Case Study 05 Hong Kong Building Exteriors and Railings

High Urban Pollution
High to Moderate Coastal Salt Exposure

Hong Kong's 63-story, Cheung Kong Center was completed in 1999. The exterior is glass and Type 316 (UNS S31600, EN 1.4401, SUS 316) stainless steel. Type 316 stainless steel contains 2% molybdenum, which improves resistance to corrosion caused by pollution and salt. **(Figures A and B)** The building is less than 1.6 km (1 mile) but more than 30 m (100 ft) from the harbor. It is exposed to sea salt in the air and rain but not salt spray. Both a coined HyClad Cambric and a fine No. 4 finish were used on the exterior. Rain and regular maintenance cleaning remove the corrosive contaminants and dirt from these smooth finishes. Cheung Kong Center was designed collaboratively by the architecture firms Cesar Pelli, Leo A. Daly, and Hsin-Yieh and has retained its original attractive appearance.

Figure A and B Cheung Kong Center is the high-rise building in the foreground of Figure A. The entrance and other details are visible in Figure B. Type 316 stainless steel with smooth surface finishes was an excellent choice because it is exposed to pollution and coastal salt. Window washing tracks were built into the building for easy cleaning. As shown in Figure A, it is in close proximity to the harbor.
(Photos Courtesy of Outokumpu)

The Hong Kong Convention Center addition was completed in 1997. It is on the man-made peninsula in the harbor shown in Figure A. The convention center is surrounded by a landscaped park with a Type 316 stainless steel railing along the perimeter. The railing is subjected to seawater spray and occasional splashing. In addition, the salt aerosol levels in the air are high. Type 316 will experience corrosion staining when exposed to sea spray unless a smooth finish is specified and it is washed frequently.

The very rough finish on the railing retains salt and corrosive pollution products, and these accelerate corrosion. **Figure C** shows the level of staining after three years without cleaning. The top rail is now cleaned daily and the lower sections are cleaned monthly to minimize corrosion staining. Specification of a more corrosion resistant stainless steel and a smooth finish would have minimized or eliminated the need for cleaning.

Figure C Seawater splashing or spray will corrode Type 316 stainless steel. The rough surface finish on these railings and infrequent washing made the problem worse.
(Photo Courtesy of the Nickel Institute)

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Stainless Steel Selection Criteria

The IMOA publication, *Which Stainless Steel Should Be Specified for Exterior Applications?*, provides stainless steel selection assistance. The site and design scores below are based on the guidelines in that brochure. Copies can be downloaded from www.imoa.info or ordered by emailing info@imoa.info.

Section 1: Environment	**Score = 3**

For this section of Hong Kong, the average annual level of sulfur dioxide is 22 µg/m^3, which is moderate. The suspended airborne particulate level, 97 µg/m^2, is the highest in Hong Kong, and its primary source is diesel vehicle exhaust, a power plant, marine salt aerosol, and dust. Due to the high particulate level and its source, both locations have a high urban pollution rating.

Section 2: Coastal Salt Exposure	**Cheung Kong Center Score = 3**	**Railing Score = 5**

Coastal salt (chlorides) can corrode architectural metals, including some stainless steels. The most corrosive coastal applications are exposed to salt-water spray, splashing, and/or immersion. Boat traffic, wind levels, and other factors can generate marine salt aerosols and spray. The railing is exposed to some sea spray and occasional splashing (+5). Cheung Kong Center is only exposed to sea salt in the air and rain (+3).

Section 3: Local Weather Pattern	**Score = 0**

Hong Kong has a subtropical climate with typical low and high temperatures of 16°C (60°F) and 29°C (84°F). Annual rainfall is about 2218 mm (87 inches). The corrosiveness of subtropical environments varies with the rain pattern. Higher temperature and humidity levels increase the potential for corrosion, but, in most cases, regular or seasonal heavy rainstorms lower corrosion potential by washing away corrosive pollution and salt deposits and produce a score of 0.

Section 4: Design Considerations	**Cheung Kong Center Score = -1 or -2**	**Railing Score = 2**

The railing's surface roughness is above R_a 1 µm (40 µin), which increases the score (+2). Rougher finishes retain corrosive substances longer allowing corrosion to occur and provide time for evaporative concentration of salt water. Cheung Kong Center has smooth finishes. The HyClad Cambric pattern was pressed onto base metal with a surface roughness of about R_a 0.1µm (4 µin). The base metal's surface roughness should be used in determining the score as long as the pattern is easily cleaned and is unlikely to retain contaminants (score = -2). The polished tubing's surface roughness was below R_a 0.5 µm (20 µin) (score = -1).

Section 5: Maintenance Schedule	**Cheung Kong Center Score = -2**	**Railing Score = -3**

The convention center railing was not cleaned during the first three years of service (Figure C), and remedial cleaning was required to restore the finish. The top rail is now cleaned daily and the rest is cleaned monthly. The sections that are cleaned monthly show light staining between cleanings. The stainless steel on Cheung Kong Center is cleaned when the windows are cleaned, which is typically four or more times per year. If the air borne particulate level continues to decrease, less frequent cleaning would be needed to maintain Cheung Kong Center's attractive appearance.

Stainless Steel Selection	**Total: Cheung Kong Center Score = 2 or 3**	**Railing Score = 7**

Type 316 with a smooth surface finish is usually the most economical choice for corrosive coastal locations if there is regular heavy rain washing and no exposure to saltwater spray, splashing or immersion. The high levels of corrosive air borne particulate make occasional cleaning necessary to maintain a pristine appearance. The Cheung Kong Center components with the very smooth HyClad Cambric finish could be washed less frequently and still remain attractive (score change from 2 to 3). Specification of a much smoother finish on the convention center railing could lower the score by as much as four points. To avoid cleaning the railings, a smooth surface finish and stainless steels such as 317LMN (UNS 31726, EN 1.4439, SUS317LN), 2205 (UNS S32205 or S31803, EN 1.4462, SUS 329J3L) and 904L (UNS N08904, EN 1.4539, SUS 890L) could be considered. For applications regularly splashed by or immersed in seawater, a super duplex, a super ferritic, or a 6% molybdenum superaustenitic stainless steel may be necessary. These stainless steels could also be used for long term installations with rough finishes that are subjected to some sea spray where no cleaning is likely and a pristine appearance is desired.

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