STAINLESS STEEL IN ARCHITECTURE, BUILDING AND CONSTRUCTION – GUIDELINES FOR ROOFS, FLOORS, AND HANDRAILS

A GUIDE TO THE USE OF NICKEL-CONTAINING ALLOYS

Nº 11013

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Published 1994

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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

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.

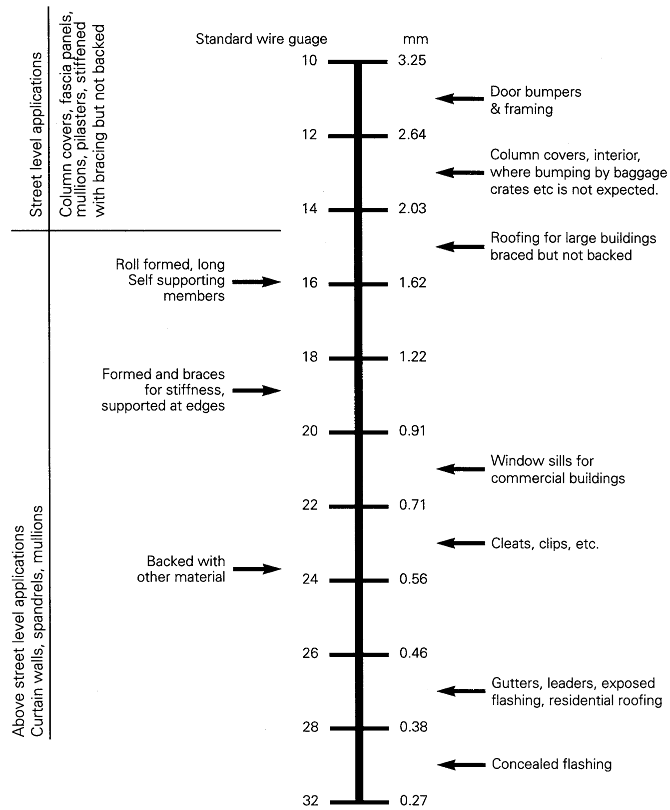
Surface appearance

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.

Roofs

Introduction

The unique properties of stainless steel are ideally suited for roofing, whether flat, pitched, arched or curved.

Stainless steel is a highly durable long lasting material, of high strength and ductility, and totally impervious to water. It requires little or no maintenance and is readily formable and weldable.

It can be coloured, by resin coating, as widely used for roofing in Japan for example, or used as a bare metal roof covering in hand built or standard profiled form.

Domestic, commercial, municipal and industrial buildings, sports stadia and Churches, have all been fitted with stainless steel roofs.

Many of these applications have been curved.

Courtesy of Nippon Metal Industry

Fig.1 Coloured Japanese roof

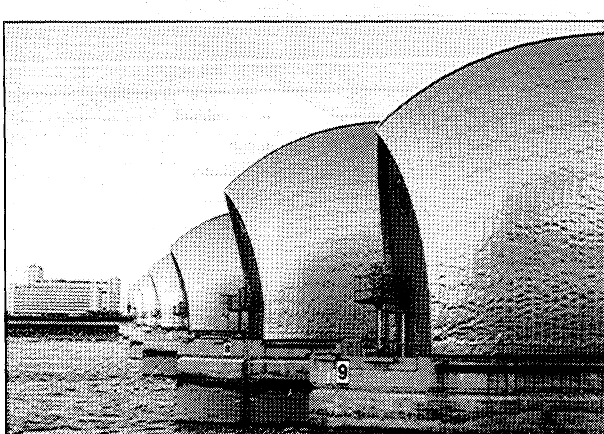


Photo D J Cochrane

Fig.2 Thames Barrier An example of a curved standing seam roof

Advantages of stainless steel

Roofing with stainless steel offers many advantages:

(a) it is highly resistant to corrosion and totally impervious to water
(b) it requires no maintenance other than the removal of leaves and debris as with all roofs
(c) it will last the lifetime of the structure[1]
(d) it is light, around 3kg/m^2 (Hand Built)
(e) it has a high degree of safety in the event of fire
(f) it is simple to lay
(g) it is cost competitive
(h) it has high strength and high ductility for forming
(j) it can safely be used with other building materials and is not attacked by cement, mortars, or timber preservatives
(k) is aesthetically pleasing
(l) it can be coloured
(m) it can be soldered and welded
(n) it can be shaped

Types of Roofing

Stainless steel can be used in the following ways:

(a) as Profiled sheeting
(b) as profiled sheeting with a Secret Fix system
(c) Standing Seam method, seam welded or folded
(d) Batten Roll method

The material can also be given a proprietary finish, used plain or terne coated, or be coloured.

(a) Profiled sheeting

In the same way that carbon steel may be profiled, stainless steel may also be used.

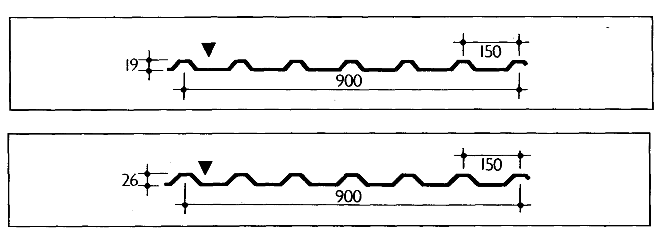


Fig.3 Typical roof profiles (dimensions in mm)

Due to its work hardening characteristics, stainless steel requires around 50% more pressure to produce the profile than is required for carbon steel, and austenitic grades of material are also subject to 'springback' during the roll forming process.

For these reasons manufacturers tend to offer a limited range of profiles.[2]

An alternative process is brake pressing. The Waterloo Terminal roof was manufactured by this route and the panels were specifically designed to accommodate the long span required by the architect.

Photo D J Cochrane

Fig.4 Waterloo International rail terminal

The method of construction, however, is the same, in that the decking is supported on purlins, generally at about 1.8m centres, although the spacing is dependent upon the depth of profile and the design loading.

With stainless steel roofing, it is important that primary and secondary fixing screws are also made from stainless steel. Austenitic fasteners must be used with austenitic roofing sheets,

As Youngs Modulus for stainless steel is similar to that of carbon steel, deflections for identical profiles will be similar.

(b) Secret Fix System

The secret fix system is similar to profiled decking in appearance but uses a hidden clip fastening to connect adjacent sheets.

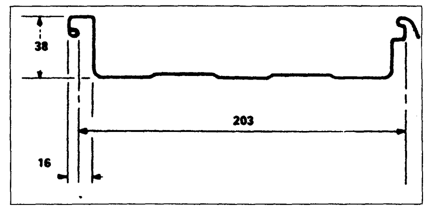
The advantage of this method is that the roof is not perforated by fixing screws, therefore, a potential source of leakage is eliminated.

There are different proprietary methods and profiles of secret fix systems available but the concept is the same for most of them.

The roof shown in Fig.7 illustrates one system. A Post Office Sorting Office in London used this particular system for which a proprietary pearl finish was given to the stainless steel.[3]

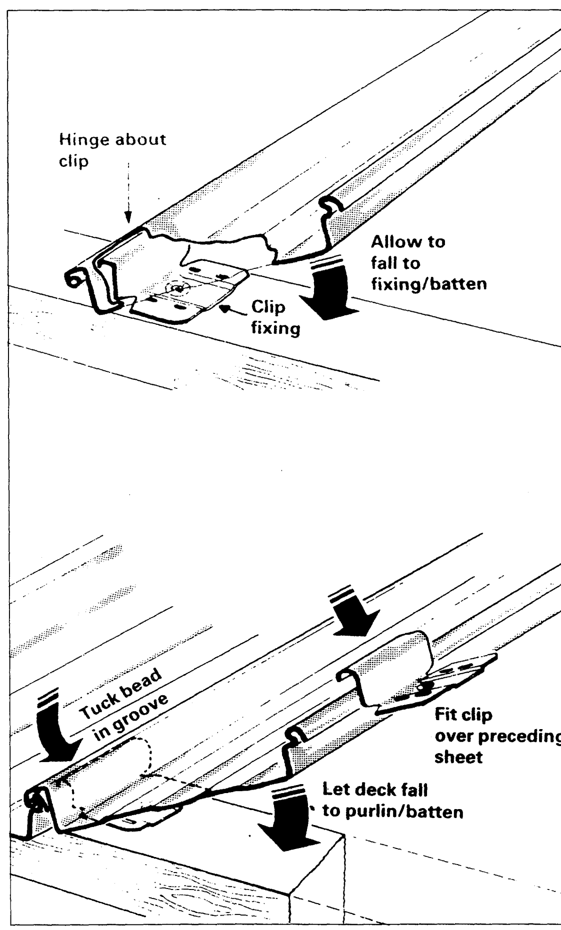
This system uses roll formed profiles which have male and female sides designed to clip over one another and thus provide a strong interlocking watertight roof membrane.

In between the interlocking members are specially designed clips which are fixed to the purlins and hold the roof down.



Courtesy of B & N Engineering Ltd.

Fig.5 Interlocking panel



Courtesy of B & N Engineering Ltd.

Fig.6 Fixing clip

The interlocking panel principle may also be used for wall cladding either external or internal.

This type of system allows thermal movement, either expansion or contraction, to take place.

Courtesy of Avesta Sheffield Ltd.

Fig.7 Example of a Secret Fix roof

Minimum Slope
As with most roof structures a minimum 1 degree slope is necessary to avoid ponding and the creation of permanent water pools.

While this is the absolute minimum recommended, steeper pitches will allow a faster water run off and improved washing action by rainwater.

It is more usual to deploy a roof slope of between 3 and 6 degrees however, to simplify flashings and gutter details.

Thickness of Sheet
Profiles are usually rolled in thicknesses of 0.5, 0.6, and 0.7mm and are designed for a multiple span condition over the purlins which may be from 1.5m to 2.25m centres depending upon the load to be carried.

Pressed panels may be of thicker material and account should be taken of the increased pressure required for stainless steel sheets as indicated in Types of Roofing (a).

Load/Span Tables
These are available from roofing manufacturers.

Accessories
As with any stainless roof structure accessories such as clips and screws should also be manufactured in stainless steel.

Installation
The installation of this type of roof begins by marking out and fixing the first row of clips.

The first profile is hinged over the row of clips and lowered on to the purlins.

The next row of clips are installed by fitting them over the sheet that has been laid and secured as before to the purlins.

It is necessary to use crawler boards during installation, and that applies to most metal roof structures, to avoid permanent deflections and surface damage.

Footwear should also be selective for this reason, and, to avoid grease contamination, it is recommended that clean gloves should be worn for handling the material.

It is normal practice at ridge joints to turn up the sheeting, using a special tool, to prevent the passage of water, and conversely turn down the sheeting at drips and sheet ends to facilitate water run off.

Preformed stop ends are usually driven in at the rib ends to provide a neat finish and prevent their use by small birds insects etc.

Details of Ridge capping, gutters, verges, fascias and drips will be available from the roofing manufacturer.

Hand Built Types of Roof
Hand built types of metal roofing require a substrate for support, and stainless steel is no exception.

Within this category of roofing there are basically two systems used, commonly known as:

Standing seam

Batten roll

Preferably, the stainless steel used for hand built roofs should be in the softened condition for ease of forming.

It is recommended that for roof pitches up to 7°, the batten roll method be used but above this roof pitch either method may be used.

Aesthetically, the standing seam system provides a less conspicuous profile than the batten roll system which gives visually bold lines at the batten joints.

Both systems may be used together if the architect so chooses.

Care should be taken in manipulation, forming of seams, and dressing, as the stainless will rapidly harden when cold worked.

(c) Standing Seam

The standing seam system comprises a series of bays formed by the sheeting trays which are laid down the slope adjacent to the clips which have already been fixed to the substrate at 375mm centres. Clip size 45mm high x 25mm x 50mm long. Expansion clip 40mm high x 85mm long, 50mm slot for 30mm clip.

The clips are secured to the substrate or battens by screws or helical twist nails. The clips are folded with the upturn of the sheeting to form the longitudinal standing seam which will be approximately 25mm in height.

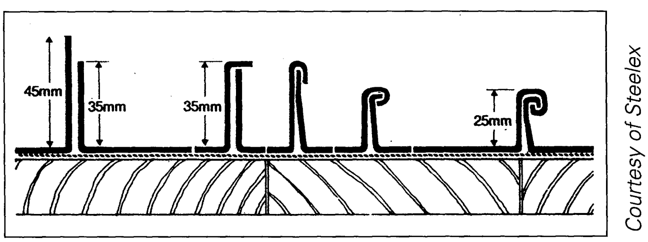


Fig.8 Forming the standing seam [4]

Plain clips are used to secure lengths up to 3m and when this length is exceeded, a mixture of 1/3rd plain clips and 2/3rds expansion clips should be used to take account of expansion, or thermal movement.

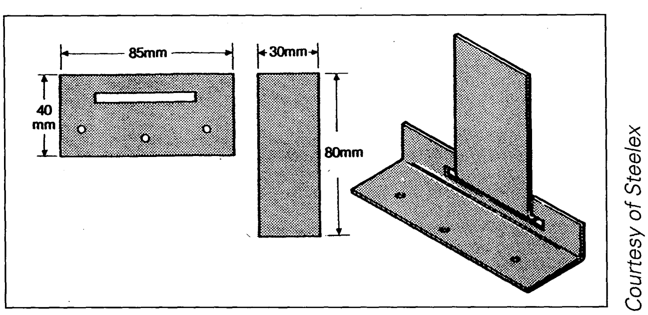


Fig.9 Expansion clip

When lengths in excess of 9m are required, sheets may be joined across the fall by a single welt, where the roof pitch exceeds 45°. Joints should be flattened to allow water to flow freely over the sheets. Where the roof pitch is less than 45° then it is recommended that a drip be formed. To avoid the difficulty of welting multiple thicknesses of stainless steel in the standing seam, cross joints should be staggered.

Standing seam

Method of Forming

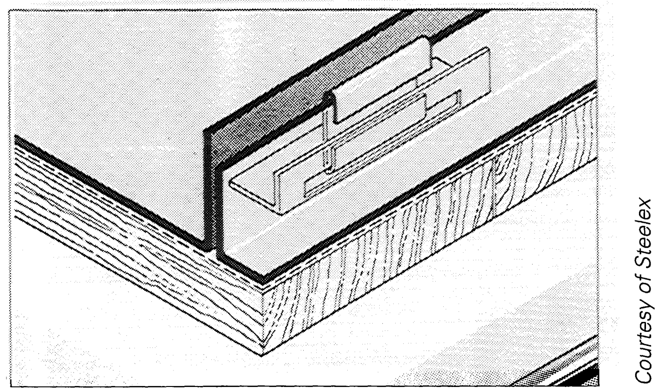


Fig.10 Securing the tray

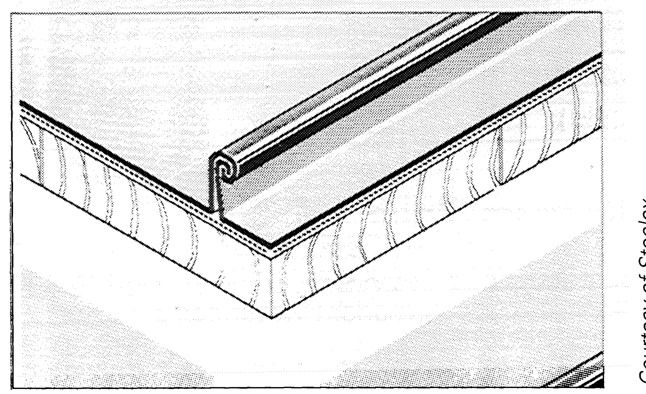


Fig.11 Seam formed securing adjacent trays

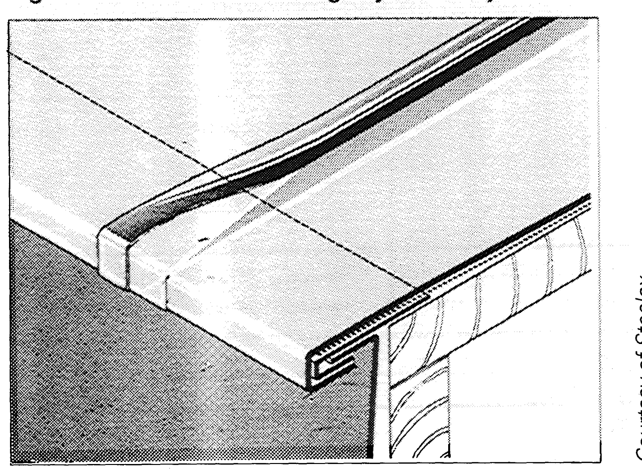
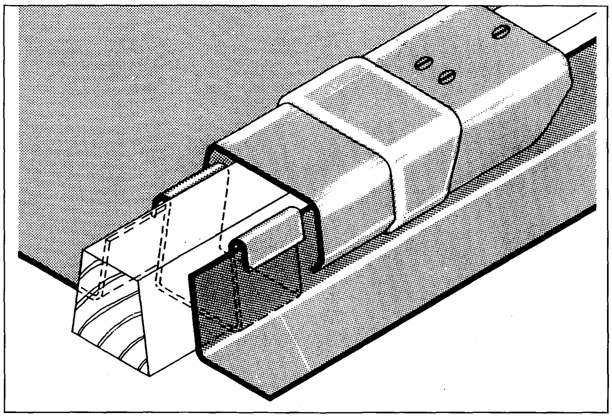


Fig.12 Folding the standing seams at drips and eaves

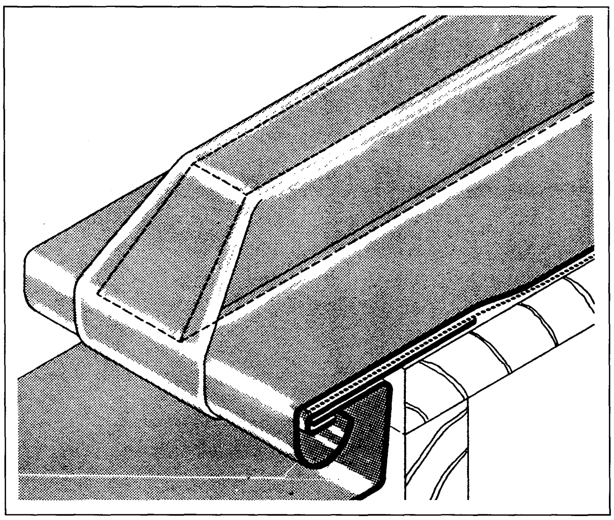
(d) Batten Roll System

In this system longitudinal timber battens are securely fixed to the substrate at 450mm centres using stainless steel number 10 size screws (3.5mm).It is important that the battens are securely fixed to avoid any displacement when dressing the metal into position and they will also be fitted with the sheeting clips prior to fitting to the substrate. Spacing of the battens is normally 425mm centres.



Courtesy of Steelex

Fig.13 Batten roll arrangement



Courtesy of Steelex

Fig.14 Forming at Drip and Eaves

At eaves and drip positions battens are usually splayed at 45° to facilitate dressing of the stainless steel capping. The main sheeting trays are formed from a coil width of 455mm with 45mm upstands along the longitudinal edges which are dressed up to the sides of the battens. The sheeting clips are folded over to secure or hold the sheet in position. Size 55mm high x 50mm long. Separate roll caps, generally 1m long should be provided for the batten rolls. The capping covers locate and lock at one end and are fixed by 3, number 10 screws at the other.

Materials

All materials associated with stainless roofing should also be made from stainless including batten covers, flashings, drop aprons, and clips and nails. Flashings may also be in lead. Austenitic grades of stainless steel are generally used for roofing purposes, and these are typically as shown in Table 1. The higher alloyed Type 316 is recommended for aggressive coastal or industrial areas and further guidance can be obtained in ref.1.

Table 1. Materials suitable for Batten Roll, Standing Seam and Seam Welded roofing

Stainless Steel Grade			Min. Tensile	Condition	Min. 0.2%	Typical
UNS	BS1449: Part 2	ASTM A240	Strength N/mm²		Stress N/mm²	H'ness Vickers
S30403	304S11	304L	480	Softened	180	150
S30400	304S31	304	500	Softened	195	150
S31603	316S11	316L	490	Softened	190	150
S31600	316S31	316	510	Softened	205	150

Table 2. Physical properties of stainless steel in the softened condition.

Stainless Grade	304S11	304S31	316S11	316S31
Density kg/m²	7905	7910	7970	7970
Specific Heat KJ/KgK (20-200c)	0.52	0.52	0.52	0.52
Coefficient of linear expansion (20–200c)	8.0 x 10⁻⁶c	18.0 x 10⁻⁶c	17.x 310⁻⁶c	17.3 x 10⁻⁶c
Thermal Conductivity W/mk100C	16.0	16.0	16.0	16.0
Melting Point°c	1415	1415	1380	1380

Substructure

The design of the substructure for stainless will be identical to that used for other metal roofing.

Timber in the form of tongued and grooved boards 25mm in thickness or exterior grade plywood 19 or 25mm in thickness will provide a suitable substrate for stainless. Alternatively a concrete sub-structure will suffice. With a concrete substructure, provision must be made for securing clips or rolls by wooden dovetailed battens or plugs set into the concrete and set flush with the finished level of concrete.

It is suggested that timber battens be 75mm x 25mm deep. All timber should be preferably pressure treated or impregnated with a preservative to prevent decay.

The substructure should incorporate an even fall to facilitate drainage with the minimum slope being 1 in 40.

An underlay should be laid on top of the substructure to provide a smooth and even surface for the roof sheeting. The underlay is not a vapour barrier and ventilation should be provided by othermeans unless the underlay comprises a composite layer impervious to water.

This is important when concrete or screeds are used as they may retain moisture for long periods.

Material Thickness and Finish

A softened material generally with a hardness value less than 150 Vickers, and only 28 SWG (0.375mm) is generally preferred for hand built roofs.

A dull matt finish similar to a 2D finish, or Terne coated material (see under Terne Coating) is the usual type of finish preferred, to avoid reflection.

Precautions

Storage and protection of stainless steel. The stainless steel should be kept dry whilst in transit and in the store on site.

At all times care should be taken to avoid marking or scoring the material by for example nailed boots or heavy tools. Stainless steel should never be cleaned by wire wool made from carbon steel as this will inevitably lead to deposits of carbon steel and result in rust staining.

Stainless steel must always be kept apart from carbon steel especially where these are being machined.

The sheeting trays formed to fit the bays of the roof should contain an allowance for expansion and contraction as appropriate.

Checks

It is worthwhile for a construction that is to last as long as a stainless one to carry out a few checks and ensure that a good job has been done.

These should take the form of the following check list:

1. ensure that the substructure surface is of satisfactory finish, flat and firm, and with no projections such as screw heads.
2. ensure that the underlay is dry and free from dirt and extraneous matter and joints are butted and not lapped.
3. ensure that the main roof covering is laid true with the substructure and secured against wind uplift
4. ensure that all welted seams are correctly formed and in the proper direction
5. ensure that aprons and flashings are secured against wind uplift and main roof coverings adequately weathered
6. ensure that all pointings and flashings are completed and and adequately dressed or weathered
7. finally, ensure that the surface of the stainless steel has been properly cleared of all debris.

Terne Coated Stainless Steel

Whilst a dull flat finish is normally recommended for roofing, in order to reduce glare, terne coated material is frequently specified for roofing because of it's appearance which is similar to that of lead.

This type of coating weathers, and in time, closely resembles a lead roof.

Terne coating is a material with an alloy coating comprising 80-85% lead and 15-20% tin, depending upon the plating company, and the coating thickness is in the order of 20 microns per side.

It was developed by Follansbee in the USA from whom details of the way in which this coating is achieved, may be obtained.

It is important to note with this type of coating that it can be worked in the same way that ordinary sheeting in stainless steel can be worked and it is the appearance that is the main difference.

It is popular for this reason.

Resin Coated Stainless Steel

Resin coated stainless steel, i.e. PVF2, has met with spectacular success in Japan where it was introduced in the mid 1980's.

Over 22,000 tonnes/annum is currently used for roofing in Japan.

Resin coated stainless steel has been developed to give a long life coating and the process involves a tempering of the skin of the stainless steel by holding the final annealing process for a little longer than normal.

To ensure good adhesion, the steel passes through shotblasted skin pass rolls. An epoxy resin layer is applied as a primer prior to the application of the resin coating.

A high weathering coat of Vinylidene fluoride resin has been developed although the general purpose coating is a Silicone acryl resin.

Because seam welding is the fast growing market in Japan, a weldable resin coating has been developed.

The coating differs to the normal resin coating by the addition of 20% in weight of stainless powder and this ensures the electrical conductivity necessary for the seam welding equipment. Profiled sheeting can be used in the usual way or installed using a 'Secret Fix' type of concealed fitting.

Seam Welding

Seam welded roofs are basically the standing seam mentioned earlier except that the seams are welded to form a watertight join.

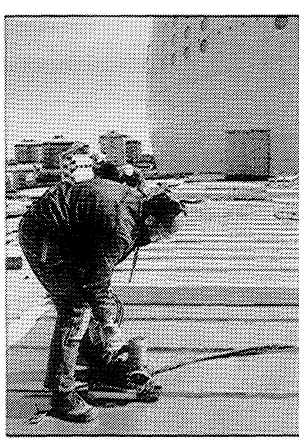
This is achieved with the aid of automatic portable machinery initially developed for the purpose by the Rostfria Tak Corporation of Sweden.

The principle of this method is that the sheeting clips are first spot welded to the sheeting.

The second is to seam weld 15mm up from the roof deck with the automatic seam welder which is self propelled.

The final operation is the folding over of the seam which again is a process carried out by a self propelled seam bending machine.

The seam welder requires a 3 phase power supply of 380V or a generator for 27 kVA and it's self propelling speed is 4 metres/ minute.



Courtesy of Rostfria Tak AB, Sweden

Fig.15 Seam welding

Gutters and Downpipes

With hand built roofing, that is batten roll or standing seam methods, gutters are generally laid on a substrate of hard board and valley gutters are generally of the preformed type also hand built. They may also be thin gauge rolled products. This is an area where the soldering of stainless may be used, not specifically for it's joint strength, but in order to seal a particular junction.

Stainless can be used uncoated or terne coated and in both cases are readily soldered.

Soldering of uncoated stainless

Soldering as a process is generally suitable for materials up to 1.25mm in thickness and it is recommended that a flux be used that suits stainless. For uncoated stainless a phosphoric based flux, which is only active at soldering temperatures, may be used. Either a 50/50 or 60/40 tin/lead solder is suited to stainless and the 2D surface finish to the roofing material means that no surface treatment other than perhaps a degrease is necessary before soldering.

Post soldering treatment

All flux residues and vapours must be removed following completion of the soldered joint.

Terne Coated Sheet

Because the coating already contains lead and tin, the soldering operation is generally simpler than the uncoated stainless, and again a Tinmens solder of 60/40 is very suitable.

Technical information on roofing is available in a well illustrated NiDI publication entitled: 'Technical Manual for the Design & Construction of Roofs of Stainless Steel Sheet'

References

1. An Architects Guide on Corrosion Resistance Published by the Nickel Development Institute.
2. European Profiles Ltd. Dyfed, Wales.
3. B. & N. Engineering Ltd. Cleveland, England.
4. Lee Steelex Publication Number 2. Sheffield, England.

Floors

Introduction

Stainless steel teardrop patterned floorplate was first produced in the UK in the mid-eighties in response to market demand, as an alternative to corrosion protected carbon steel.

Stainless flooring has since found applications in many different industries, for a variety of reasons, appearance, cleanliness, ease and frequency of cleaning - sometimes with chemicals - hygiene, hostility of the environment, and cost effectiveness.

Food processing plants, dairies, breweries, abattoirs, industrial and chemical plants, hospitals, motor plants, have all installed stainless flooring.

Commercial buildings, offices, and railway stations have also fitted stainless steel floorplate.

Electro-polished, floorplate is visually attractive and provides a surface finish that is least likely to harbour bacteria and dust - a requirement in Hi-tech plants and food processing areas for example - while security underfoot is provided by it's pattern which may be rolled, pressed, or etched.

It is an ideal material for applications where corrosive conditions place demands upon materials and protective finishes that require regular inspection, and often costly maintenance or replacement.

Basic Forms of Flooring

The following types of stainless steel flooring is produced:

1. Raised pattern solid floorplate.
2. Etched pattern solid floorplate
3. Grid
4. Plank

1. Raised Pattern Solid Floorplate

This is a hot rolled product produced by the rolling mills at the steelworks.

Floorplate is usually supplied in coil up to a weight of 23 tonnes, or in plate form which is already cut to size. With a maximum width of 1830mm the rolled product is produced in thicknesses of 3, 4.5, 6, 8, and 10 mm with a raised teardrop pattern at a cross centre pitch of 27mm. Typically the height of the studs or teardrops will be in the range 1.5 - 2.2mm and the teardrops themselves are 27mm long and a maximum width of 9mm.[1]

This pattern facilitates the removal of surface water which can readily be swept away.

It has been shown by tests, that stainless steel floorplate of this pattern has considerably higher resistance to abrasion than materials such as carbon steel and aluminium.[2]

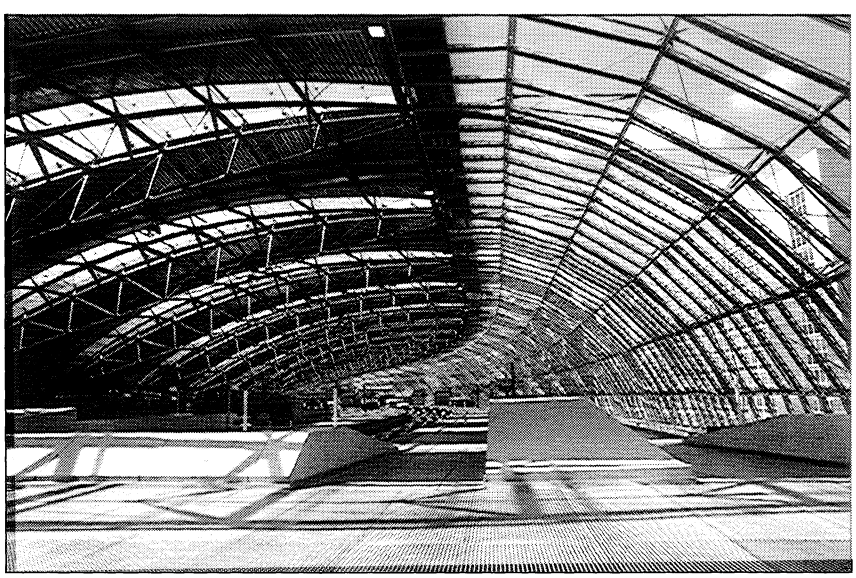
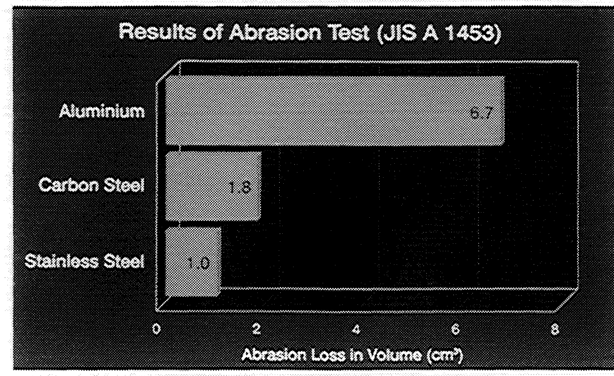


Photo D J Cochrane

Fig.1 Waterloo International rail terminal teardrop raised pattern floorplate



Courtesy of Nippon Yakkin Kogyo

Fig.2 Abrasion resistance of floorplate

Courtesy of Nisshin Steel Co., Japan

Fig.3 Etched patterned floorplate

Thin gauge floorplate, a recent development, is available as a pressed product in thicknesses of 1, 1.5, 2, and 3mm.[3,4]

This product is finding application as wall liner and floors of transport vehicles such as refrigerated lorries, and floors of fire service vehicles, and milk lorries.

Adjacent sheets may be joined by the lock seam method to provide the necessary width, and the sheet may also be bonded in position using epoxy resin.

It can also be bonded to carbon steel floorplate where the pattern has worn flat - on steps for instance - where the bonding effectively acts as a barrier between the dissimilar metals and prevents galvanic corrosion.

2. Etched Patterned Solid Floorplate

Architectural floorplate is available in a variety of patterns and is principally produced in Japan.[5]

Patterns are etched to a depth of around 800 microns and the bottom of the etching is coated to prevent contamination and corrosion.

Proprietary patterns are available, however, any pattern can be applied.

This product is commonly found at the bottom of escalators.

Plate thickness is in the range 3 to 8mm and the maximum width available is 1.5m.

Loading

Unless laid on a flat surface, floorplate will require support and the load carrying capacity will depend upon whether this is in the simply supported condition or encastre (fixed) on all four edges.

Load tables are provided by the manufacturers of the stainless floorplate for given width and breadth spans and are based either on deflection or a maximum skin stress of 180 N/mm^2. This value for bending stress was derived from load tests.

Fixing

Floorplate may be bolted to a suitable subframe or welded depending upon the application.

Countersunk headed bolts can be used provided that the material has sufficient thickness to prevent protruding boltheads.

The subframe may be either of stainless or carbon steel and bolts should be stainless to prevent corrosion between the dissimilar materials. If the subframe is carbon steel and the environment a corrosive one, then a suitable barrier should be used to separate the metals - a coat of bitumen would suffice, or a non-metallic barrier such as Teflon or a rubber strip.

If the floorplate is welded in position, and this may be necessary between floorplates to seal the floor for washing purposes, thermal movement should be taken into consideration. The welds should be cleaned up to restore the surface to prevent rust staining occurring due to the oxidised or weld heat tinted surface.

This may be achieved using proprietary pickle pastes which are available for this purpose. Manufacturers full instructions should be followed when using this method which involves brushing on the paste followed by a thorough water rinse.

When welding material less than 4.5mm thick, some distortion may occur due to the heat input and the solution is to adopt a stitch and gap technique where small runs are welded, a gap left, followed by another weld run and gap and so on. The gaps are filled when the metal has cooled.

Forming

Not all applications require flat square plates and floorplate is readily formed and cut in the fabrication shop. Upstands may be formed to facilitate washing to prevent the water from going over the edge.

Finishes

Floorplate is generally supplied in the rolled condition or is descaled to provide a dull matt appearance.

Where appearance or exceptional cleanability is concerned, it can be electro-polished to provide a superb finish. This type of finish leaves a smooth surface which is not susceptible to collection or harbouring of contaminants.

Stairtreads

The formability of floorplate readily allows its application for stairtreads. A fully stainless stairway, with stairtreads in floorplate as well as the handrail support frame, makes an attractive, practical installation.

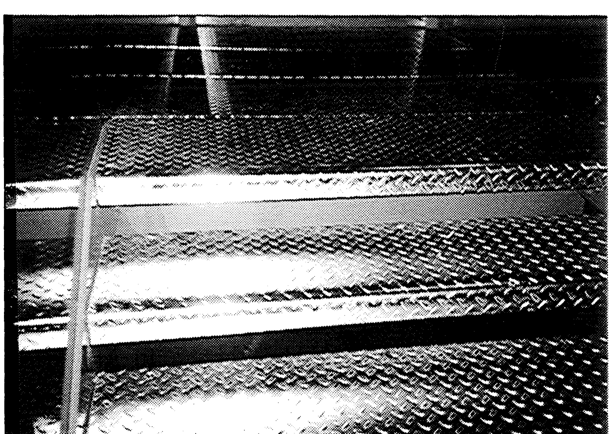


Photo D J Cochrane

Fig.4 Stairtreads, Science Museum London

Aesthetics

Floorplate with a raised pattern, if not in stainless, is subject to wear particularly at the high points in well used areas. Stainless steel has a good surface which will not become readily worn in the way that softer material such as aluminium will.

Painted surfaces, often found on carbon steel flooring, tend to become unsightly where the surface becomes worn at its high points and the same applies to galvanised surfaces. With any surface protection and raised projections, there is inevitably going to be wear exposing the substrate and leaving it bare and susceptible to attack and corrosion. Periodic recoating to restore the protection may be necessary for painted and galvanised steel.

In ship engine rooms, for example, it has been found necessary to remove floorplates and return for regalvanising before refitting. The cost of this exercise is such that stainless steel has become the standard material used by one of the UK major shipbuilders.

Stainless steel does not show the effects of abraded surfaces as protected surfaces do, and this is a clear advantage.

3. Grid Flooring

Grid flooring is often used as walkways, frequently elevated, or mezzanine floors, where the transmission of light and ventilation are required. In certain industries they may be subject to a highly aggressive working environment.

Grids are formed from bars welded or held in position and carbon steel grids can lose load carrying capacity if corrosion occurs, therefore, regular inspection and maintenance is essential.

It is an ongoing cost.

Stainless steel can be cost effective in this type of environment. Likely disruption and possible shut down for maintenance/replacement can be avoided by using stainless steel.

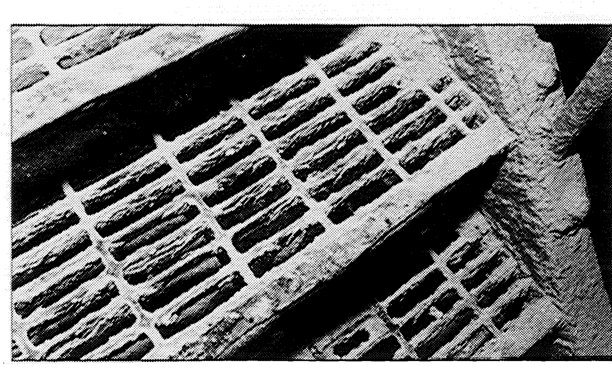


Fig.5 Corroded grid in carbon steel

As shown in Fig.5 the structural capacity of a carbon steel grid may not be evident simply by visual inspection. Clearly any elevated walkway in this type of environment is unlikely to tolerate this degree of attack without impairing its safety.

On a typical walkway with 5mm bearer bars, the thickness of a galvanised coating is approximately 65 microns i.e. a coating mass of 460 gm/m^2. This, by itself, is unlikely to provide a long service life in aggressive conditions because the surface will wear underfoot and reduce the life to first maintenance.

In addition to industrial applications, stainless steel grids have also been installed as an architectural feature on the outside of a building, where it was used to break up the monotony of the glass facade and serve as access for window cleaning purposes.

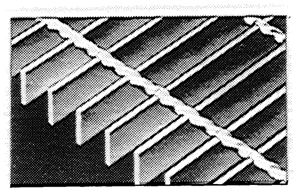
Weight for weight grids have a higher load carrying capacity than solid floorplate and load tables are available from the manufacturers.

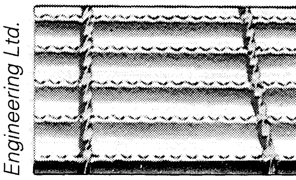
There is more fabrication involved with the manufacture of grid flooring than with solid floorplate, but cut-outs and special shapes can be accommodated in the workshop so that site work is simply an assembly process.

Site modifications are difficult with grid flooring and involve cutting, rewelding, and clean-up of the weld areas to restore the surface to full corrosion resistance.

Because grids are made up from a number of components, welding of the individual bars could be a time consuming process and automated processes are a cost effective production method.

An example of an automated process is the forge weld process where the bearer bars and the transverse bars are fused in one press.[6]





Courtesy of Redman Fisher Engineering Ltd.

Fig.6 Grid Floor, Plain

Fig.7 Grid Floor, Serrated

The bars are placed in position and subjected to a pressure of 100 tons and a 2000 k.V.A. electrical charge simultaneously. The transverse bars are pressed into the bearer bars under this welding process and fused together.

The twisted top transverse bars provide for grip underfoot and the bearer bars can be serrated to provide improved grip.

The principle of bearer bars with transverse bars which stiffen the frame and provide support to the compression part of the bearer bars can be achieved in different ways.

Small grids or gulley cover plates are commonplace in many commercial areas particularly in kitchens, food processing areas, and abbatoirs that are washed frequently.[7]

Fig.8 Kitchen grid floor

From a hygiene standpoint, the use of stainless for the gulleys as well as the grid covers has become popular. It is worth noting that the smooth surface of stainless facilitates the removal of food particles and other droppings that occur in food processing and preparatory areas, that are washed into the drainage gulleys.

The smoothness of stainless means that particles are less likely to cling to the sides of the gulley walls where they can store bacteria and lead to unpleasant odours if not cleaned completely.

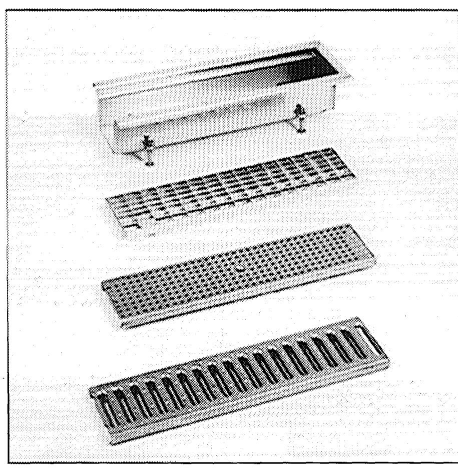
Plastic and other materials do not have the same high quality, durable surface to facilitate this removal.

It has been demonstrated by independent tests that the cleanability of stainless, i.e. the removal of bacteria, is comparable with glass and ceramics.[8]

About 98% of bacteria is removed on these surfaces and this is one of the reasons why stainless is so widely used in the food processing industries and in the kitchens of the world's leading hotels.

Grid flooring can take different forms but basically transverse members are installed for rigidity to the frame as a whole and for the support of the compression part of the bearer bars.

Interlocking bars can be used to stabilise the frame while reducing the welding needed and generally this type of frame would have serrations at the top to provide grip underfoot.



Courtesy of ACO Technologies plc

Fig.9 Grid floor and drainage system

Member Sizes

Grid flooring has the advantage that the size of the bars can be selected as appropriate for the load and span required, and typical sizes for the main bearer bars range from 20 x 3mm for a clear span up to 900mm, to 60 x 5mm for spans up to 3m.

This will support a load slightly higher than $5kN/m^2$ when in a uniformly loaded condition and with the bearer bars at a pitch of 30mm.

Deflection under this condition would be a little over 8mm or span/360 which is acceptable.

4. Plank Flooring

Typically this is formed from 2mm thick sheet which may be of the teardrop patterned type. Alternatively, it may incorporate punched holes that also form small upstands for underfoot grip.

Generally this type of floor is produced in a range of widths from 63mm to 333mm to accommodate different sizes of end uses. Depths can be as necessary but are usually around 35 to 50mm. Spans are up to 2m generally but may be more if required provided that the thickness and depth can take the design loading.

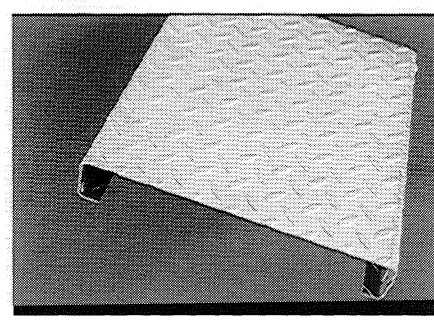


Photo D J Cochrane

Fig.10 Formed Plank

This type of floor is literally laid like wooden planks, side by side, requiring only end supports, and it has the capacity to carry very high loads and remain light in weight by bolting the planks together through the webs, effectively forming an I beam.

Should a plank be badly damaged for any reason it can be replaced quite readily.

Plank flooring is produced by pierce and blank tooling and press brake forming.

This type of flooring may be produced with any type of punched pattern to provide the strength required, generally punched round and slotted holes are used to reduce the product weight, allow the passage of air and light, and provide a surety underfoot.

Whereas with grid flooring items which may be dropped onto it could fall through, bolts for example on a site, the plank form will not be susceptible to this, hence it's usefulness over the other 2 forms.

Life Cycle Cost Analysis

A typical life cycle cost analysis was instigated by NiDI on the walkways for an offshore oil platform operating in the North Sea.

Contractor's normal maintenance practice is to use galvanised walkways, and in this type of environment, platforms are subject to aggressive salt water conditions.

Normally walkways last between 8 and 10 years before they are stripped out and new walkways shipped out and installed. In process areas this means cutting and welding equipment will be required and the rig may be shut down whilst the refit takes place.

The life cycle cost study showed that the use of stainless steel obviates the need for any replacement during the life of the platform which may be 30 or 40 years.

For a 30 year platform, there would be 2 replacements at years 10 and 20 of the carbon steel walkways and stainless would become cost effective at the time of the first replacement. The second results in very significant savings.

This study emphatically proved that it is not only the first cost that should be taken into consideration when specifying materials but the total ongoing related cost including operational and maintenance costs.

Stainless steel has the added benefit of increased safety in a fire situation, as it retains a higher level of strength at elevated temperatures, than carbon steel. In a separate study in which stainless steel and other materials were subjected to direct and radiated heat, structural integrity was maintained, whilst under load, at temperatures over 1,000°c.

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Handrails

Introduction

Whether for interior or exterior use, stainless steel can be seen in most countries in the world, in the form of handrails, balustrades, and staircases.

There are a great many variations in design for these components using tubular or oval sections, square or rectangular, flat plate, or drawn section (thin gauge stainless drawn onto a hardwood core).[1]

Drawn sections permit variations is section shape whilst providing a solid rail with a thin skin of stainless steel.

Infill panels may be safety glass, stainless wire mesh, or simple sections.

Key features in the use of stainless steel are aesthetics, strength, corrosion resistance, formability, weldability, and ease of maintenance.

In densely populated areas such as shopping malls and airports where rails may be subject to accidental damage from trolleys, cases etc, the high impact resistance of stainless steel and the fact that it has no added surface protection such as paint that will show damage, reduces the need for ongoing maintenance.

In roadside areas, or as bridge rails and parapets, stainless steel provides a maintenance free security barrier that will not be adversely affected by road de-icing salts.

Stainless steel provides the designer with a wide choice of end product to suit the location.

Surface Finish

Satin finish and bright polished (number 4) are the types of finish popularly specified. Sections may also be electro-polished.

Material Specification

The readily weldable austenitic grades 304 (for interior use) and 316 (for exterior use) are usually specified. A ferritic grade type 430 may also be used for interior dry atmospheres.

Design & Fabrication

GTIG and argon arc welding are the most common processes used and provide a neat weld that can be ground smooth and polished.

Courtesy of Krupp, Germany

Fig.1 Handrail with stainless steel infill wire

Care must be taken in design and manufacture to ensure that the welds can be ground and polished particularly with uni- directional finishes where polishing must be carried out in the direction of the pattern or grain.

All end plates, ball joints, screws and fixings must be in stainless steel of similar grade to avoid galvanic corrosion or staining. All manufacture should be carried out in a separate part of the workshop to carbon steel fabrications, and all tools and grinding wheels used should be dedicated to stainless production to avoid contamination by iron particles.

Austenitic stainless steel has high ductility, around 40%, and is, therefore, readily formable. Account must, however, be taken of the work hardening characteristics of the material and springback. Approximately 50% more load or force is required to form stainless steel than for carbon steel and about 5% should be allowed for springback.

Bending

Tubular handrail sections can be bent to a tight radius on specialist equipment.

2 x diameter is the minimum inside radius for tubular sections and the use of core bars are often used to prevent surface wrinkling.

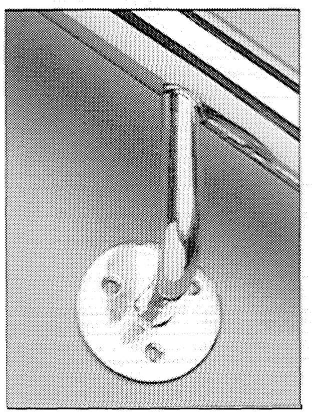
Plate sections can be bent to a radius equal to the thickness of the material.

Joining

Tube lengths may be joined by a variety of methods. Welded joints, sleeved joints (which may incorporate a socket set screw on the underside to secure the connection), or the use of a spigot pressed into the tube end, are all popular types of handrail connection.

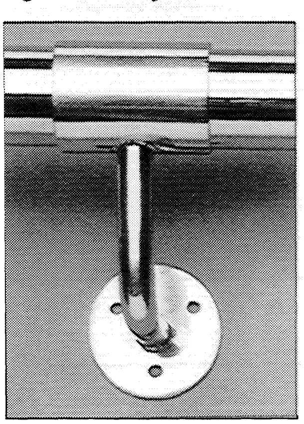
Care must be taken to ensure that socket set screws do not protrude from the tube surface. The use of square or rectangular section stanchions will alleviate the need for profile cutting and simplify weld clean up.

Welding can be avoided, or concealed, by the use of ball joints or sleeved ends.[2]



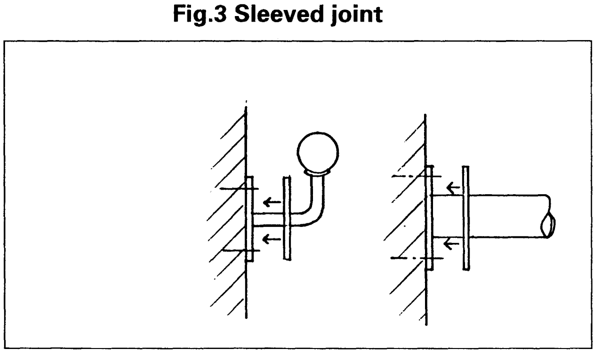
Courtesy of Racco Products Ltd.

Fig.2 Welded joint



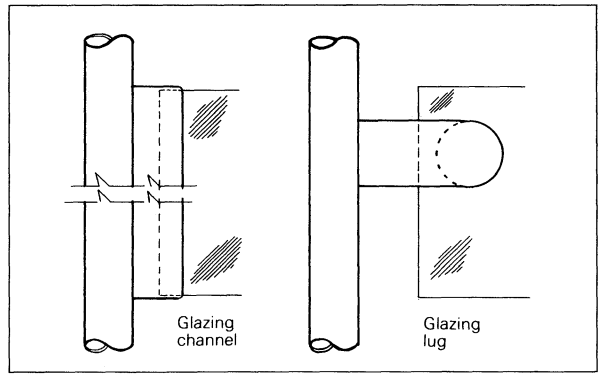
Courtesy of Racco Products Ltd.

Fig.3 Sleeved joint



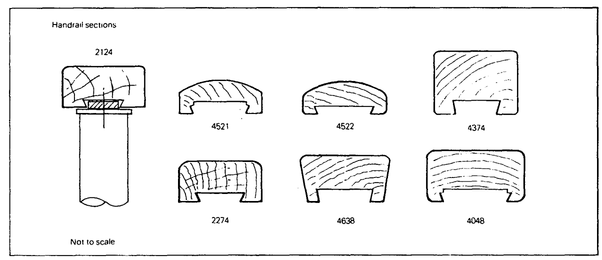
Courtesy of Racco Products Ltd.

Fig.4 Wall fixings



Courtesy of Racco Products Ltd.

Fig.5 Glass fixings

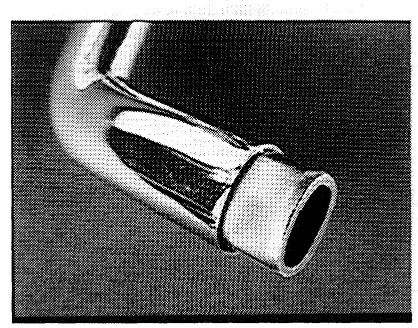


Courtesy of Drawn Metal Ltd.

Fig.6 Handrail sections using thin gauge stainless steel drawn onto a timber core

Photo D J Cochrane

Fig.7 Flat bar handrail



Couresy of Malcom Cole Group

Fig. 8 Joining with a spigot[4]

Cleaning

Generally, an occasional wipe with a damp cloth followed by a dry duster will retain the pristine surface of stainless steel.

Proprietary stainless steel cleaning agents are available which will remove finger marking and other light contaminants. Wire wool must never be used unless made from stainless steel. In swimming pools, modern pool atmospheres are highly aggressive due to the use of chlorine, hypochlorite, and other chemicals in the water.

Under these conditions it is advisable to clean the stainless steel weekly to avoid the build up of contaminants on the surface which could lead to staining.[4]

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