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THE GROWING MARKET FOR STAINLESS STEEL ROOFING

The potential use of stainless steel for roofing has only recently become more widely recognised, despite an early example of the use of stainless steel for the art deco spire of the Chrysler Building in New York, completed in 1930. In addition to a growing appreciation of stainless steel as an architectural material, other factors such as the introduction of low reflective, matt finishes and the development of improved methods of construction have played an important part in this process.

Benefits of Stainless Steel for Roofing

Stainless steel is a highly versatile material, which offers the owner as well as the architect an attractive combination of benefits over the life-time of the building. These include:

Choice of surface finish

Stainless steel is best known for its bright, reflective appearance. A low reflective or matt finish is frequently preferred for roofing, both to reduce reflectivity and to blend in with more traditional materials. Terne coatings, either containing a combination of 80-85% lead and 15-20% tin or containing tin only, are a popular choice. Stainless with a PVF resin coating, or alternatively coloured by the Inco process, has proved a popular choice in Japan and other parts of Asia, and is now also found in Europe.

Long life & low maintenance

The inherent corrosion resistance of stainless provides a life expectancy well beyond the standard requirement for new buildings. The most commonly used 1.4301 (304) grade contains 18% chromium and 8% nickel, to which the addition of molybdenum provides increased protection. The molybdenum containing grades, including 1.4401 (316), 1.4404 (316L) or 1.4436 (316 Hi Mo) are recommended for roofs in coastal and heavy industrial environments, and for flat roofs, which may retain standing water.

Stainless steel is not entirely maintenance free. Natural rain washing, regular removal of roof

debris, and an occasional wash down of areas, where dirt and contamination have built up, will ensure that corrosion resistance, as well as appearance, are maintained for the design life of the building.

Fire safety

The austenitic stainless steel grades most frequently used for roofing have a higher melting point than a number of other common metals used in roofing, providing additional safety. They also retain a higher proportion of their strength than carbons steels above temperatures of about 550°C, and a higher proportion of their stiffness at all temperatures.

Sustainability

Stainless steel can frequently be refurbished, rather than replaced following superficial damage, due to its strength, corrosion and fire resistance. It can be fully recycled at the end of building life.

During use, the chromium oxide passive layer, which provides corrosion resistance to stainless steel, also inhibits leaching of its constituent alloys, preventing contamination of rainwater as it returns to the water table.

Versatility

Stainless steel is not usually thought of as a lightweight material. However, the strength of stainless steel can be significantly enhanced through work hardening, either in the process of cold rolling or profiling. Typical thicknesses for stainless steel for roofing can therefore be as thin as 0.4mm, making it a viable option for light weight applications. Despite work hardening, austenitic stainless steels will retain sufficient ductility to allow bending and forming into roof panels and accessories.

Stainless steels offer other physical properties, which are beneficial to roof design. The standard austenitic grades are tolerant to the climatic extremes from temperatures below freezing to temperatures above 35° C. Stainless steel's smooth reflective surface provides it with excellent heat reflecting properties. It can also contribute to electromagnetic shielding, which may be required for buildings with sensitive electronic equipment.

Life cycle benefits

Although the initial cost of stainless steel may often be higher than other commonly used roofing materials, the difference in installed cost can often be reduced by optimising the specification of materials and the method of construction. Due to the superior strength of stainless steel, the material thickness can be reduced and the cost minimised by selecting dimensions standard to producers. Measured over the lifetime of the roof, the durability of stainless steel, its low maintenance requirements and retained scrap value, will often result in a life cycle cost which compares favourably with alternative materials.

Design and Construction

Roof design

There are many different ways of designing the structure to accommodate a stainless steel roof. The main constraints are usually:

- the shape of the roof
- the type of structural frame
- the insulation requirements

Stainless steel should be fully supported: this is usually done with plywood, sawn timber, rigid insulation or a structural composite panel. In the case of plywood, the use of minimum 19mm exterior grade ply deck is recommended. All timber structures should be proofed against fungoid and insect attack.

Although condensation on the stainless steel is not known to cause corrosion, it is important to ensure a good vapour barrier to avoid the risk of damage to the substrate and insulation materials. The need for ventilation depends upon various factors associated with the design of the roof structure. In the case of a traditional, cold deck structure, the support is usually made of wooden planks fixed with a 3mm air gap between them. However, increasing use is now made of warm deck structures, in which a continuous, unventilated underlay is formed, using rigid insulation as a support.

Detailed advice should be sought from recognised installers of stainless steel roofing, but a brief description of the most commonly used methods can illustrates some of the key principles involved.

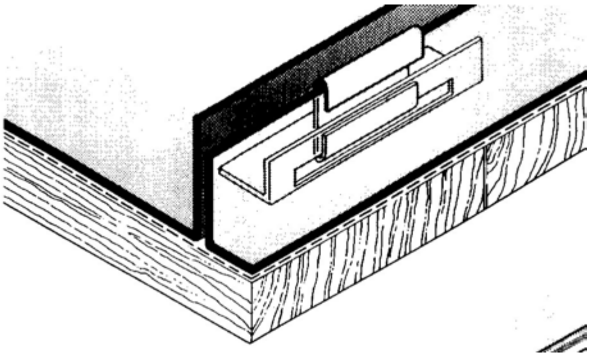
Profiled sheeting

Stainless steel may be profiled by similar methods to mild steel, either by roll profiling or brake pressing. Stainless steel requires about 50% more pressure to produce the profile, restricting the number of companies able to supply and the size range produced. The method of construction is nonetheless similar with the decking supported on purlins with centres from 1.5m to 2.25m, dependent on the depth of profile and the design loading. Profiles are usually rolled in thickness from 0.5 to 0.7mm, while pressed panels may be thicker. Proprietary secret fix systems, using a hidden clip fastening to connect to the adjacent sheets, are also available.

With all types of stainless steel roofing, it is important that primary and secondary fixing clips and screws are also in stainless steel to avoid any risk of galvanic (commonly referred to as bi-metallic) corrosion. The austenitic stainless steels are higher on the galvanic scale than other commonly used roofing materials, such as zinc, aluminium and carbon steel. Contact with condensation or rainwater, can result in rapid corrosion of the less noble material. Where stainless steel is used in conjunction with other materials, care should therefore be taken to ensure that there is appropriate insulation at the point of join.

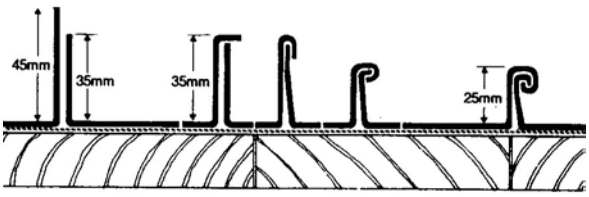
Standing seam and batten roll

As with other types of metal roofing, these methods of construction require a timber or concrete substrate to support the sheets, which are laid on top of a suitable underlay. In the standing seam system the roof is laid in a series of trays, secured by clips fixed to the substrate by screws or helical twist nails. The clips are folded with the upturn of the sheeting to form the longitudinal standing seam approximately 25mm in height. In some cases this is carried out with a special folding machine. In the batten roll system, longitudinal timber battens and clips are fixed to the substrate and the sheets are dressed to the side of the battens. The sheeting clips are folded over to secure the sheets in position and cappings provided for the battens. Sliding welted clips (coulisseau) are provided for vertical and soffitt panels.



Fastenings for the tray

The standing seam system provides a less conspicuous profile than the batten roll system, which gives bold visual lines at the batten joints. For shallow roof pitches up to 7°, the batten roll system is recommended, but above this pitch either system may be used. Double folded seams are normally used unless the roof slope is steeper than 75°.



Forming the standing seam

For hand built roofs of this type, a thin section (0.375/0.4mm), specially softened to a hardness value less than 150 Vickers, is preferred for ease of handling, as the stainless steel will work harden as it is folded and formed at the joints. Coil widths of between 350 mm and 650 mm are the most commonly used.

Seam welding

Continuous seam welding of stainless steel roofs became possible with the introduction of portable welding machines, which automatically follow seams created in a similar way to the standing seam method. Sheeting clips are first spot welded to the sheeting and the seams are then continuously welded at a specified height from the roof deck by a process of resistance welding without the use of filler. The speed of the process (4m/min) and the thin gauge of the material create minimal surface oxidation mitigating the need for post-weld treatment. The final operation of folding over the seam is carried out by a separate self-propelled seam bending machine. This process strengthens the joint and helps to straighten the seam.

These techniques were developed originally in Japan by the Nippon Stainless Steel Co and in Sweden by Rostfria-Tak Corporation and began to be marketed in the 1980's through licensed contractors. The advantage of this system is the creation of a completely watertight and airtight seal. Suitable for flat roofs, it is also ideal for "green" or garden roofs because of resistance to corrosion and mechanical stress, and to damage from roots and algae.

The stainless steel used for this system is usually the austenitic 1.4404 grade, or the higher molybdenum variant 1.4436, supplied in coils of 0.4 or 0.5 mm thick of similar width to traditional standing seam. However, full width coil up to 1250mm can be used.

Stainless steel has a higher thermal expansion coefficient than mild steel and this is taken into account in design and installation of all methods of roof construction. Special expansion joints are required for seam welded roofs, in order to make the necessary allowance for expansion and contraction of the welded area.

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Case Studies

Waterloo International Terminal, London 1992

Architect: Nicholas Grimshaw and Partners

Waterloo International Terminal: Courtesy of Outokumpu

Built in 1992, the Waterloo International Terminal is a foremost example of the use of stainless steel profiled sheet. Designed to exceed a design life of 125 years, the 400 m long structure snakes to follow the twist in the rail tracks and is made up of a series of asymmetric three-pinned arches, each comprising one long and one short bow string truss. The cladding to the long trusses is formed from grade 1.4401 (316) 0.9 mm thick stainless steel sheets, which were brake pressed to form a trapezoidal profile and laid in a herringbone pattern. The material was given a matt finish, in order to reduce reflectivity, by rolling the finished coil through shot blast rolls.

The Ruskin Library, Lancaster, 1998

Architect: Sir Richard MacCormac

The Ruskin Library, Lancaster University: Courtesy of Eurocom Enterprises and Tetrarch Design Associates

Lancaster University's award winning Ruskin Library provides the home for the Whitehouse Collection of the work of the 19^{th} century critic and social reformer, John Ruskin. The library's curved external walls provide an envelope for a treasury at the core of the building extending through three floors, where the collection of watercolours, manuscripts, books and photographs are kept in stable conditions. Lead-free tern coated stainless steel was selected for the roof, which was constructed using a standing seam.

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Library of the Faculty of Law, Cambridge, 2001
Architect: Foster and Partners

Library of the Faculty of Law, University of Cambridge: Courtesy of Stainless Building Consultancy

The new library building for the Cambridge University Law Faculty was built to blend in with neighbouring buildings and mature trees. In order to keep the building to scale, the larger lecture theatres were built below ground level. The library and additional seminar and faculty rooms are built on four terraced floors topped by a steel-framed roof spanning 35 m across the building. The roof was seam-welded and falls away in a flowing curve to form the glazed north-facing façade.

Conclusion

In a recent European survey, respondents were unanimous that the use of stainless steel for roofing was likely to grow. This is supported by an expanding portfolio of buildings with stainless steel roofs, including museums and galleries, churches, sports facilities, railway stations and commercial offices. Increased awareness of the benefits offered by stainless steel and greater knowledge about the available construction methods will help to encourage this process.

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The author is grateful to the following sources, which indicate the range of information now available to architects and designers:

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Steelex Handbook, Outokumpu Precision Strip (formerly Lee Steel Strip)
Technical Guide to Stainless Steel Roofing, Euro Inox, 2004

Further technical advice on the use of stainless steel in architectural applications can be obtained by consulting the BSSA Stainless Steel Advisory Service
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This article by Duncan Munro, Director, British Stainless Steel Association, was originally published as an editorial feature in the Steel Construction Yearbook 2004 and is reproduced with kind permission of SCI and the publishers of the Yearbook, McMillan-Scott PLC