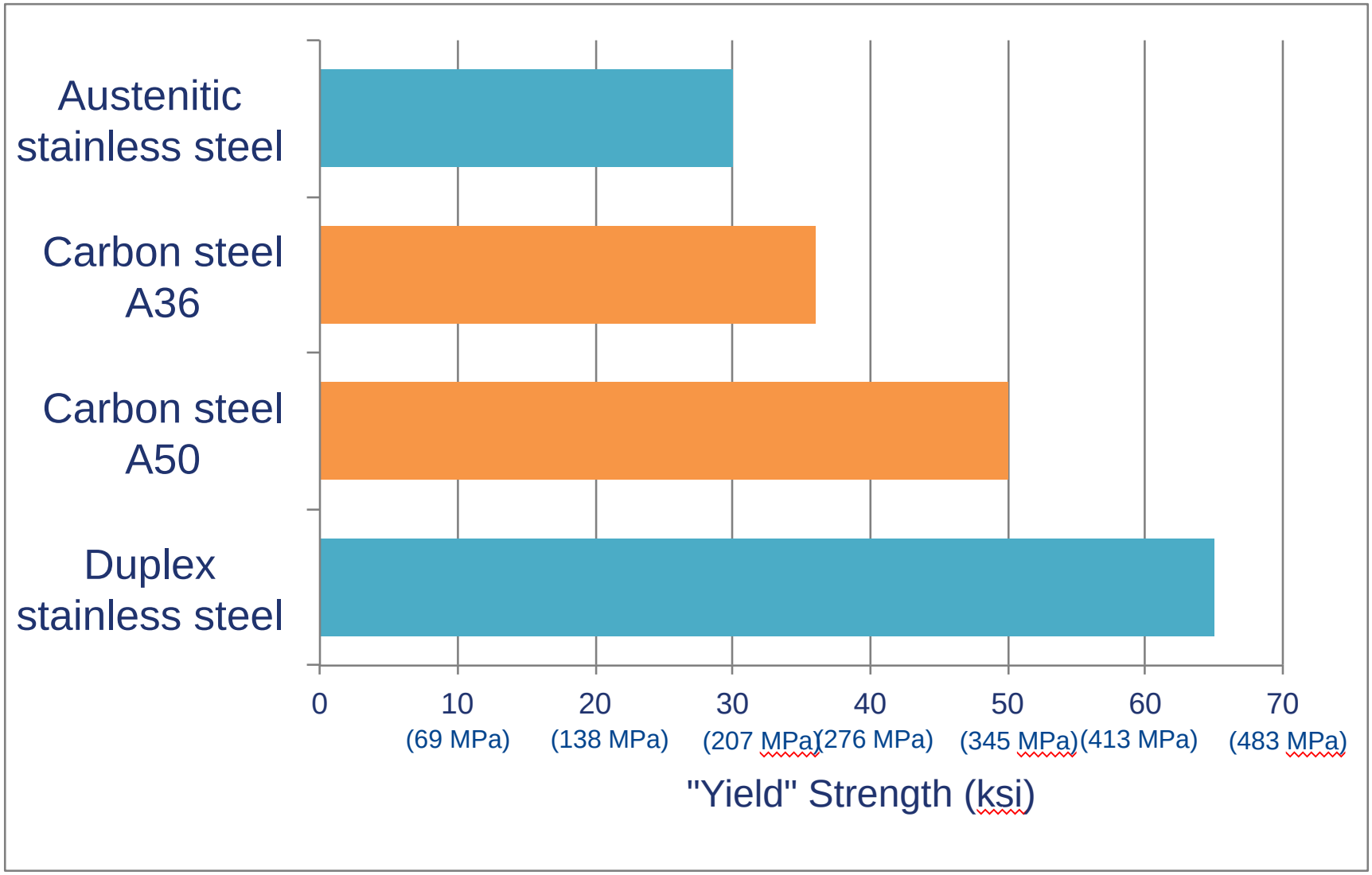
* Type 304/316 guidance was used. Lighter gage maybe possible.
** A G140 coating (0.001 inch) was assumed to have delayed carbon steel corrosion by 1 year based on zinc corrosion rates, this may not be accurate.
*** Zinc thickness for a double rolled standing seam per Rheinzink Applications in Architecture

Near Dubai Site
King Abdulaziz Center for World Culture

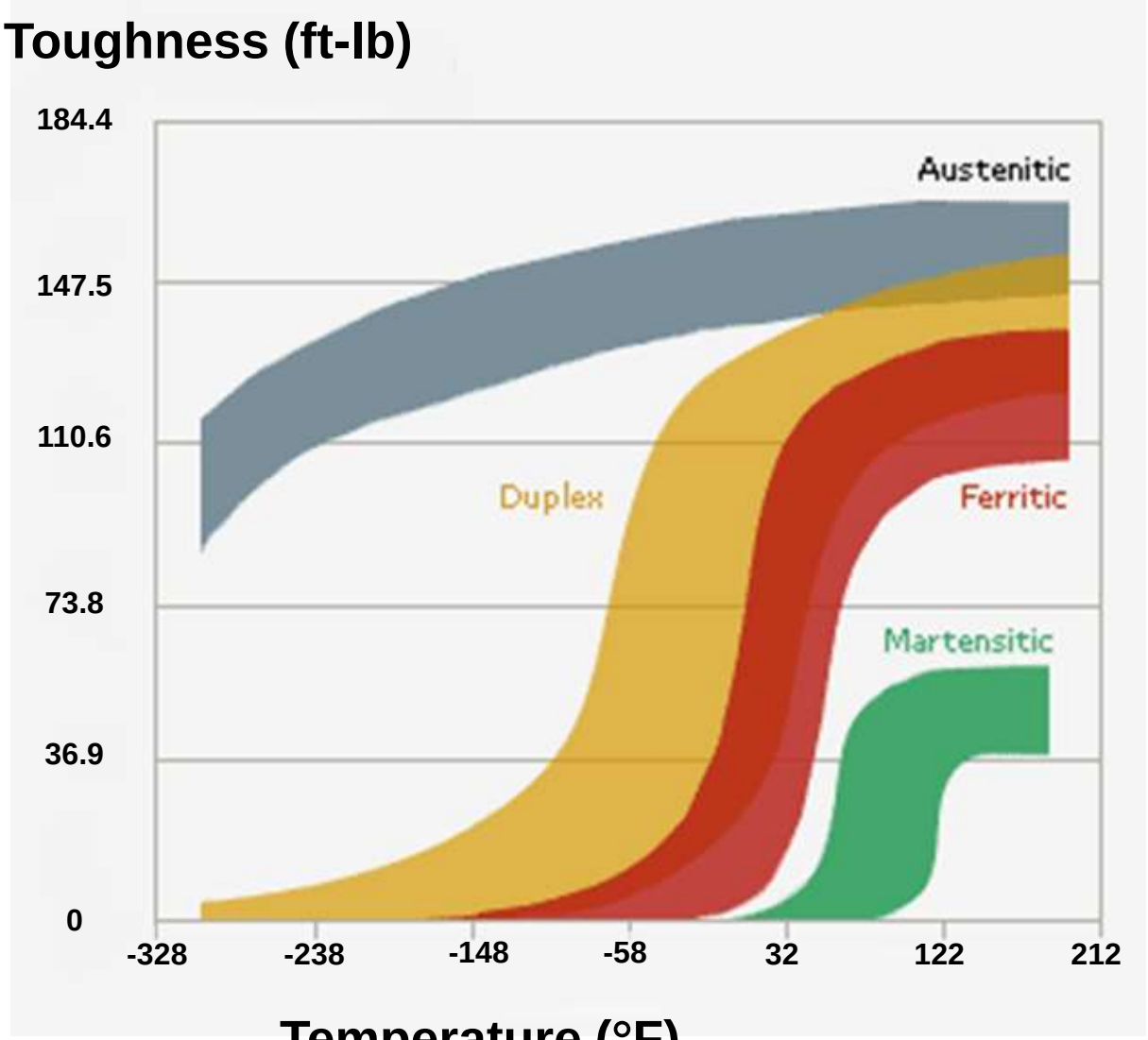
Duplex 2205 Stainless Steel Selected

- Corrosion testing documented severity of location
- Paint would have failed & not been repairable
- Less highly alloyed stainless steels would have had a corrosion problem
- High strength allowed lighter tube wall

Minimum Design Strength



Impact Toughness at Low & Ambient Temperatures



7 World Trade Center, New York

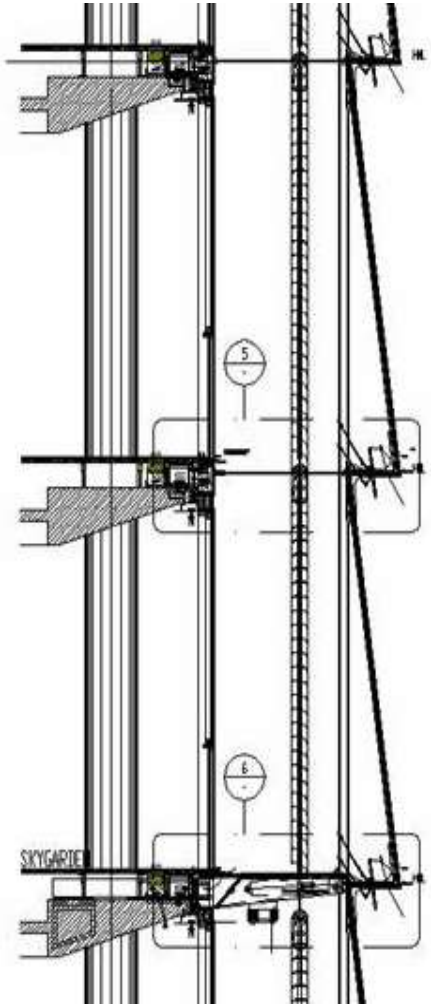
Security: 316 bollards & 2205 structural sections below the canopy

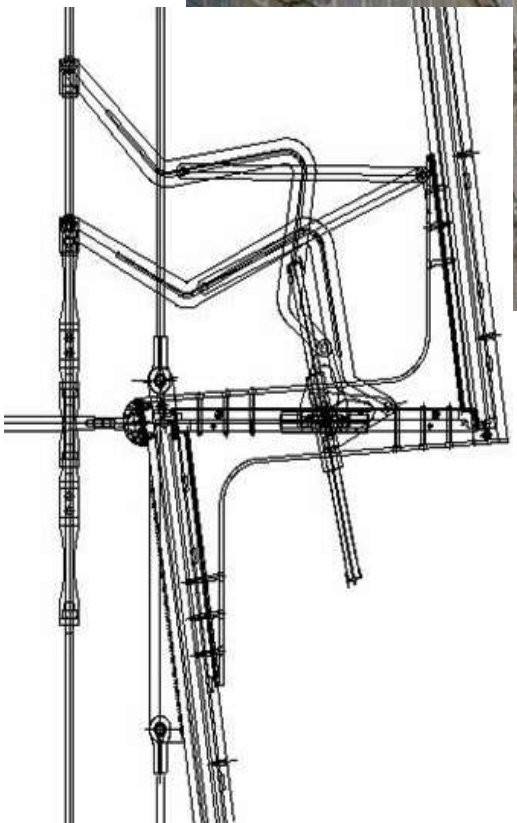
Doha, Qatar, Convention Center & Tower (2015), Jahn

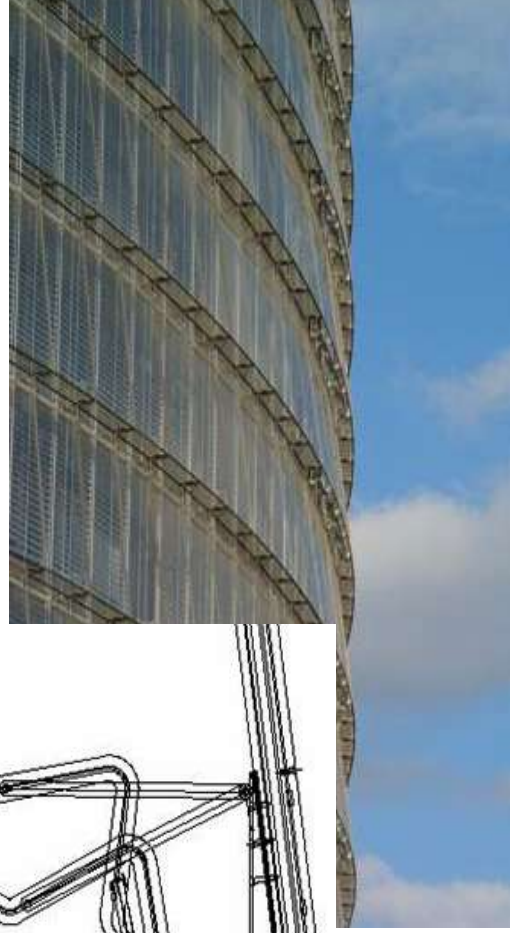
- 2205 stainless
- Convention center column covers, bollards
- Wall panels bottom 18 m of 550 m tall tower

Private Gates, Durban

Post Tower
Bonn, Germany
Helmut Jahn







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

New Poly Plaza Building, Beijing, SOM

One of the world's largest cable net walls
2205 spiders and tension rods,
Type 316 cable and connectors
50 year design life

Al Hamra Firdous Tower, Kuwait

- Skidmore Owings & Merrill, New York
- When completed in 2010, it will be
  - Kuwait's tallest building at 412 m (1351 ft, 74 floors)
  - Clad in Type 316

Jin Mao Tower, Shanghai, China

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

Kingdom Tower, Saudi Arabia – Adrian Smith

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

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

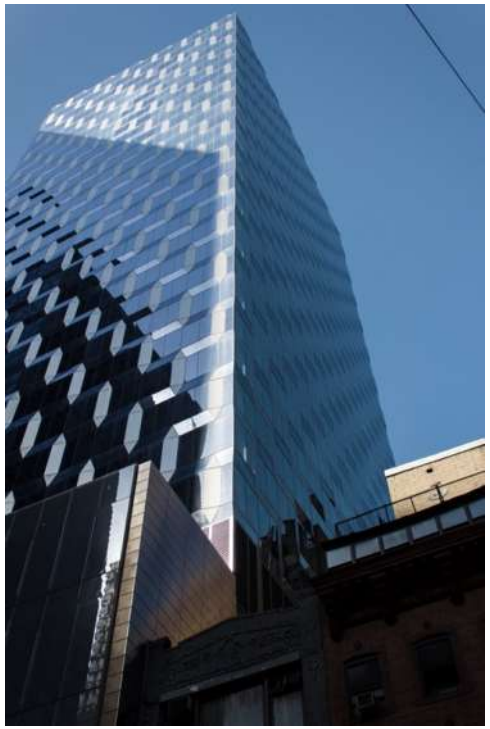
Trump Tower
Chicago
SOM
2009 completion
Type 316
1389 ft, 423 m

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

250 West 55th St, 316

West 57th St, 316

Javits Convention Ctr,
Renovation/Expansion 316



Gem Tower, 316

7 Bryant Park
316 façade

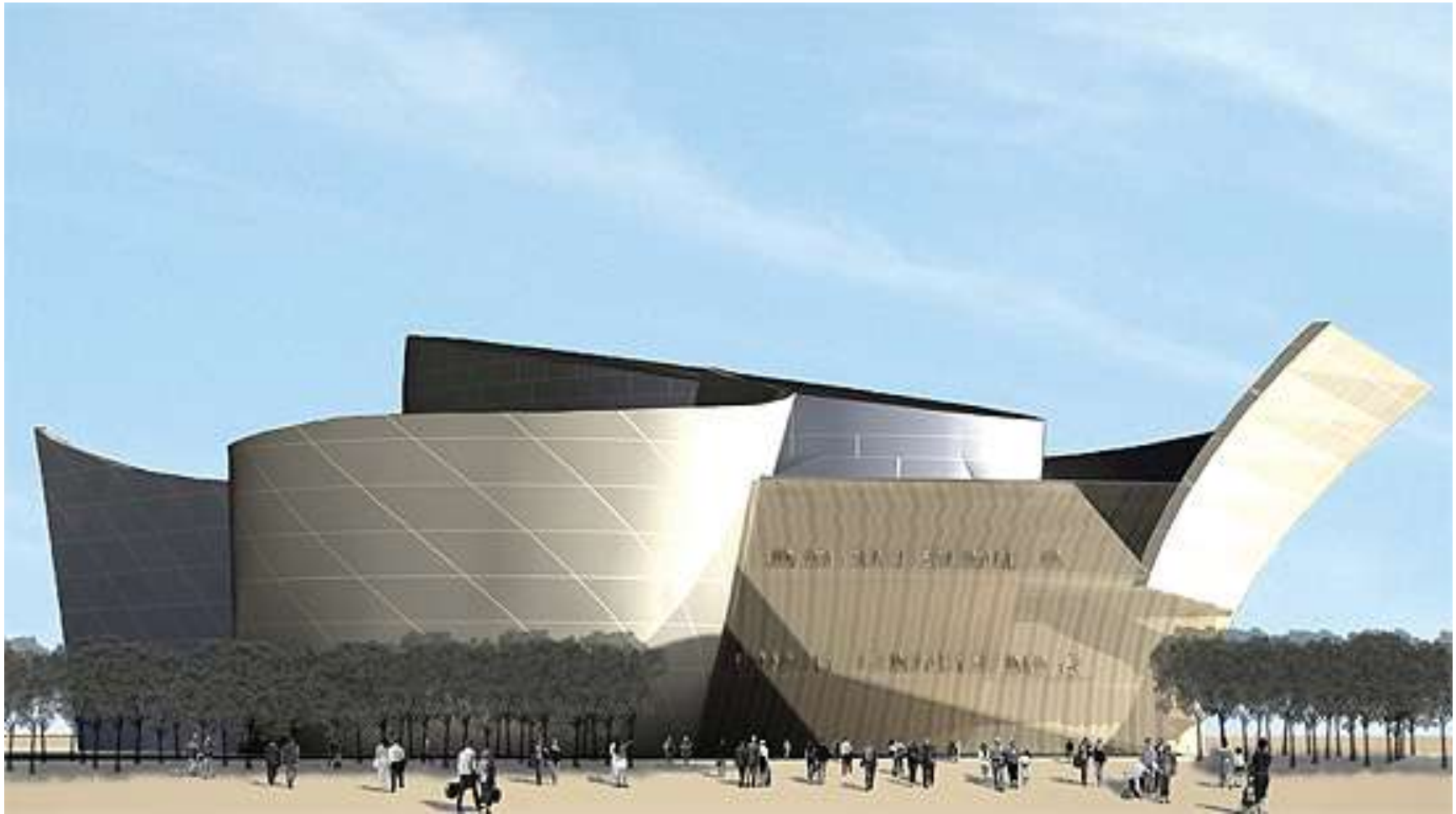
Walt Disney Concert Hall, Los Angeles

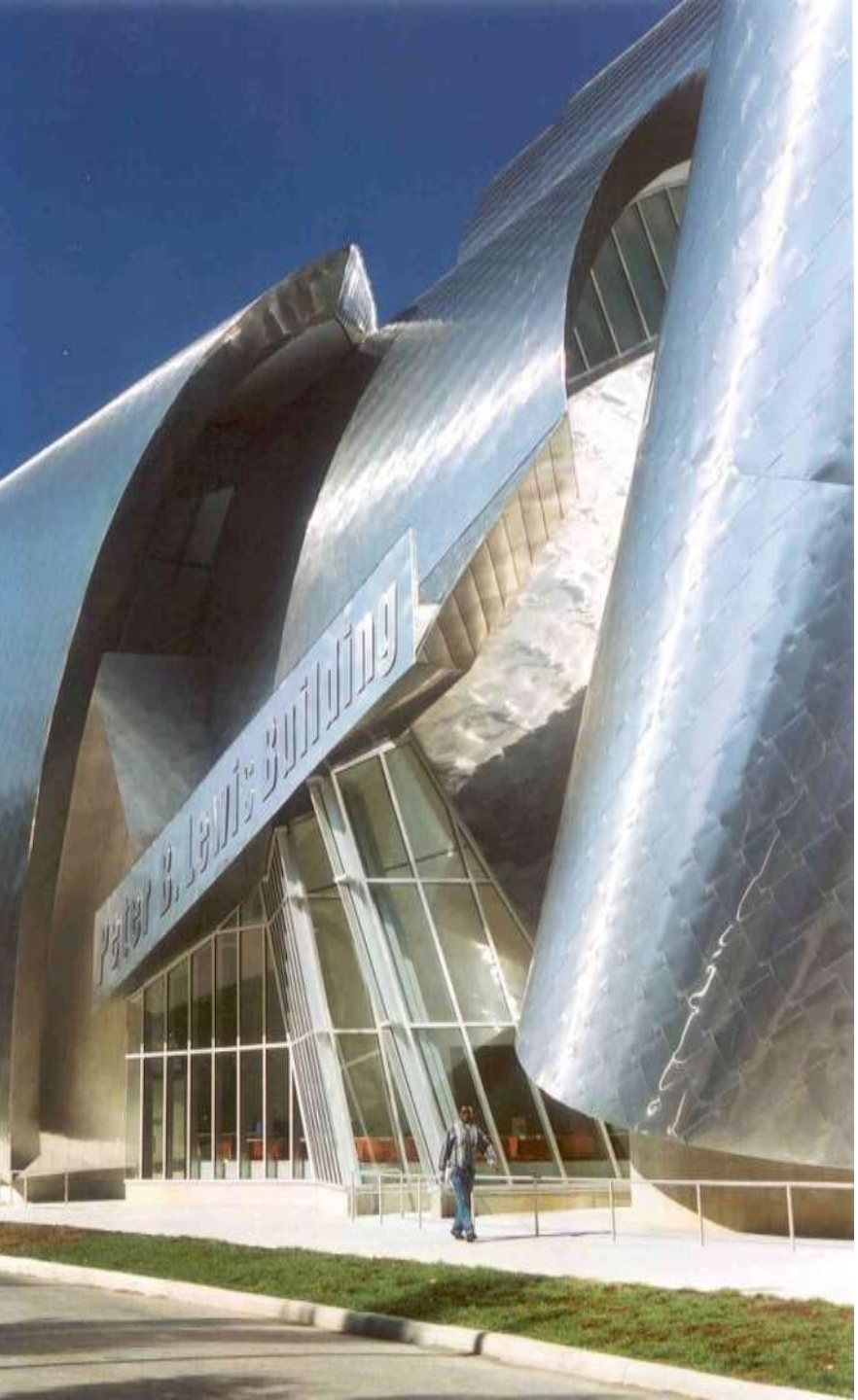
Gehry Partners

Type 316, vibration and mirror polished finishes

National Polish Symphony Concert Hall
Katowice, Poland (2008)

- Frederick Swartz Architects
- Glass and stainless steel exterior





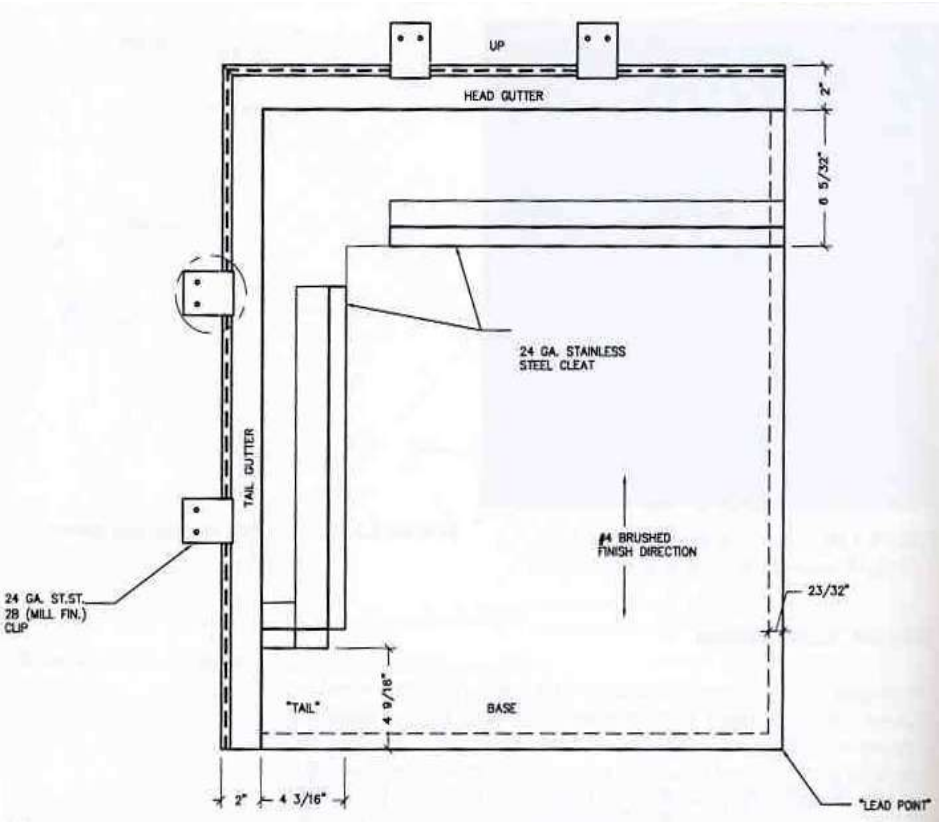
Peter B Lewis Building

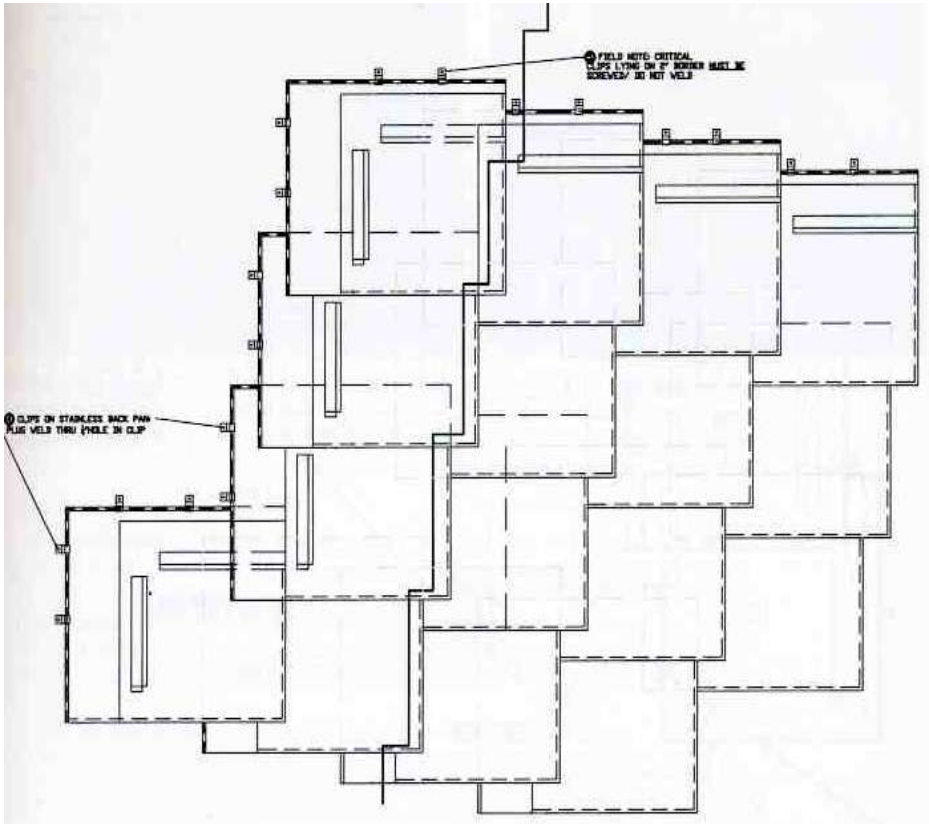
Case Western Reserve University, Cleveland, Type 316

Gehry Partners

Peter B Lewis Building Details

Overlapping, interlocking shingles in a predetermined design





University of Texas

Natural Science & Engineering Research Building

Zimmer Gunsul Frasca Architects

Type 304, electrochemically colored stainless shingles

Design for 50+ year life to sustainable design standards

Shenzhen China
OCT Creative Exhibition Center

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

Contemporary Jewish Museum

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

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

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

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

- Type 316, vibration finish on corrugated panels

Singapore Residence

Electrochemically colored stainless steel

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

The Helix Bridge, Singapore, 2010

Length: 280m

Design Life: 120 Years

Duplex 2205 650 tons, tube (plate & sheet) and bar

Surface: mirror polish

Type: 5 spans, double helix structure from tubes.

San Diego Harbor Dr. Bridge, 2012

- 2205 is primary structural material
- One of world's longest self-anchored, suspension bridges 168 m (550 ft)
- T. Y. Lin structural design

Conclusions

- Stainless steel is a sustainable material
- There are endless design possibilities
- It contributes to safety and security
- Evaluate each site carefully & use IMOA and Nickel Institute literature and software to help select an appropriate stainless steel and finish
- If technical questions arise, contact the ISSDA
- In more corrosive environments, have a metallurgical engineer with architecture experience evaluate the site and applications