Stainless Steel Architectural Design

Sponsors: Nickel Institute
        ISSDA

Speaker: Catherine Houska
Topics

- Sustainability
- Selection, design & maintenance
- Finish options
- Project Specification
- Interior & exterior applications
- Roofing
- Structural applications
Why is Sustainable Design Important?

• Buildings consume
  – 40% of the world’s energy
  – 32% of world’s materials
  – 12% of our water

• India Green Building Council estimates
  – Domestic market for green building materials & equipment will exceed $50 B by 2012
Stainless Steel Provides Proven Longevity

- Numerous projects 80+ years of service
  - Excellent performance
- Appropriate specification & maintenance
  - Potentially 100’s of years of service

Chrysler Building
1930
First large stainless roof

Gateway Arch, 1965
First large stainless structural application
### The Driving Force – World Green Building Council (WGBC) Countries

- Scoring systems for all types of building and construction projects
  - All building types, water treatment plants, infrastructure, industrial buildings
- LEED
  - Formally used in US, Canada, India
  - Dominant international scoring system
  - Internationalization of LEED
    - Input from 22 countries
    - Adaptable to local priorities
World Green Building Council Countries
92 countries with current/emerging scoring systems
International Corporate Commitment

% of firms dedicated to green building on at least 16% of projects, by region

<table>
<thead>
<tr>
<th>Region</th>
<th>2008</th>
<th>2013 - expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>67%</td>
<td>94%</td>
</tr>
<tr>
<td>Europe</td>
<td>75%</td>
<td>95%</td>
</tr>
<tr>
<td>North America</td>
<td>67%</td>
<td>96%</td>
</tr>
<tr>
<td>South America</td>
<td>40%</td>
<td>88%</td>
</tr>
<tr>
<td>Australia &amp; New Zealand</td>
<td>67%</td>
<td>95%</td>
</tr>
<tr>
<td>Asia</td>
<td>74%</td>
<td>91%</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>58%</td>
<td>85%</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>59%</td>
<td>93%</td>
</tr>
</tbody>
</table>
Sustainable Construction Characteristics

• Design for long service life
• Minimize material use, waste & impact
  – Avoid replacement during service life
  – High recycled content or renewable
  – No landfill waste or high recapture rate
• Preserve natural resources & building environment
  – Minimize energy and potable water use
  – Minimize toxic run-off and other environmental impacts
  – Capture and reuse gray water
• Healthy productive indoor environment
  – Low emission materials and natural light
Life Cycle Cost
Two Piers, Progreso, Mexico

Long service life = no material replacement
Cost effective and environmentally friendly
Minimum service life mandated in countries with
green building requirements

- Functional pier
  - About 70 years old (1937-1941)
  - Stainless rebar

- Non-functional pier
  - 30 years after construction
  - Carbon steel rebar

Photo courtesy of the Nickel Institute
### Average Rates (%)

<table>
<thead>
<tr>
<th></th>
<th>Recycled Content</th>
<th>Recapture Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon Steel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet/strip</td>
<td>25-35 **</td>
<td>70</td>
</tr>
<tr>
<td>Structural</td>
<td>≤95 **</td>
<td>97</td>
</tr>
<tr>
<td><strong>Stainless Steel</strong></td>
<td>60 - 90 **</td>
<td>92</td>
</tr>
<tr>
<td>Zinc</td>
<td>23 **</td>
<td>33</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical wire</td>
<td>0 *</td>
<td>&gt;90</td>
</tr>
<tr>
<td>Other products</td>
<td>70 – 95 *</td>
<td>&gt;90</td>
</tr>
<tr>
<td><strong>Aluminum</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet</td>
<td>0 *</td>
<td>70</td>
</tr>
<tr>
<td>Extrusions</td>
<td>Varies *</td>
<td>70</td>
</tr>
<tr>
<td>Castings</td>
<td>≤100 *</td>
<td>70</td>
</tr>
</tbody>
</table>

* ABC Industry  ** All Applications
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
Stainless Steel Can Be Easily Restored

150 East 42nd Street, New York City
Cleaned for the first time after 40 years of service
Jamaica Train Terminal, New York
100 year design life - with low maintenance
Type 316 - coastal, moderate urban pollution
Wayne L Morse US Federal Courthouse
Eugene Oregon, US Gold LEED 2006

Type 304, vibration finish
100 year design life
Reducing Energy Use & Heat Islands

- Material and finish choice affects performance
  - Exterior roof & wall panel materials
  - Sunscreens
- Solar Reflective Index (SRI)
  - Calculated based on ASTM E1980
  - Solar Reflectance & Emittance
  - Varies with finish
- Roof slope (1:6) & exterior walls ≥ 29
- Low slope roofs ≥ 79

Perforated sunscreens
San Francisco Federal Building
Woven sunscreens Planet M, Hanover
<table>
<thead>
<tr>
<th>Product</th>
<th>Temperature Rise, at °C (°F)</th>
<th>Solar Reflective Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel, bare</td>
<td>27 (48 F)</td>
<td>39-60</td>
</tr>
<tr>
<td>Galvanized steel, bare</td>
<td>30 (55 F)</td>
<td>46</td>
</tr>
<tr>
<td>Aluminum, bare</td>
<td>27 (48 F)</td>
<td>56</td>
</tr>
<tr>
<td>Any metal, white coating</td>
<td>9 (16 F)</td>
<td>107</td>
</tr>
<tr>
<td>Clay tile, red</td>
<td>32 (58 F)</td>
<td>36</td>
</tr>
<tr>
<td>Concrete tile, red</td>
<td>39 (71 F)</td>
<td>17</td>
</tr>
<tr>
<td>Concrete tile, white</td>
<td>12 (21 F)</td>
<td>90</td>
</tr>
<tr>
<td>Asphalt, generic white</td>
<td>36 (64 F)</td>
<td>26</td>
</tr>
<tr>
<td>Asphalt, generic black</td>
<td>46 (82 F)</td>
<td>1</td>
</tr>
<tr>
<td>Wood shingle, brown</td>
<td>37 (67 F)</td>
<td>22</td>
</tr>
<tr>
<td>Wood shingle, white</td>
<td>6 (10 F)</td>
<td>106</td>
</tr>
</tbody>
</table>

Sources: LBNL Cool Roofing Materials Database and finish producers
Pittsburgh Convention Center (2003)
World’s First Sustainable Convention Center

- Type 304
- Batten cap design
- High wind uplift resistance

- Heating/cooling by 33%
- High recycled content
- Locally produced
- 50+ year life requirement
Guangzhou China
2nd Children’s Activity Center

Type 316 woven mesh sun screens helped to eliminate air conditioning in public spaces.

Curving sunscreens made a simple concrete building very modern at reduced cost.
US Federal Building, San Francisco

• Type 316 perforated sunscreens
• Surpasses the U.S. government energy performance criteria by 50%
University - Cooper Union
New York

- Type 316 sunscreens contributed to 40% energy savings
- USGBC Platinum LEED rating
Italian Engineering Building Renovation

Perforated stainless sunscreens
Reduce air conditioning requirements and provide low maintenance long service life
Stockholm Congress Centre
2205 Sunscreens reduce energy requirements
Swedish Green building certification expected
 ThyssenKrupp AG Corporate Headquarters

- Type 316 sunscreens on multiple buildings
- Contributing to 20-30% energy savings
- Pre-certificate Gold German Certification for Sustainable Buildings
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
<table>
<thead>
<tr>
<th>Material</th>
<th>Copper</th>
<th>Lead</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rusty galvanized</td>
<td>20</td>
<td>302</td>
<td>12,200</td>
</tr>
<tr>
<td>Asphalt</td>
<td>11</td>
<td>10</td>
<td>1,980</td>
</tr>
<tr>
<td>Galvanized iron</td>
<td>ND</td>
<td>100</td>
<td>3,600</td>
</tr>
<tr>
<td>Concrete tile</td>
<td>ND</td>
<td>90</td>
<td>1,600</td>
</tr>
<tr>
<td>Type 304 Stainless*</td>
<td>0.3 - 0.4</td>
<td></td>
<td>0.25 - 0.3</td>
</tr>
</tbody>
</table>

*In many samples, nickel and chromium levels were below detectable limits. The average concentration per liter was well below typical drinking water levels.
Stadium Australia

Type 316, 2B finish

Drainage system collects water in underground tanks for watering grass and flushing toilets
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
Stainless Steel
Ideal For Sustainable Construction

- Indefinitely recyclable
- High scrap content
  - not down-cycled
  - highly valued and recaptured
- Can reduce building energy and environmental costs
- Can help to save water
- Extends building life
- Can be restored and reused
How Does A Stainless Steel Work?

Stainless steel is iron + at least 11% chromium

Rust

< 11% Chromium

Carbon Steel

Passive Film

> 11% Chromium

Stainless Steel
Major Alloying Elements

• Iron (Fe)
• Chromium (Cr)
  – Improves corrosion resistance
• Molybdenum (Mo)
  – Improves resistance to corrosion caused by salt (chlorides) and pollution
• Nickel (Ni)
  – Improves ductility, toughness, and weldability
• Nitrogen (N)
  – Improves strength and corrosion resistance
Families of Stainless Steels

• **Austenitic**
  – 300-series numbers (304, 316)
  – Strengthened by cold work
  – Nonmagnetic

• **Ferritic**
  – 400-series (430, 447)
  – Magnetic

• **Duplex**
  – Austenitic/ferritic (2205)
  – More corrosion resistant
  – Higher strength
  – Magnetic
What Factors Influence Corrosion?

• Pollution
  – Acid rain
  – Sulfur Dioxide & particulate
• Coastal and deicing salt exposure
• Weather conditions
• Maintenance
• Design/specification
  – Crevices
  – Finish
• Surface finish roughness & application method
• Handling & post fabrication cleaning
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
Select More Corrosion Resistant Stainless Steels

- Industrial pollution
  - High sulfur dioxides levels
  - High particulate levels
- Coastal or deicing salt
  - Salt water splashing or immersion
  - Sheltered unwashed applications
  - Significant deicing salt deposits

Type 316 railings
Hong Kong Convention Center
seawater spray exposure
rough surface finish
## Architectural Stainless Steels
*(Nominal Chemical Composition, Wt. Pct.)*

<table>
<thead>
<tr>
<th></th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>PREn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferritic 430</td>
<td>17</td>
<td>---</td>
<td>---</td>
<td>0.03</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>444</td>
<td>17.5</td>
<td>---</td>
<td>1.75</td>
<td>23</td>
</tr>
<tr>
<td>Austenitic 304</td>
<td>18</td>
<td>9</td>
<td>---</td>
<td>0.06</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>316</td>
<td>17</td>
<td>11</td>
<td>2</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>317LMN</td>
<td>17</td>
<td>13.5</td>
<td>4</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>6% Mo</td>
<td>19.5</td>
<td>17.5</td>
<td>6</td>
<td>0.18</td>
</tr>
<tr>
<td>Duplex 2304</td>
<td>21.5</td>
<td>3</td>
<td>0.5</td>
<td>0.05</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2205</td>
<td>22</td>
<td>5</td>
<td>3</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Super duplex</td>
<td>24</td>
<td>6</td>
<td>3</td>
<td>0.24</td>
</tr>
</tbody>
</table>

**PREn (Pitting Resistance Equivalent number)**

\[ \text{PREn} = \%\text{Cr} + 3.3(\%\text{Mo}) + 16(\%\text{N}) \]

Provides a comparison of relative corrosion resistance that is helpful for many but not all service environments.
## Rating Pollution Levels

<table>
<thead>
<tr>
<th>City</th>
<th>Pollution Level</th>
<th>Suspended Particulate $\mu g/m^3$</th>
<th>Sulfur Dioxide $\mu g/m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio de Janeiro</td>
<td>High</td>
<td>139</td>
<td>129</td>
</tr>
<tr>
<td>Beijing</td>
<td>High</td>
<td>377</td>
<td>90</td>
</tr>
<tr>
<td>Calcutta</td>
<td>High</td>
<td>375</td>
<td>49</td>
</tr>
<tr>
<td>Moscow</td>
<td>High</td>
<td>100</td>
<td>109</td>
</tr>
<tr>
<td>Tokyo</td>
<td>Moderate</td>
<td>49</td>
<td>18</td>
</tr>
<tr>
<td>New York</td>
<td>Moderate</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>Chicago</td>
<td>Moderate</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>Stockholm</td>
<td>Low</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Paris</td>
<td>Low</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

World Health Organization Data
Rain Acidity (pH)

Precipitation pH isolines
- < 5.6
- < 5.0
- < 4.5
- < 4.0
## Critical Temperature/Humidity Combinations for Salt (Chloride) Corrosion

<table>
<thead>
<tr>
<th>Temperature °C (°F)</th>
<th>Sodium Chloride</th>
<th>Calcium Chloride</th>
<th>Magnesium Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 (77)</td>
<td>76</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>10 (50)</td>
<td>76</td>
<td>41</td>
<td>50</td>
</tr>
<tr>
<td>0 (32)</td>
<td>---</td>
<td>45</td>
<td>50</td>
</tr>
</tbody>
</table>
Coastal Salt Exposure
US Coastal Salt Map

Sites not pictured:
AK01 0.1 kg/ha
AK03 0.2 kg/ha
PR20 95.9 kg/ha
VI01 32.0 kg/ha

Nickel Institute
knowledge for a brighter future
New Corrosion Map for India
Chloride Accumulation In Sheltered Locations

Chlorides oz/inch $^2$

- Roof
- 15 deg.
- 30 deg.
- 45 deg.
- 60 deg.

Eave Angle

0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35

Chlorides oz/inch $^2$

- Roof
- 15 deg.
- 30 deg.
- 45 deg.
- 60 deg.
Surface Finish
As Critical As Stainless Steel Selection

Increasing Corrosion Rate

Surface Roughness, \( R_a \) microns

\( R_a 0.5 \) microns or 20 micro-inches
## Typical Sheet Surface Roughness Range

<table>
<thead>
<tr>
<th>Finish</th>
<th>2D</th>
<th>2B</th>
<th>BA</th>
<th>No. 4</th>
<th>Hairline</th>
<th>No. 7</th>
<th>No. 8</th>
<th>Super No. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rₐ Micro-inch</td>
<td>5 - 39</td>
<td>2.4 - 20</td>
<td>0.5 - 4</td>
<td>7 - 25</td>
<td>5.5 - 8.0</td>
<td>2.4 - 8</td>
<td>0.8 - 4</td>
<td>0.4 - 0.8</td>
</tr>
<tr>
<td>Rₐ Micron</td>
<td>0.13 - 1.0</td>
<td>0.06 - 0.5</td>
<td>0.01 - 0.10</td>
<td>0.18 - 0.64</td>
<td>0.14 - 0.2</td>
<td>0.06 - 0.2</td>
<td>0.02 - 0.10</td>
<td>0.01 - 0.02</td>
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</tbody>
</table>
## Evaluation Scores

<table>
<thead>
<tr>
<th>Section</th>
<th>Cheung Kong</th>
<th>Railings</th>
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</thead>
<tbody>
<tr>
<td>Pollution</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Coastal salt</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Weather</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Design</td>
<td>-1 or -2</td>
<td>2</td>
</tr>
<tr>
<td>Maintenance</td>
<td>-2</td>
<td>-3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2 or 3</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

Available at www.imoa.info

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Cheung Kong Center, Type 316

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Hong Kong Convention Center railings, Type 316

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Photo courtesy of Nickel Institute

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Photo courtesy of Outokumpu
Galvanic Corrosion Requires...

- Dissimilar metals
- Electrical connection between metals (i.e., metal-to-metal contact)
- Moisture is present and connects the metals on a regular basis

Solution

- Prevent direct contact
  - Inert washers
  - Paint
  - Other non-conducting barriers

Surface area ratio is important!
Surface Area Ratio Affects Potential For Corrosion

Good ratio = no impact on corrosion
• Stainless steel fasteners in carbon steel

Bad ratio = rapid corrosion
• Galvanized fasteners in stainless steel
Sites for Crevice Corrosion

If the design will be exposed to salt (chlorides) and moisture, avoid crevices or seal them to prevent corrosion.
Prevent Carbon Steel Contamination

- Protective surface - removable UV rated film
- Store components off site until installation
- Clean tools and equipment
- Do not use
  - Carbon steel brushes, wool, shot
  - Media used on carbon steel or iron
- Do not grind carbon steel near stainless
- Require certification that surfaces are free of contamination

Photo courtesy of Nickel Institute
Sea Walls & Pier Concrete Corrosion

Sidney Opera House
Carbon steel reinforced concrete retaining wall corrosion
Replaced with Type 316 rebar
Stainless Steel Finishes
Obtaining a Uniform Appearance

- Use one coil or consecutive coils from one supplier
- Mark rolling direction and number panels
- Install all panels in the same rolling direction
- Install numbered panels consecutively
- Failing to follow these rules produces a checkerboard appearance
No. 4 Finish Design Example
Achieving Flatness

- Use adequate panel thickness

  Column Covers 2 – 2.8 mm
  Wall panels 0.5 – 3 mm
  Roofing, supported 0.5 – 0.6 mm
  Countertops 2 - 2.8 mm

- Avoid long or wide unsupported panels
<table>
<thead>
<tr>
<th>Metal</th>
<th>Thermal Expansion (^{\circ}\text{C} \times 10^{-6})</th>
<th>Thermal Conductivity ((\text{W/m-}\text{C}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 304/316</td>
<td>16.9</td>
<td>0.16</td>
</tr>
<tr>
<td>2205</td>
<td>13</td>
<td>0.23</td>
</tr>
<tr>
<td>Carbon steel</td>
<td>12</td>
<td>0.54</td>
</tr>
<tr>
<td>Alloy 400</td>
<td>13.9</td>
<td>0.26</td>
</tr>
<tr>
<td>Copper</td>
<td>16.9</td>
<td>3.86</td>
</tr>
<tr>
<td>AA 3003</td>
<td>23.2</td>
<td>2.04</td>
</tr>
</tbody>
</table>
Dull or Embossed Finishes Look Flatter Than Reflective Finishes

• Both samples are equally flat
# Flat Unlaminated Panels

<table>
<thead>
<tr>
<th>Reflectivity</th>
<th>Width-to-Thickness Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>150 max.</td>
</tr>
<tr>
<td>Medium-to-low</td>
<td>200 max.</td>
</tr>
<tr>
<td>Coined/Embossed</td>
<td>200 or higher</td>
</tr>
</tbody>
</table>
No. 2D Mill Finish

- Low reflectivity, semi-matte, uniform silver-gray
- 2D for roofing has final pass through dull rolls
- Not repairable
- Susceptible to fingerprinting
- Primary use - roofing
- Surface roughness
  - $R_a$ 5.0 to 39.0 micro-inches (0.13 to 1.0 microns)
  - Roofing gauges are usually under $R_a$ 20 micro-inches
Singapore Turf Club  Architect: Ewing Cole
No. 2B Mill Finish

- Smoother and more reflective than No. 2D
- Significant finish variation
  - Cloudy to mirror-like
- Susceptible to fingerprints
- Flashing, roofing, starting point for other finishes
- Surface roughness
  - 2.4 to 20 micro-inches (0.06 to 0.51 microns)
Bright Annealed (BA)

- Buffed BA
- Highly reflective, mirror-like
- No apparent polishing lines
- Ornamental trim finish
- Minor scratches removable by buffing
- Surface roughness
  - 0.5 to 4.0 micro-inches
  - (0.01 to 0.10 microns)
No. 4 Polish

- Directional, short parallel lines
- Repairable
- Conceals minor scratches
- Applied with abrasive belts (120 to 320 grit)
- Wet or dry polishing
- Significant variation in corrosion performance
- Surface Roughness
  - $Ra$ 0.18 to 0.64 microns
Hairline

- Directional, long fine parallel lines
- Applied with Scotch-Brite® (non-metallic abrasive pads)
- More reflective than No. 4
- Repairable – often used for refinishing
- Rolled-on version available
- Surface roughness
  - $R_a$ 0.14 to 0.20 microns
No. 8 Polish

- Mirror-like
- Very fine lines visible upon close examination
- Fine No. 4 polish followed by about 15 to 20 minutes buffing
- $R_a$ 0.02 - 0.10 microns
Super/Supreme No. 8, 9, 10, 11, 12

- Mirror finish, no visible grit lines
- Abrasive polishing plus up to 60 minutes buffing
- Not in ASTM A 480
- Surface roughness
  - $R_a$ 0.01 - 0.20 microns
Low Sulfur

• For standard finishes specify “low sulfur”
  – 0.005% or less
  – Improved corrosion performance
  – Finish appearance
• For mirror finishes
  – Specify 0.002% or less
• Low sulfur tube and pipe may not be available
  – Sulfur makes high speed welding easier
**Acid Etching**

- A protective coating is applied selectively to the surface using silk screening or other methods.
- Unprotected areas are etched to create the design.
- The acid is rinsed off and the coating is removed.
- Etched areas are a dull silver color.
Vibration Finish
(angel hair, suede, non-directional polish)

- Stainless wire brush or non-metallic abrasive pad
- Applied to a mirror polished or bright annealed finish
- Non-directional, fine, random scratch pattern
- Lines are smaller, finer than distressed finish
- Use control samples
Walt Disney Concert Hall, Los Angeles

Gehry Partners

Type 316, vibration and mirror polished finishes
Distressed Finish (pre-vandalized)

- Non-directional
- Applied over mirror or bright annealed finish
- Grinding wheel or coarse stainless wire brush
- Coarse scratch pattern
- Appearance may not be uniform
- Use control samples
Swirl Finishes

- Applied over 2B or 2D finish
- Grinding wheels or stainless wire brushes
- Swirl patterns
- Use control samples
Proprietary Mechanical Finishes

Pattern Polish Finishes
Courtesy Main Steel Polishing, Scott Pease Photographer
Engine-Turned Finishes

- Small circular lines, rings, or overlapping complete circles
- Circles range from 1/2- to 12-inch (13 - 305 mm) diameters
- Applied over a mirror finish
- CNC machines control spinning abrasive disks
Abrasive Blasted Finishes

- Non-directional and repairable
- Surface distortion if panels are too thin
- Texture and color vary with blast media
- Susceptible to fingerprinting
- Clean surface before and after blasting
- Always use clean blast media
## Effect of Abrasive Blast Media

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine sand</td>
<td>Dark, coarse</td>
</tr>
<tr>
<td>Glass beads</td>
<td>Light, smooth, grainy</td>
</tr>
<tr>
<td>Silicon carbide</td>
<td>Dark, coarse</td>
</tr>
<tr>
<td>Stainless shot</td>
<td>Small, curved indentations</td>
</tr>
<tr>
<td>Ground quartz</td>
<td>Shiny, coarse, angular indentations</td>
</tr>
</tbody>
</table>

Liner Museum
Appenzell, Switzerland
3 mm glass bead blasted
Embossing and Coining

• Applied by passing a stainless steel coil between two rolls

• Coining
  – One roll is patterned
  – One roll is smooth

• Embossing
  – Both rolls are patterned
Jin Mao Building, Shanghai

Skidmore, Owings & Merrill

421 m or 88 stories

220 tons Type 316

Vertical spine panels
1.5 mm, coined
Cambric, bright
annealed

Tubular features,
No. 4 polish
Embossing and Coining

• Increases rigidity and impact resistance
  – Light patterns 10 to 15%
  – Heavy patterns up to 35%

• Conceals scratches and reduces scratch depth
  – Increased surface hardness
  – Uneven surface breaks up visible line
Rolled-On Finishes
Can mimic abrasive blasted finishes
Electrochemical Colors

Obtained by thickening the passive film
Color can be uniform or deliberately varied
Often called “interference” or “living” color

Bronze    Blue    Gold    Red
Purple    Black    Green
Shakaden Temple, Japan
Completed 1975
Electrochemically colored
Black roof with gold dots and clips
Sputtering or Plasma Vapor Deposition

- Thin, adherent, abrasion resistant, uniform, non-fading
- Color determined by coating
  - Gold (titanium nitride)
  - Black (titanium carbide)
  - Brown or Blue (titanium aluminum nitride)
- Others: Rose Gold, Silver Gold, Brass
Perforated Stainless
Woven Stainless

• Broad range of styles and weights
• Hide scratches
• Impact resistant
• Adds tactile and visual texture
• Interior and exterior applications
  • Ceilings
  • Walls
  • Room dividers
  • Furniture
• Salt (chloride) crevice corrosion must be considered