Do's and don'ts in selecting and specifying stainless steel surface finishes

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Summary

Patterned or plain, self-colour or with vivid colour, the range of stainless steel finishes available to the architect is probably greater than for any other material and should be carefully chosen.

The inherent corrosion resistance of stainless steels is generally recognised although often taken for granted, and, while a paint coating can be applied to the surface, it is most widely specified in its basic, uncoated, states. These range from mill rolled surfaces to highly decorative coloured and textured finishes and the ultimate selection could be important, in external building applications or internal hygiene areas, for example, where it will have a major influence on the appearance, corrosion resistance, ease of cleaning, and resistance to damage.

Architectural uses of stainless steel often demand the combination of longevity with aesthetics and in order to meet these expectations, an appreciation of the finish options and their appropriate specification, fabrication, handling, design, storage, and application, are important for optimum realisation and performance and will be discussed in this paper.

Two case studies will be illustrated to highlight finish options and variations, and aspects of design in practice.

Finishing Processes

The reference specification for process route and surface finish for stainless steel sheet, plate, and strip, is the European Standard EN 100088 Part 2. This standard uses a combination of letter and number for designation purposes which are given, as appropriate, in the following descriptions. It is not the intention here to describe each individual category, for example, there are several mill finishes which are appropriately described in manufacturers' data and Standards, but to provide a general overview of the finishes and their application.

1. Mill finishes
   These form the basic supply condition for all stainless steel flat products. They can be used in the supply condition but also form the basis for subsequent finishing operations. The 2D finish provides a suitable non-reflective surface that is widely used for roof sheeting.

2. Mechanically polished and brushed finishes
   This further operation involves the use of abrasive materials such as belts, brushes and/or polishing mops and compounds. A wide range of finishes are available and both finish, and abrasive medium, should be carefully selected and agreed with the contractor in applications where consistent quality is important.
   For external marine environments and architectural applications EN 10088 Part 2 stipulates a clean cut finish with a surface roughness of R_a 0.5 microns maximum.

3. Patterned finishes

Achieved by rolling or pressing, a variety of proprietary finishes are available with a surface roughness suitable for external architectural cladding, and for applications where clean ability and hygiene is important.

They are decorative and functional and particularly suitable for large flat areas, cladding for example, where visual optical distortions known as 'oil canning', are considerably reduced and undesirable. Care should be taken to ensure that in external applications the pattern runs from north to south to facilitate rainwater run off. Rainwater is beneficial to stainless steel for removal of airborne dust particles.

Rolled material will have a directionality that is not obvious when viewed at ground leveland, for the cladding of large areas on tall structures, care should be taken to ensure that panels are fabricated and installed using material with the same rolling direction orientation.

Under certain sunlight conditions, cladding panels which have been installed using the reverse rolling direction, can display a different shade to the other panels when viewed at an angle. The steel producer will mark the direction of rolling on the underside of the sheet if requested.

Panel on left side is deliberately fitted with the rolling direction reversed 180°

This will help to ensure consistency of appearance in ensuing operations.

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At ground level in areas of high public usage, for example, airport terminals, lift cages, and shopping malls, patterned finishes are popularly used as any damage effects tend to be less apparent.

4. Bead blasted finishes
Finishes with low reflectivity and no directionality are obtained by bead blasting and contrast well visually when adjacent to polished stainless steel. The texture of the surface varies with the bead material. Suitable materials include stainless steel particles, ceramic bead, shredded nut shell, aluminium oxide, and glass which may be bead or shredded. Sand, which may contain ferrous particles, and carbon steel, should not be used as blasting material as they may contaminate the stainless surface and lead to corrosion staining.

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5. Electro-polished surfaces
Generally used for sheet, plate, or intricate shaped components, this electro-chemical process improves the surface finish by removing the peaks of the irregular surface. In broad terms it will halve the degree of starting roughness, enhance reflectivity, and facilitate ease of cleaning. The process is used, for example, with teardrop patterned stainless steel floorplate to good effect.

6. Coloured finishes

(a) Electro-chemical colour
The inert chromium oxide layer on the surface of stainless steel can be coloured by chemical process. The time dependent process is particularly suitable for the austenitic stainless steels. During immersion in a hot acid bath and by applying an electric current, the surface film passes through a range of colour: bronze, gold, red, purple, blue and green, and consistency of colour is dependent upon the skill of the operator.
Stainless steel coloured by this process cannot be subsequently welded without destroying the colour, and repair of damaged surfaces is extremely difficult. The material can be formed and bent after colouring taking care that the surface is protected from damage during the process.
The final appearance is influenced by the substrate appearance, for example, a matt surface will result in a matt colour, and a highly polished substrate will result in a high gloss coloured appearance.

(b) Sputtered colour
Referred to as plasma vapour deposition, sputtered colouring is a dry process, which deposits a thin coating of ceramic on the stainless steel. Titanium carbide, titanium nitride, and silicon oxides are also used in the process. The ceramic coating is extremely hard wearing and tough, and will not show fingermarking. Welding destroys the colour and damaged coatings cannot be repaired. Can be used on patterned material for additional aesthetics and uses include escalator panels, elevator linings, and wall paintings.

(c) Nickel-clad stainless steel
Developed in Japan especially for roofing, nickel clad stainless steel is an attractive alternative to resin-coated material. Only 30 microns in thickness, the nickel oxide at the surface, grey-green in colour, is resistant to corrosion over a wide range of acidity and alkalinity. It is also protective to the stainless steel substrate and has the same formability.

7. Organic coloured coatings
Stainless steel can be coated with organic PVF2 or Acrylic materials using specialist pre-treatment and coating processes. This material was developed for roofing and cladding and is available in a range of colour. It has been particularly successful in Japan.

8. Specialist finishes
An infinite range of exciting and dynamic designs are produced by specialist finishing companies. Almost any graphic design can be given to stainless steel using processes that include photoresist, acid etch, colour, pattern, polish and grind. These processes can be used individually or in combination, and end applications include building entrances, lift cages. Care should be exercised in cleaning these highly decorative finishes to ensure that the surface is not scratched or damaged.

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Surface Roughness

The performance of stainless steel in terms of resistance to corrosion and clean ability has been shown by research to be dependent upon the smoothness of the surface. Smooth surfaces will retain less dirt and contaminants than rough surfaces, and this is recognised by EN10088 Part 2 in stipulating a maximum surface roughness value of R_a = 0.5 microns for marine and architectural applications.

Stainless steel surface finishes are achieved by the use of abrasives and compounds and it should be borne in mind that these effectively 'cut' the surface of the steel to varying degree.

Surface roughness is likely to vary from finisher to finisher, according to the equipment and pressure applied, and the abrasive medium used.

Typical roughness values for three commonly specified architectural surfaces are as shown in Table 1 from which it can be noted that the tolerance band within each grade is quite wide.

It is advisable, therefore, to agree with the producer, or specialist finisher, an acceptable level of R_a. In areas where a consistent finish is desirable, reference panels should be produced and held by each party, and an inspection procedure agreed.

Table 1. Typical Surface Roughness Values

EN10088 Part 2 Designation	R_a in microns
2B	0.1 – 0.5
2J	0.2 – 1.0
2K	0.5 max.

Working with stainless steel

A protective plastic film is usually added to stainless steel by the producer or specialist finisher, and this should be retained wherever possible during fabrication, transit, and erection, to protect the surface from damage. Some plastic films have an adhesive backing that will degrade when exposed to ultraviolet light, i.e. sunlight for extended periods. In the specific case of cladding on high rise structures, the film may not be stripped from the stainless steel for several months and could result in adhesive particles remaining on the steel. To prevent airborne contaminants from adhering to these particles and subsequent staining, it will be necessary to remove the particles by cleaning. Early discussions with the steel producer and film manufacturer should result in the correct specification of film and adhesive alleviating the need for a cleaning process.

Retaining the film on the stainless steel until building work has been completed will protect the surface from mortar splashes and other undesirable stain creating compounds during erection of the building. In the event of site operations such as grinding and cutting of structural carbon steels, it is vital to protect stainless steel from the carbon fallout created by the process.

Stainless steel is readily fabricated by normal processes such as roll form, press brake, guillotine, punch, drill, and weld. The choice of fabrication process will depend upon the chosen surface finish, the design, method of connection, and end

application. Importantly, equipment used to fabricate stainless steel should be clean and tools ideally should be dedicated stainless only to prevent particles of carbon steel contaminating the surface of the stainless steel. In exposed wet conditions the carbon steel particles will very quickly show as corrosion stains.

Welding processes particularly suitable for stainless steel include tungsten inert gas (TIG), plasma arc, metal inert gas (MIG), and resistance welding.
Stud welding using capacitor discharge is a popular method deployed for the attachment of cladding panels as it eliminates weld clean-up and there is no visible surface marking on the outer face. This technique can be used for sheet as thin as 0.9mm, although some ghosting may be apparent with this gauge of material.
Care should be exercised with all welded components to ensure that the surface finish can be restored to the original finish after welding. Junctions and joints should be detailed to accomplish the restoration without undue difficulty.
Stainless steel is compatible with other building materials. Other materials, however, can affect stainless steel. For example, mortar droppings should be cleaned off as soon as is possible to prevent staining and subsequent cleaning.
Abrasive and chloride bearing cleaning agents must not be used on stainless steel.
Stainless steel should be isolated from carbon steel products in areas where moisture will be present as stainless steel is more noble than carbon steel and corrosion and corrosion staining, could result. Non metallic isolating materials such as nylon or teflon should be used as a separating barrier. Preferably, stainless steel fixings should be used to join stainless steel and these should at least be the same grade as the stainless steel it is joining.
Uncovered stainless steel should be always be handled using clean gloves, as oily or greasy gloves can contaminate the steel surface.

Cleaning Stainless Steel

Maintenance and cleaning aspects should be considered at design stage as they can have a major effect on future ownership costs over the lifetime of the building. Stainless steel benefits from rain washing and opportunities for dirt to collect can beneficially be designed out at the design stage, sloping ledges, for example are preferable to flat ledges. Similarly, joints should be designed to avoid dirt accumulation, and use of a sealant between panels will prevent this occurrence and eliminate capillary action. The use of guide rails for window cleaning cradles should be considered on high rise buildings to prevent damage to the cladding during the cleaning operation.
The frequency of cleaning will be dependent upon location and aesthetic requirements. In general, washing with soap and water, detergent or 5%ammonia using a soft long-fibre brush, followed by a water rinse and drying with a squeegee is sufficient. On no account should a chloride containing solution be used. If chemical cleaning is considered necessary, the stainless steel manufacturer, or specialist cleaning contractor, should be consulted. Abrasive cleaning pads can also visually damage stainless steel finishes and must not be used. In heavily populated areas finger marking may require more frequent cleaning and use of a non-chloride bearing ‘smear free’ window cleaner and a soft cloth can be effective. Cleaning of stainless steel with a directional finish, satin for example, should always be in the direction of the ‘grain’.

Care must be taken in cleaning electro-chemically coloured stainless steel as repair of damaged surfaces is not possible. A soap and water solution, water rinse, and drying, is generally sufficient. Soft cleaning cloths or brushes must be used.
It is intended to give only an outline of basic cleaning of stainless steel in this paper as guidance is freely available from the producers, the Nickel Development Institute, and the British Stainless Steel Association. Some references are given in the bibliography.

Case Studies

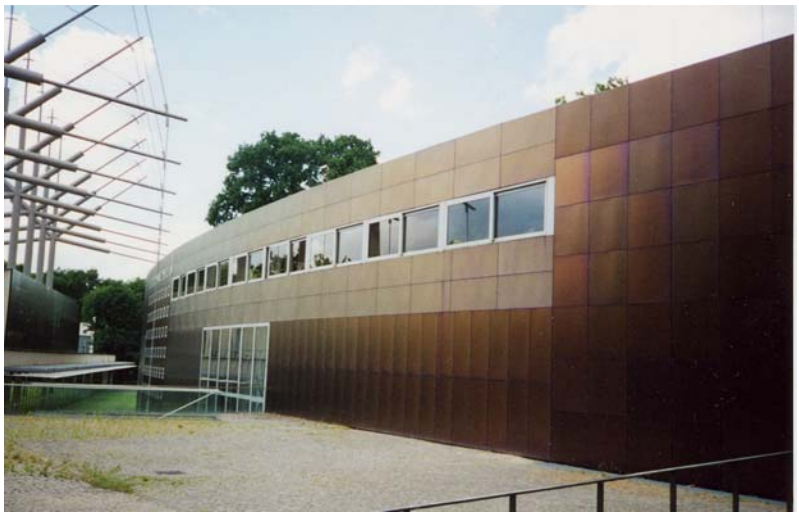
The following two case studies have been chosen to highlight aspects of design mentioned earlier in this paper, and, to illustrate the effective use of coloured stainless steel in providing a 'living exterior'.

1. Herne Bay Pavilion, Kent

The sports pavilion was built in 1976 at the end of the pier at Herne Bay, a part of the Kent coast that juts out into the North Sea. Clad with trapezoidally profiled stainless steel sheeting, the building was designed to be free from routine maintenance, and, after 26 years of exposure to the marine environment, no maintenance has so far been carried out.
The stainless steel used was type 316 with a 2B finish, which had a measured surface roughness of 0.35 microns. The cladding was attached using stainless steel rivets.
A visually attractive feature of the pavilion is the roof overhang, which effectively shields the upper part of the wall cladding from rainwater. It does not, however, shield it from sea-spray.

From the shore end of the pier, the pavilion is attractive and displays the familiar stainless steel sheen. At close range (2m) some staining can be seen, particularly on the upper cladding directly under the overhang, and on the walls facing the ocean. Almost certainly, the stains are the result of salt deposited from sea-spray that dry out on the steel. This staining is considered, however, to be superficial and could be removed by cleaning if desired.
Of benefit is the vertical direction of the trapezoidal cladding which allows most of the cladding to be beneficially washed by rainwater and the smooth finish of the stainless steel which minimises the adherence of unwanted airborne contaminants and facilitates rainwater washing.
Considering the non-maintenance aspect, the stainless steel is in very good condition.

2. Horst Korber Sports Centre, Berlin



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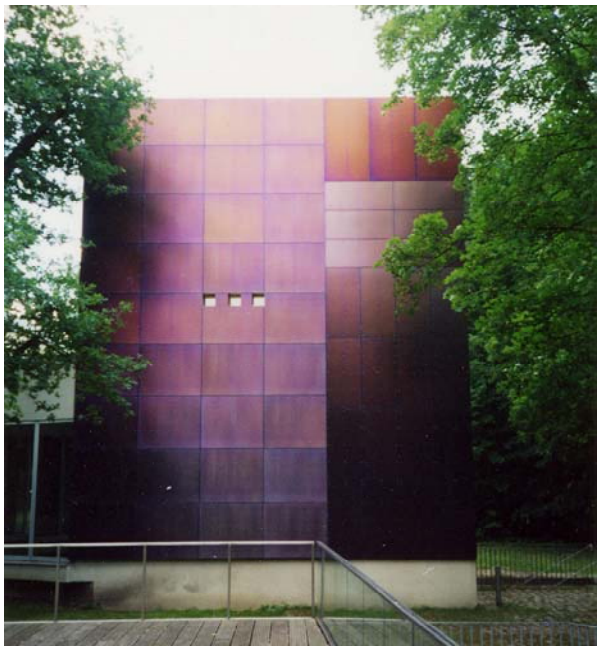
The sports centre was built in 1975 and is situated on the outskirts of Berlin close-by to the 1936 Olympic Stadium.
To give visual effect, two of the outer entrance walls were built using coloured stainless steel.
60 tonnes of 1.5mm thick, stainless steel grade 1.4401 (316) was used. This material was rolled to a proprietary 6WL pattern prior to colouring red using the Inco electro-chemical process. This involves the immersion of the stainless steel sheets in an acid solution and results in a build-up of the surface film. Since red is one of the earliest colours to be realised during the process, the thickness of the surface film is only marginally increased. The effect, however, is that a spectrum of colour will be seen depending upon the viewing angle, amount of sunlight, and cloud present. To further add variance to the visual effects, the pattern rolled and coloured sheets were given a light, heavy, and heavier, degree of grinding which removed the high spots of the patterned sheets to varying degree. The end result is self-coloured stainless steel with a basic red colour in the dimples of the pattern.



The sheeting panels were simply riveted to the sub-frame using stainless steel rivets and mastic applied to seal the panel joints. Since erected about 25 years ago the panels have only been rain washed. No visual staining of the panels was apparent when the building was viewed in 2000.

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Conclusions

Stainless steel has a dynamic, exciting, and wide range of finishes, suitable for both interior and exterior architectural applications. While it can be fabricated by normal processing equipment and tools, care should be taken to ensure that the surface finish is not contaminated by particles of other corrosive (ferrous) materials, which can quickly lead to a visual and unsightly staining in external atmospheres. With appropriate selection and handling stainless steel can provide a durable, aesthetic, and cost-effective solution for many building applications. Testimony to the versatility and durability of stainless steel can be seen by it's use in many of the world's tallest structures from the Canary Wharf Tower in London to the Kuala Lumpur twin towers. Installed at the top of the Chrysler Building in New York in 1930, it has been cleaned twice, in 1961 and 1995, and still remains in excellent condition.

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