Stainless Steel - *the modern material with a 60 year track record.*

The term "stainless steel" is used to describe over one hundred different stainless steels, with each one tailor-made to give outstanding performance in specific applications. The key to successful use is understanding the application and then specifying the correct type from the six generally associated with Architectural and Building products.

Grade Typical Chemical Composition

Grade	Typical Chemical Composition			
430	17% Cr		0.07% C	
304L	18% Cr	10.0% Ni	0.03% C	
304	18% Cr	10.0% Ni	0.06% C	
316L	17% Cr	12.0% Ni	0.03% C	2.5% Mo
316	17% Cr	12.0% Ni	0.06% C	2.5% Mo
2205	22% Cr	5.5% Ni	0.03% C	3.0% Mo

Why do stainless steels resist corrosion?

All metals react with oxygen in the air to form a film of oxide on the surface. The oxide formed on ordinary steel allows the oxidation to continue producing the typical rusty appearance. However,- because stainless steels contain more than 11 % chromium, the characteristics of the oxide are changed. Further oxidation is prevented and if the film is accidentally removed, a new one forms to continue the protection.

In practice, stainless steel contain at least 18% chromium. The most frequently used grades also contain at least 8% nickel.

Typical Uses

Type 430 stainless steel performs reasonably well indoors, but steels containing nickel are required for satisfactory service outdoors. Type 304 is widely used for curtain walling, side walling, roofing etc. but Type 316 stainless steel is preferable for coastal regions and locations where atmospheric pollution is a problem. Guidance on selection can be obtained from the companion brochure "Advantages for Architects".

The European specification Eurocode 3 Part 1.4, will include Grades 304L, 316L and 2205 for structural applications.

Product forms

Stainless steel is produced in virtually all standard metal forms and sizes, plus many special shapes and castings. The most commonly used products are made from thin sheet and strip.

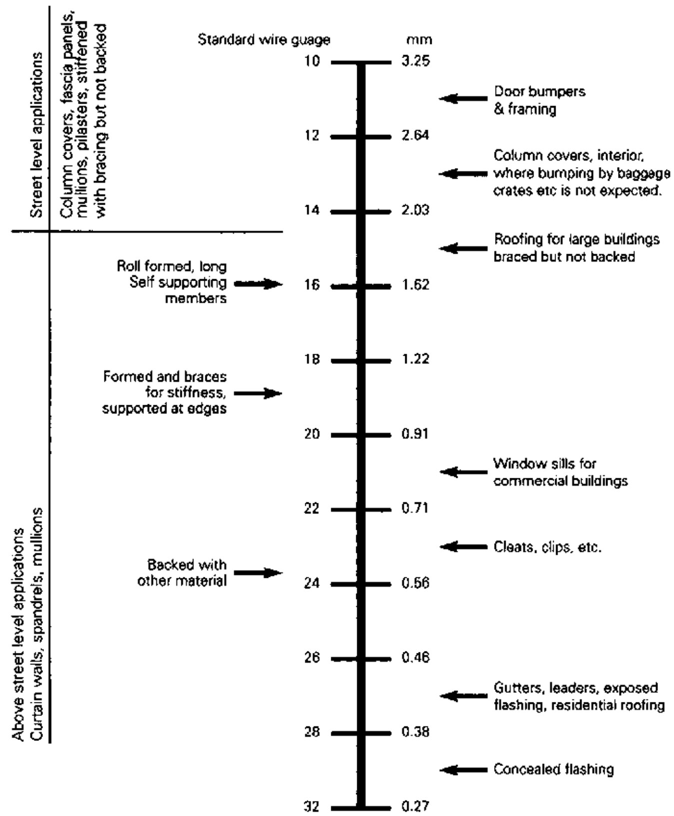
Surface appearance

A wide range of commercial surface finishes is available. The surface can be highly reflective or matt; smooth, brushed or embossed; painted, coloured or even coated with terne alloy to produce an appearance similar to lead.

Fabrication

Techniques used for welding, forming and cutting ordinary carbon steel can be used for stainless steel, but adjustments in equipment settings and recognition of the higher strength of stainless steel will be required. When these differences are accommodated, stainless steel can be readily fabricated.

Thickness of Stainless Steel used in Architectural applications



Design

For over 60 years, architects have used stainless steel to produce permanent expressions of their design concepts. Some, such as the Chrysler Building in New York City, are highly visible, but there are many other external and interior applications where stainless steel plays a less dramatic but vital role in the aesthetics and performance of a building. Stainless steel's role as a long life, high integrity structural material is recognised by design codes such as the American Society of Civil Engineers standard ANSI/ASCE - 8 - 90 "Specification for the Design of Cold Formed Stainless Steel Structural Members" and the "Design Manual for Structural Stainless Steel" published by the Nickel Development Institute in conjunction with Euro Inox.

Future

Stainless steel already has many ideal characteristics required for an architectural material - but its development continues.

Existing types have been improved to give even better performance and new steels are being marketed to meet the demands of advanced architectural applications.

Building Exteriors

Introduction

Throughout the world, architecture is recognised as one of the greatest arts of any civilisation and, like all art forms, it responds to cultural and technological changes within society. For instance, the development of iron and steel production during the 19th century was a major factor influencing modern architecture. The 20th century invention of stainless steel further extends the influence into a wider range of architectural, building and constructional applications.

At first, stainless steel was mainly used for prestigious applications, with a prime example being the Chrysler Building in New York City. Constructed in 1929, the stainless steel cladding and artefacts designed by William Van Alen are permanent features of the City's skyline. Since then, however, the continuous invention of new ways to make stainless steel has both dramatically reduced its cost, in real terms, and expanded the range of products available. Consequently, stainless steel's combination of proven performance and cost effectiveness is now being exploited, in mundane as well as prestigious applications (1).

The partnership between architecture and stainless steel continues to flourish.

Curtain Walling

The development of cast iron and rolled steel sections in the 1800's gave architects the opportunity to develop curtain walling for use in buildings such as The Crystal Palace in London (1851), The Leiter Building in Chicago (1897) and The Maison du Peuple in Brussels (1896) (2).

The concept was readily adopted by the modernist architectural movement, although the twentieth century invention of stainless steel added another design dimension, as indicated by this extract from a paper published by the School of Architecture at Princeton University (3).

> "The art and science of building is greatly affected by the development of materials. When understood and applied, the inherent qualities of stainless steel can lead to distinguished expressions in architecture. Stainless steel combines two fundamental and highly desirable qualities that make it an excellent building material. These are strength and durability. So outstanding are its combination of strength and durability that, alone among building materials, stainless steel can be used for permanent and complete exterior wall surfaces in thicknesses measured in a few hundreds of an inch.
>
> We know of no other material with which this is possible."

It appears that the earliest use of stainless steel curtain walling was in 1948, on a four-storey office building attached to the front of the General Electric Turbine Manufacturing Plant in Schenectady, New York. This was planned to be a three storey masonry building, but after site work had started the need for extra space was realized. By changing to stainless steel curtain walls, the dead load of the exterior walling was sufficiently reduced to allow the addition of another storey without changing the original framing or foundations. Stone and Webster adapted standard Robertson Q-panels, 3.25" thick and 24" wide, using an external face of S 30400 stainless steel , 0.038" thick, with a 2B surface finish (3). Later, in 1966, the building was extended using the same system, Fig1.

Several other low-rise buildings were built in the late 40's, but Harrison and Abramovitz William York Cocken's 525 William Penn Place, Pittsburgh, was the first multi-storey building to

H H Lawson

Fig. 1 The General Electric Plant Offices, Schenectady. (The photograph was taken in 1993, forty five years after the curtain walling was erected.)

use stainless steel windows and spandrels, in combination with vertical wall elements made from limestone.

The 1950's saw many other examples of stainless steel curtain walling introduced in North America and elsewhere in the world. For instance, Prof. Dr-Ing. Hentrich's Thyssenhaus in Dusseldorf, Fig 2, was one of the first high-rise buildings in Europe to use stainless steel. Now classified as one of Germany's architecturally important buildings, it bridges the bustle of the city on one side with the tranquillity of the lakes and park on its northern perimeter. The walling is trapezoidally profiled 1.0 mm thick S 31600 stainless steel, with a number 4 finish. Other buildings followed rapidly in Europe and the Orient, Fig 3.

P G Stone

Fig. 2 The Thyssenhaus, Dusseldorf.

Courtesy of Nisshin steel Co.

Fig. 3 Printemps Store, Osaka.

Courtesy of Avesta Sheffield

Fig. 4 Canary Wharf Tower, London.

Over this period there has been a trend towards minimising the amount of work done on site. In the early days, curtain walling was usually assembled on site and this may still be the cheapest design solution for small contracts. However, when the size of the project justifies the initial investment in manufacturing facilities, factory assembly provides the lowest installed cost. This may mean walling arriving on site as pre-fabricated sections, as used in Pei, Page and Steele's Commerce Court Building, Toronto (4), or fully completed curtain walling modules being fixed as one unit to the building framework, as at Cesar Pelli's Canary Wharf Tower, London (5), Fig 4. In all cases, the design must include adjustable fixing devices to prevent structural tolerances being transferred to the walling.

Like the World Trade Centre Building in New York (2),and the C I L House in Toronto (6), the Canary Wharf Tower curtain walling has been designed as a rain screen, not as a continuous watertight envelope. The panel joints are not sealed and a slight gap is left between adjacent panels. This system uses the principle that the gap allows equalisation of air pressure to occur during a storm. The ingress of rain is therefore prevented, although provision is made for any that might enter to freely drain away.

Courtesy of Avesta Sheffield

Fig. 5 Lloyds Building.

Hi-Tech. Buildings

The hi-tech architectural style of the Lloyds' Building in London, Fig 5, encompasses Prof. Patrick O'Sullivan's philosophy on the relative periods of obsolescence associated with the elements that make up a city. Richard Rogers and Partners designed the main usable areas to be separate from those parts that make the Lloyds' building function, but become obsolete more quickly. The objective was

> "to separate out completely the served and the servant areas. To take all the toilets, the services and structure out of the main rectangle of usable space" (7).

This was achieved by locating the servant elements in six satellite towers placed around the building's perimeter. Not only did this generate 350,00 square feet of uninterrupted floor space, but it allowed the conventional central service core to be replaced with a light, airy atrium. All the towers and external services are clad in stainless steel. The wall cladding is 1.6 mm thick S 31600 stainless steel having a HyClad Linen embossed surface to give a soft, diffused reflective sheen. The wall system consisted of 900 mm panels and snap-on rolled weather strips. Wherever possible, the high value content of the building was manufactured under factory conditions. For instance, the toilet modules were made and fitted out using production line techniques in order to optimise quality and costs as well as to minimise the amount of site work and site storage space required. The modules were merely hoisted into position, fastened to the structure and connected to the services.

The increasing communication requirements of companies and consumers introduces yet a different high technology. Whether at ground level as in the computer centre in Italy, fig 6 or over 1000 feet up in the air in a communication tower, Fig7, stainless steel has been chosen for curtain walling, cladding, safety barriers, screens and high integrity structural components, (6, 8).

Courtesy of Centro Inox

Fig. 6 Cassa di Risparmio di Biella, Italy.

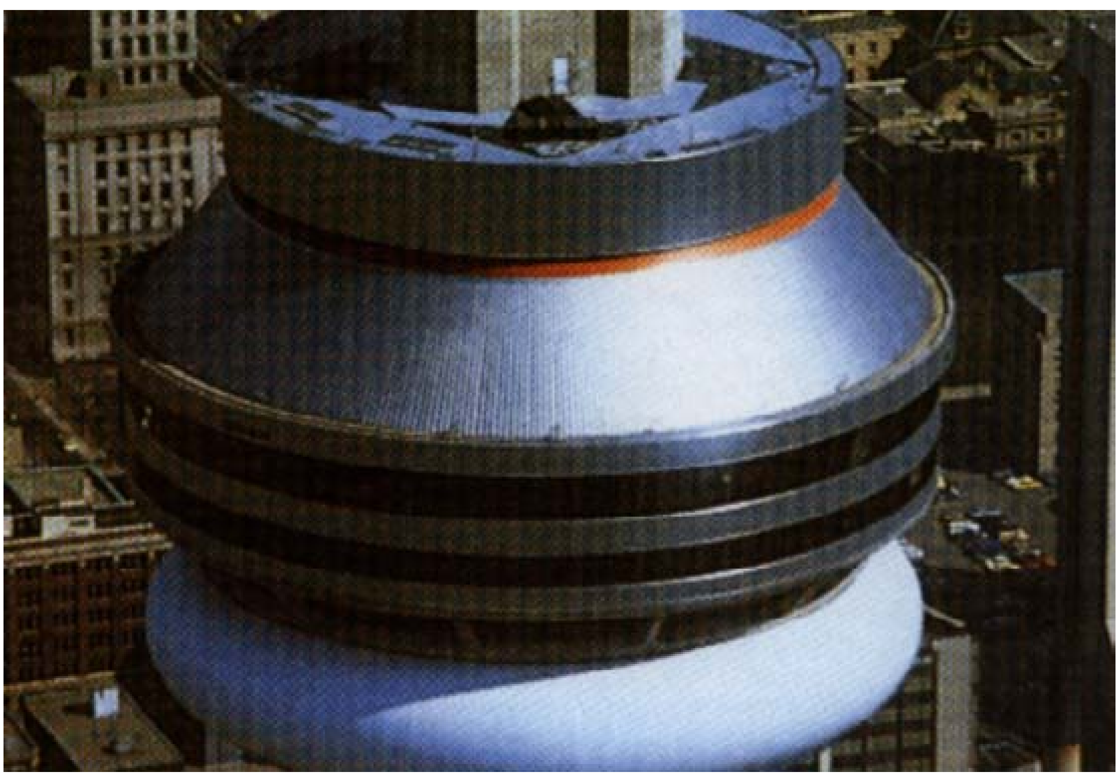


Fig. 7 CN Tower, Toronto, Canada.

Courtesy of Avesta Sheffield

Fig. 8 Bus Workshop, Doncaster.

Industrial Buildings.

It should not be forgotten that stainless steel has an important role to play in somewhat more mundane buildings.

Cost is obviously an important consideration but owners are becoming increasingly aware that they should be concerned with the total cost of ownership, rather than just the initial cost of the building. Consequently, stainless steel components have found success in markets where ownership cost, or more correctly "life cycle" cost is important. This introduces factors such as maintenance cost, replacement cost and disruption cost into the cost analysis (9).

The use of stainless steel cladding on offshore oil and gas platforms is an extreme example (10) but the logic applies equally well to onshore industrial buildings.

The approach is not new. For instance, the decision taken over 20 years ago to use S 30400 stainless steel walling on a railway workshop in Cleveland, Ohio (6), or to use S 31600 pressed panels on an electricity substation at the centre of the heavily used Elephant and Castle road junction in London (11) must have applied the concept either formally or intuitively.

More recently, Barry Stancer's decision to use stainless steel for cladding a municipal bus workshop in England was based on life cycle costing, Fig 8. He selected an embossed S 31600 stainless steel, HyClad Mosaic, in order to reduce the visual effect of any accidental scratching, and used conventional industrial cladding fixing techniques.

Fascias

The design objective of a fascia may vary from delineating the building's wall, to providing a functional transition between the wall and the roof, or merely to serve as an independent decorative element. Whatever the objective, it is vital that its appearance is maintained over a long period of time, usually the full design life of the building. It is also usual for fascias to be located in regions that are difficult to reach and so it is important that maintenance is not required. This means the material chosen for the fascia should not produce corrosion products that would need to be cleaned from its surrounding areas.

Stainless steel satisfies all these requirements, as well as possessing the ability to be formed and fabricated into the variety of shapes required by fascia designers.

One aspect associated with fascia design is the need to avoid producing "waviness" in the relatively long length of a typical fascia. The first point to consider is the type of surface finish to be specified. Obviously, the use of a highly reflective finish will visually accentuate amounts of waviness that would be tolerated on a dull surface. Consequently, it is preferable to avoid bright annealed or highly polished stainless steel and use less reflective material, such as a No. 4 finish or an embossed surface. It is also important to specify tension-levelled, stretcher-straightened or other similar architecturally flat material as well as using a competent fabricator who will maintain the flatness when fabricating the component and during transportation to the site. Similarly, it is important to employ competent erectors and to include three dimensional adjustment facilities in the design so that any irregularities in the wall can be accommodated.

If a reflective surface is specifically required then the use of stiffening members behind the fascia or laminating the stainless steel to a rigid material such as plywood should be considered. The use of ribbed sheet or strip may also be an alternative way to reduce waviness by increasing the rigidity.

Shop Fronts and Doors

Stainless steel shop fronts and doors have long been a popular choice with shopkeepers who want to establish a presence in the neighbourhood. Their inviting, pleasant, clean appearance is an obvious advantage, but there are many other practical reasons why stainless steel is a good choice for these applications.

For example, because stainless steel is one of the hardest architectural metals available its surface is better able to withstand wear from passing traffic. Combine this with good resistance to discolouring or weathering and you can see why it has established a reputation for retaining its good looks.

Obviously, stainless steel is not immune to soiling, but a simple wash is generally all that is required to restore its appearance.

The strength of stainless steel also allows slender and delicate frame members to be used, enabling the designer to achieve an entrance in which light and spaciousness predominate. But shopkeepers need to combine visual attractiveness and ease of entrance for customers and staff with security against unwanted intruders. Consequently, the high strength to weight ratio of stainless steel has been exploited by designers to produce entrance systems that are both light and easy to handle, as well as having the strength and rigidity required for security.

The same high level of rigidity also means that a well designed stainless steel door resists sagging or loss of alignment due to constant usage. Its fit in the door-frame is therefore retained, keeping out noise, dust, heat or cold.

In view of this it is not surprising that shop fronts and doors were some of the earliest applications for stainless steel and an impressive track record of success has been achieved. It has been used on all types of entrance systems including swinging doors, sliding doors and revolving doors, including those specially designed to accommodate supermarket shoppers and their trolleys.

Courtesy of Summit Steel (Pty).

Fig. 9 Norwich Union Building, South Africa.

Column Covers

Columns of all shapes and sizes can be covered with stainless steel to transform them into features that combine attractive appearance with resistance to wear, durability and low maintenance costs, Fig 9.

The most economical designs combine standard or easily formed shapes with light gauges. However, in locations where heavy traffic, abuse or impact damage is likely to occur, some method of stiffening may be required - simply specifying a thicker gauge is not cost effective. Using panels with deep formed patterns such as fluting, bonding the stainless steel to rigid panels or using internal stiffening members offer better design solutions to the problem. It is also recommended that bright annealed or highly polished stainless steel is not specified for heavy traffic areas. The reason is that some articles carried by pedestrians can be surprisingly abrasive and the fine scratches produced on these highly reflective surfaces are easily seen by the human eye. In such locations it is better to specify an embossed surface or a number 4 finish. Not only are the scratches much less noticeable on these less reflective surfaces, but the localised surface work hardening associated with embossing can make it more resistant to abrasion. Obviously, if a number 4 finish is used then the "grain" should run in the same direction as any anticipated scratching by pedestrians.

In steel framed buildings, stainless steel column covers can be an attractive way to cover the fire insulating material. In concrete framed buildings, the cover may be largely decorative or be used to conceal service piping. In the latter case the design may call for easy access facilities.

Design - Practical aspects.

It is being increasingly recognised that good design is not merely concerned with aesthetic aspects but it also plays a broader role in establishing the competitiveness of a product by influencing both manufacturing and ownership costs. Clearly, this is valid whether stainless steel is specified purely for aesthetic reasons or to obtain structural integrity. In both situations a common factor is the corrosion resistance or surface integrity of the material.

The first step, therefore, is to ensure that the service environment is known, the aesthetic standards are agreed and the most cost effective type of stainless steel is selected. Merely specifying "stainless steel" is wrong and could lead to disappointing service performance. There are many types of stainless steel, but most architectural projects can be satisfied with either S 30400 or S 31600 stainless steel. The methodology used to select the most appropriate type is described in a companion brochure, (12).

The second step is to select the type of surface finish required. Some factors influencing the decision have been mentioned in this brochure, but the final choice should not be made purely on the appearance of a small sample. It is important to view samples that are of similar size to those used in the final artefact, and at viewing angles and distances similar to those that would occur in service. When the decision is made, the chosen sample should be cut into two pieces, each piece engraved with the signature of the supplier and the architect, and one of the pieces retained by each of them for use as the agreed standard.

Thirdly, it should be noted that the human eye is very good at detecting quite subtle changes in surface appearance. Consequently, it is good practice to optimise the visual consistency of large areas, such as curtain walling, by specifying that sheets should be numbered as they are cut from the coil and their rolling direction be indicated on the reverse face. Components from sequentially numbered sheets should then be fixed adjacent to each other and with their rolling direction pointing in a specific direction.

The fourth requirement is to agree a flatness specification. For many small components it is possible that "commercial flatness" will be adequate, but in some cases, such as large panels, flatter material may be required. There have been several attempts to quantify "architectural flatness", but no universal definition has emerged. One possible reason is that the degree of flatness required depends on the type of component involved and the reflectivity of the chosen surface finish. It is suggested, therefore, that the flatness specification should be agreed individually and be based on past experience or the results from prototype work.

Obviously, the fixing system should use stainless steel fasteners or rivets in exposed locations. Normal carbon steel fasteners must not be used in such situations because severe staining will occur when they rust. However, satisfactory service experience may be obtained using carbon steel fasteners with a stainless steel cap. If aluminium fasteners are used care should be taken to ensure that the junction between the metals will be kept dry and /or they are electrically insulated from each other to prevent galvanic corrosion occurring. The fixing system should also be capable of allowing for relative movement between the stainless steel and the building structure.

Summary

As the end of the century approaches, stainless steel is in an enviably dynamic and exciting situation. It has successfully met the requirements of architects for over sixty years, and yet it is continuously developing to keep its place as the premier material to meet architectural challenges.

It combines the right image for prestigious applications with the utility of a cost effective material for industrial buildings. It is selected at one moment for purely aesthetic reasons and the next moment it is buried in the fabric of a building to provide indefinite structural support. It is equally at home as oil platform walling facing the aggressive offshore atmosphere as it is facing the knocks of baggage trolleys in the retrieval area of an airport. It is used as a cladding material on a tower 1200 feet high and in a subway tunnel 200 feet below ground level.

Such versatility makes the list of current applications almost endless, and provides ongoing opportunities for future cost effective solutions to architectural problems, wherever they are encountered in the world.

References

1 Answers For Architects. Nickel Development Institute. 1988.

2 Facciate Continue. Una Monografia. Tecnomedia. Milano. 1990

3 Curtain Walls Of Stainless Steel. School of Architecture Princeton University.

4 BA Smits. Stainless Steel in Architecture. NiDI Technical Series No 10037.

5 Canary Wharf Special Supplement. Building. Oct. 1991.

6 Stainless Steels for Building Exteriors. American Iron And Steel Institute. 1984.

7 J Young. Stainless Steel Cladding: The Lloyds' Building. The Second Harry Brearley Conference. British Steel Stainless. 22 Nov. 1989.

8 UInox alla Cassa di Risparmio di Biella. Inossidabile 97. Centro Inox. Milano.

9 Life Cycle Costing Case Studies and Diskette. Euro Inox. Zurich. 1994

10 PG Stone et al. Performance of Stainless Steel in Topside Constructions Offshore. Stainless Steels '84 Conference. Metals Society. March 1985.

11 Stainless Steels in Buildings Symposium. Stainless Steel Development Association. April 1970.

12 Advantages For Architects. Nickel Development Institute. 1990.