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APPROPRIATE SELECTION OF METAL THICKNESS FOR USE IN WALLING AND ROOFING APPLICATIONS

MCRMA Technical Paper No. 20

The Building Envelope Authority

Contents

For up to date information on metal roof and wall cladding, including downloadable construction details, visit **www.mcrma.co.uk**.

Foreword

The Metal Cladding and Roofing Manufacturers Association represents leading manufacturers in the metal roofing and cladding industry and seeks to foster and develop a better understanding amongst specifiers and end users alike of the most effective use of metal building products, components and systems.

The Association has two main objectives: -

1. To make sure that published standards in the UK and Europe for metal roof and wall cladding are in accordance with best practice so as to ensure a European-wide standard of product excellence which can be written into product specifications.

2. To provide a basis for technical excellence encompassing product development, component and detail design, improved manufacturing and co-operation on installation techniques and standards

1.0 Summary

The effect of thickness (gauge) on the performance of metal systems in building applications cannot be under-estimated and the responsibility for not only ensuring that appropriate materials are specified, but selected and used correctly is placed upon all parties within the supply chain.

With regard to the selection of coil or sheet for use in roll-forming applications it is of particular importance that the material selected and used complies fully with the appropriate standards of tolerance on dimension and shape: BS EN 10143:2006 for pre-finished steel and BS EN 485 Part 4 for cold rolled aluminium with normal tolerance as a minimum requirement.

For those specifying and using materials the key points must be: -

- To state the standard that is to apply.
- Ensure that the material to be ordered and used: -
  - Meets the requirements of the standard.
  - Is delivered correctly.
- Ensure that the structural calculations used are specific to the profile proposed and the nominal thickness of the material proposed.
- Ensure that the reaction to fire performance is valid for the nominal thickness of the material proposed.

The use of metal for roofing and walling applications has, through structural calculation and over a period of successful performance in service, determined those thicknesses of material which are normally specified.

The performance of these materials in use (including the construction phase) is determined by loading arising from positive and negative forces, wind, dead weight and point load or impact, with the main requirements being: -

- Safety in use.
- Weatherproofing
  - Water penetration
  - Air tightness
  - Robust details
- Appearance and ability to maintain in the long term.

Using materials which vary beyond the limits of the tolerances allowed introduces the possibility that the building design performance will not be met and, although this may result in short term savings, could add considerably to the whole life costs of the building through poor performance and potential for remedial works or worse.

2.0 Introduction

Metal cladding systems provide an efficient, attractive and reliable solution for a wide variety of external building envelopes. Over the years they have evolved from the single-skin metal cladding often associated with agricultural buildings to sophisticated systems which are used in industrial, retail and leisure applications throughout the United Kingdom.

However, as with all construction components, the ability of the cladding to satisfy its functional requirements is dependent on its correct specification and installation and, equally as important, on its interaction with the other elements of the building envelope and structure.

In the continuing quest for improved cost effectiveness in all forms of business generally and construction in particular, combined with the need to meet budgetary constraints, the consideration of alternative methods and choice of materials to meet a specified desired outcome is a valid and necessary process that must be undertaken. The completed cost of construction is directly impacted by the costs of materials used within the construction process.

It is key, however, in each step of this process to understand that any one choice of a material type or component does not exist in isolation and has potentially wider reaching implications on other aspects of the performance of the completed whole.

The individual components that make up the cladding system are often specified and supplied separately, with the potential for insufficient attention being paid to the way in which they interact.

This paper will focus on the potential effects of seeking to reduce the effective gauge of a steel sheet used in the manufacture of an external cladding system.

It will consider the following: -

- Nominal thickness and adherence to the relevant standards.
- Tolerance specification and the potential for non-compliance within a normal distribution.
- Safe working load as a function of material gauge.
- Use of appropriate load span tables as guides to cladding performance incorporating bending moments.
- Potential impacts on performance and other components in the building system.

It is the clearly stated position of the MCRMA and its members that the best assurance of compliance with the appropriate standards and performance expectation is to source systems and products from reputable manufacturers who can demonstrate the pedigree of the materials used and support design requirements with job specific data.

3.0 Nominal thickness/gauge

When sheet metal is manufactured at the mill it is produced to a target or 'nominal' thickness. However, as with all manufacturing processes it is inevitable that there is a variation in the production process and, as such, variations in the final thickness of the finished material is unavoidable.

3.1 Steel

With regard to the selection of steel for use in metal roofing and cladding applications gauge tolerances for hot dipped products are determined from the standard BS EN 10143:2006, Continuously hot-dip coated steel sheet and strip: tolerances on dimensions and shape, and the allowed positive or negative variance (tolerance) compared with the nominal thickness of the material varies with the nominal thickness, coil width and the grade of steel (as determined by its minimum specified yield strength).

Under normal circumstances the steel coil used in UK markets is typically within the following ranges: -

- Nominal steel thicknesses of between 0.4mm and 0.7mm.
- Coil widths of: -
  - less than 1200mm
  - greater than 1200mm and less than or equal to 1500mm
- Minimum specified yield strengths of: -
  - less than 260 MPa (260 MN/mm^2)

3.2 Aluminium

The standard from which the tolerances on thickness of aluminium sheet may be determined is as follows: -

- BS EN 485: Aluminium and aluminium alloys, sheet, strip and plate. Part 4 – tolerances on shape and dimensions for cold-rolled products

The tolerances positive or negative vary according to the Alloy Group (I or II) which relate to the chemical composition of the materials and are determined according to BS EN 573:3. Material belonging to Alloy Group I is normally used for roll forming and construction purposes in the UK.

4.0 Normal range of thickness

Whilst the thickness of metal selected for use will vary depending on product and application the nominal values in Table 1 are generally accepted as being normally used in the UK.

Table 1

Millimetres (mm)	Steel	Aluminium
Roof Weather Sheet	0.7	0.8 to 1.2
Wall Weather Sheet	0.5	0.8 to 1.2
Flashings	0.7	0.9
Liner Sheet	0.4	0.5
Structural Liner Sheet	0.7	0.9

5.0 Commonly used coil widths

The profile of the finished product will tend to dictate the requirements of the manufacturer with regard to selection of the coil width of the material in the first instance.

In general terms most manufacturers seek to achieve a cover width of the finished product of 1 metre with steel roofing and walling products.

- Weather sheets with a typical profile depth of 31mm or 32mm generate a need for coil widths of the order of 1220mm to 1250mm.
- Liner sheets with a typical profile depth of 19mm or 20mm generate a need for coil widths of the order of 1110mm to 1150mm.

Aluminium sheet products available in the market typically provide cover widths of the finished product of up to 500mm and would as such require coil width of up to 700mm although certain profiles could require coil widths of less than 500mm.

It is worthy of note that aluminium profiles made from coils of greater width are available in the market.

6.0 Yield strengths – construction purposes

From the UK and European perspective the key issue in terms of performance under load relates to the bending moment of any force applied.

Typically, the yield strength of steel supplied for the manufacture of wall or roof profiles is in the range less than 260 MPa and is generally of yield strength 220 MPa.

As outlined above, aluminium used for roll formed products is in Alloy Group I and usually from series 3000 and 5000 alloys for which the maximum specified magnesium and manganese contents are each no greater than 1.8 % and their sum no greater than 2.3 %.

With reference to the standards applying the tolerances on thickness (in millimetres) allowable for steel materials with these typical characteristics are as below: -

Table 2

Nominal thickness		± Tolerance in mm for given width			
		Normal Tolerances		Special Tolerances	
Min	Max	≤ 1200	1200 ≤ 1500	≤ 1200	1200 ≤ 1500
0.2	0.4	0.040	0.050	0.030	0.035
0.4	0.6	0.040	0.050	0.035	0.040
0.6	0.8	0.050	0.060	0.040	0.045
0.8	1.0	0.060	0.070	0.045	0.050
1.0	1.2	0.070	0.080	0.050	0.060

A summary of the tolerances on thickness allowable for aluminium from Alloy Group I are contained in the following table: -

Table 3

Specified Thickness		± Tolerance in mm for given width		
Min	Max	≤ 1000	1000 ≤ 1250	1250 ≤ 1600
0.2	0.4	0.020	0.040	0.050
0.4	0.5	0.030	0.040	0.050
0.5	0.6	0.030	0.050	0.060
0.6	0.8	0.030	0.060	0.070
0.8	1.0	0.040	0.060	0.080
1.0	1.2	0.040	0.070	0.090
1.2	1.5	0.050	0.090	0.100

7.0 Tolerance specification – potential for non-compliance

As may be seen from the foregoing key points with regard to material specification there are several factors to be considered when selecting material(s).

7.1 Steel

In terms of coil width and yield strength the ranges for compliance are relatively wide.

However in terms of the nominal thickness of the metal it is important that: -

- The material is specified to the appropriate tolerance.
- The material is supplied as specified.
- It is understood what is being measured and how.

In order to highlight the potential for non-compliance it is sensible to consider the case for each nominal thickness used in everyday circumstances as follows: -

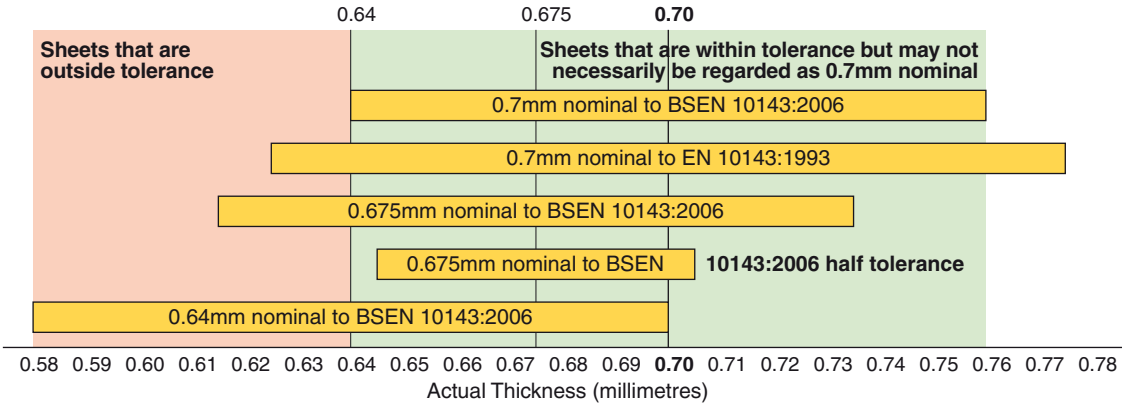
7.1.1 Roofing weather sheet

Normally the outer sheet of a roof will utilise a profile manufactured from coil of 1250mm width with nominal thickness of 0.7mm and minimum specified yield strength of 220 MPa.

From BS EN 10143:2006 the tolerance on thickness is ± 0.06mm (see tables in Section 6.0) the lower limit on thickness being 0.64mm with an upper limit of 0.76mm.

If we consider that 100% of material can be produced within these tolerance limits by the producing steel mill it is reasonable to assume that the thicknesses measured across a wide enough sample would be normally distributed – i.e. follow a bell shaped distribution curve about the mid-point of the range

Figure 1

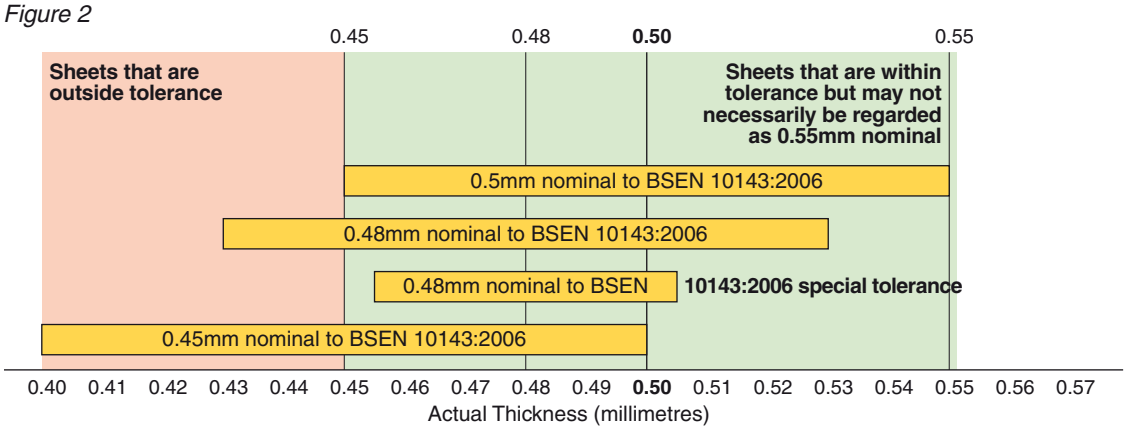


7.1.2 Walling weather sheet

The outer sheet of a wall will typically utilise a profile manufactured from coil of 1250mm width with nominal thickness of 0.5mm and minimum specified yield strength of 220 MPa.

From BS EN 10143:2006 the tolerance on thickness is ± 0.05mm (see tables in Section 6.0) the lower limit on thickness being 0.50mm with an upper limit of 0.55mm.

Figure 2

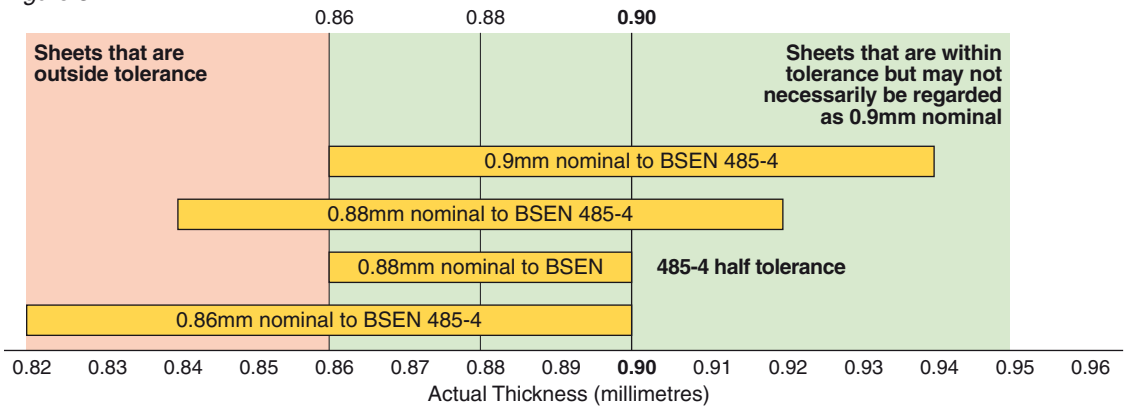


7.2 Aluminium weather sheet

Most aluminium weather sheets will be manufactured from material of less than 1000 mm width with nominal thickness of 0.9 mm and from Alloy Group I.

From BS EN 485-4 the tolerance on thickness is ± 0.04 mm (see tables in Section 6.0); the lower limit on thickness being 0.86 mm with an upper limit of 0.94 mm

Figure 3



7.3 Flashings

Flashings are typically made from metal of nominal thickness in accordance with the roofing weather sheet, i.e. 0.7mm in the case of steel.

The most commonly identified effect caused through the supply of below tolerance metal for flashings is the tendency of the flashing to bow or ripple post installation.

Generally whilst there are few guarantees or warranties applied in the case of flashings and whilst there may be no major structural implication resulting from the supply of out of tolerance material the flashings have a major role with regard to: -

- Weather tightness of the completed building.
- Robust detail – the interfaces between the structural elements.
- Aesthetic appearance.

Hence it is of the utmost importance in this regard, whether relating to water ingress or air tightness, that great attention is paid to the specification of the materials used for the manufacture of flashings since the impact is most noticeable at the interface between complementary systems.

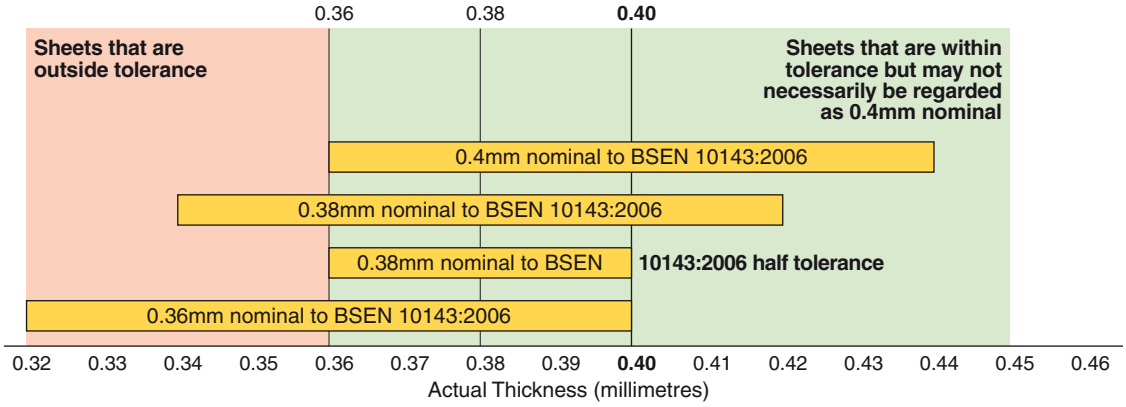
7.4 Liner sheets

The liner sheet of a roof or a wall in a built up construction will typically utilise a profile manufactured from coil of 1150mm width with nominal thickness of 0.4mm and minimum specified yield strength of 220 MPa.

From BS EN 10143:2006 the tolerance on thickness is ± 0.04mm (see tables in Section 6.0) the lower limit on thickness being 0.36mm with an upper limit of 0.44mm.

Whilst the foregoing represents what the standard on tolerance for steel with nominal 0.4 mm thickness allows, it should be noted that to ensure full compliance and safe roofing systems, MCRMA members have undertaken to only provide liner sheet with actual thickness of 0.4mm or greater.

Figure 4



As may be seen from the graphics it is possible to specify a nominal thickness (that whilst not necessarily the accepted nominal thickness for that particular use) with a tolerance that could be contained within the tolerances for the nominal thickness whether under BS EN 10143:2006 or BS EN 485-4; i.e. by specifying a (target) thickness with special tolerance, for example 'half tolerance' or 'zero negative / full positive' tolerance.

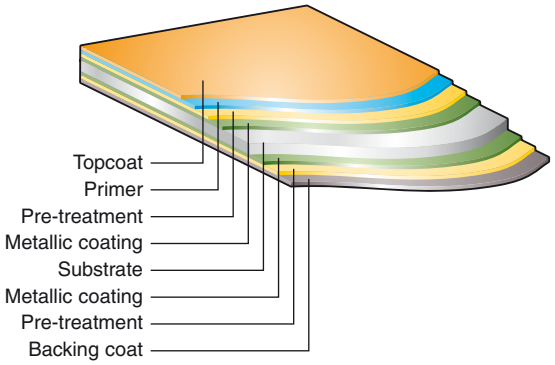
It is not possible to specify a lower than nominal thickness under normal tolerances and be able to guarantee that the coil will be within tolerance for a generally accepted nominal thickness for that particular use. This means that on some occasions the coil (due to the normal distribution of manufacturing processes) will be below the lowest level of thickness allowable and hence out of tolerance.

8.0 Measuring the thickness of a coil or sheet

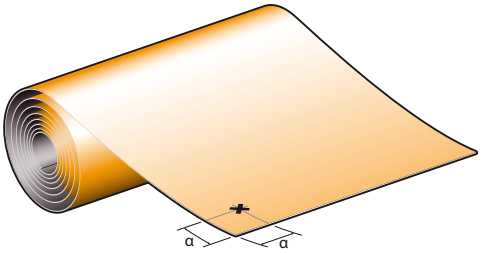
Coated metals may have a protective coating and decorative finish to both sides; each of these coatings has its own tolerance.

How these layers of surface treatments and coatings combine to produce the finished product is shown in Figure 5 below.

Figure 5



According to BS EN 10143:2006 the thickness of steel substrate should be measured a minimum distance of 40 mm from the cut edge; for aluminium under BS EN 485-4 this distance is 10 mm.



In the UK the most commonly used external coating for steel is plastisol of 200 microns thickness with an embossed finish accompanied by a reverse side coating of up to 20 microns, depending on the application, but other finishes do exist and each has its own 'normal' thickness and tolerance. Other paint finishes or coatings may be applied whether polyester or similar with varying thicknesses, each with their own tolerance levels.

Similarly aluminium may also be supplied with a paint coating. For external purposes the most commonly used would be a PVDF material of 25 micron thickness and for internal purposes of 15 or 18 micron thickness.

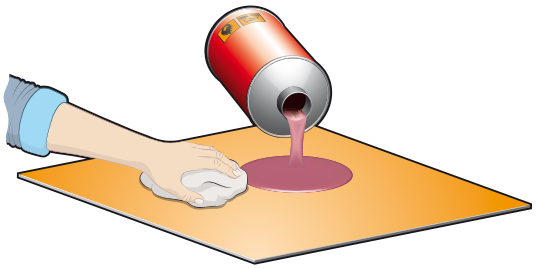
Many aluminium applications retain the standard mill finish and for flashings and similar apply a powder coating treatment post manufacture.

All coatings applied are designed to provide a particular characteristic in terms of the paint system but do not contribute directly to the load bearing capability of the metal.

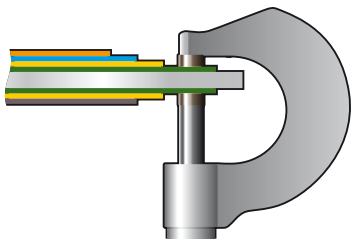
It is important in measuring gauge to only measure those elements which bear the load. This is necessary since each coating that is applied carries a tolerance on thickness and whilst it may appear simpler to measure the external thickness of the whole paint system it cannot be relied upon as a true (or indicative) measure of the thickness of the substrate and its metallic coating.

For example, in the case of a complete paint system of up to 0.25mm thickness, tolerances of say approximately 0.03mm are possible which, in the case of these being positive where the steel substrate was below the lower tolerance limit, could result in a total thickness appearing to be acceptable within the "overall" measure of thickness.

Therefore in order to properly measure the true thickness of the load bearing element it is necessary to remove the paint coatings. This may simply be achieved through the appropriate use of a proprietary paint stripper, taking care to follow the guidance on use.



This measurement should be conducted by use of a properly calibrated micrometer as shown…



9.0 CE Marking – ensuring that the correct material is delivered

The CE mark and its associated information label helps demonstrate that any product has been tested in accordance with the appropriate European standard and in the case of metal supplied for walling and roofing applications complies with the Construction Products Directive.

Where CE marking is in place the product should be supplied with labels or packaging that clearly identify the values of the characteristics tested, all of which are subject to external inspection and checking.

The requirement for CE marking of coil or sheet will require the following to be included in the labelling: -

- Standard to which the product has been manufactured
  - Tolerance class
- Description of the product
  - Coil width
  - Yield strength
  - Coatings, paint finish(es), and colour
- Fire rating

It should be noted that within the tolerances allowed there are three classifications, as follows: -

- Class 1 Full (normal) tolerance
- Class 2 Special tolerance
- Class 3 Zero negative tolerance

The product specification and requirements for supply of 'Self supporting metal sheet for roofing, external cladding and internal lining' are covered in BS EN 14782:2006, which again allows for the comparison between products supplied and cover the following criteria: -

- Nominal gauge
- Resistance of roofing products to concentrated forces
- External fire performance
- Reaction to fire performance

10.0 Safe working load as a function of material thickness

Intuitively it is straightforward to understand that as the thickness of a given material reduces so does its resistance to bending under loading conditions, assuming that all other characteristics of the material remain constant, i.e. composition, yield strength and coil width.

Figure 6

Safe Working Load at 1.8m span for given thickness on 32/1000 profile

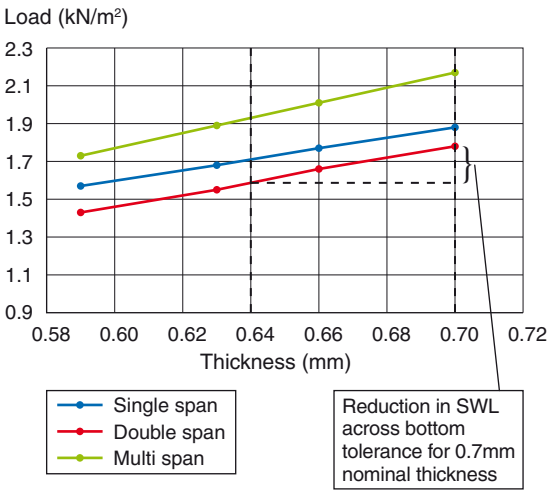


Figure 6 shows the range of variation typically occurring where span conditions are different for the same material, where the thickness is the actual material gauge after allowing for coating systems.

However, it should also be noted that for materials which, in some cases, may possibly be considered to be within tolerance but not necessarily complying with a nominal 0.7mm thickness, the safe working load capability may be reduced by factors in excess of 20%, i.e. where the actual thickness is 0.58mm or less (see Figure 2).

The information used to construct the above graphs is taken from the load span tables of MCRMA members using Corus Colors material and verified to EC3 methods.*

**Note: These calculations were produced for Corus Colours by the Steel Construction Institute. The profile was a typical 32/1000 which could be manufactured from one or all of Corus's supply chain partners. The properties were calculated to EC3 using material with a minimum yield strength and using material with tolerance as defined within EN 10143:2006*

11.0 Resistance to loading

11.1 Non fragility

A major cause for concern in construction work is the potential for death or serious injury caused by falls from height and in particular from, or through, a roof.

It is clearly necessary to ensure that all working conditions, safe systems of work and materials specified should take account of this potential.

It is appropriate that the following points should be addressed in the specification: -

- The specified construction/assembly is designated as being non-fragile.
- The supplier classifies the roof system as being non-fragile and can support this claim with relevant test data.
- Any condition affecting the non-fragility of the construction should be clearly stated.

Compliance with these key points will help ensure adherence to the ACR (CP)001:2007 Rev 3 *Recommended Practice for Work on Profiled Sheet Roofs*.

How to check whether a particular roof system may be considered non-fragile is covered in ACR (M)001:2005 *Test for Non-Fragility of Profiled Sheet Roof Assemblies* which verifies whether the system can support without catastrophic failure the loads that will be applied by a person falling onto it.

11.2 Walkability

Walkability is a commonly used word/phrase which tends to be used for thicker liner sheet systems but which should not necessarily be used to denote metal thickness since the phrase may only be considered appropriate where the system is completely fixed and deemed non-fragile.

The need for a walkable liner sometimes arises from the desire to use a liner system as a safe method of access but without the potential for damage through local distortion to the sheet.

The likelihood of deformation or damage to any sheet that is walked upon is increased with thinner materials. Products that have shallower profiles are more likely to be susceptible to damage or distortion.

Where safe access to a roof for general maintenance and repairs are required, the metal system must be designed to accommodate and withstand the loads produced by those persons conducting any such work.

The design loads to be met are: -

- General load of 0.6 kN/m^2
- Point load of 0.9 kN

These performance criteria are established in accordance with EC3.

Any failure to meet the nominal requirements within the relevant standards may affect the capability of the system or product to meet the required load span requirements and increase the potential for failure.

11.3 Use of load span tables

Each manufacturer/supplier of profiled metal sheet used for construction will provide as a matter of course a set of load span tables which serve to assist in the selection of the appropriate metal cladding or roofing solution for a given set of design parameters or likely loading conditions in use.

What will be noticed is that each manufacturer will identify slightly varying figures either for span, given a set load, or for the maximum safe imposed load given a specific span requirement.

It is important to be aware of these differences since they arise for a variety of reasons but may normally be attributed to the following: -

- Choice of material
- Profile design/shape
- Fixing regime

The choice of material, the main subject of this paper will to some degree impact on the other two potential variants.

12.0 Profile shape

As with all roof or wall sheeting the design of the profile will help determine its load bearing capability in use; all profiles will have their own variations depending on: -

- Historic perspective
- Roll forming equipment used

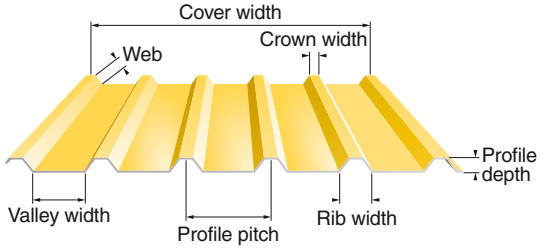
The dimensions of the sheet, for example in a typical 32/1000 roofing profile made from steel with a nominal 0.7mm steel will vary across each element to achieve the 1000mm cover width requirement.

Variations in the following elements will help determine how the profile performs in use: -

- Profile pitch
- Profile depth
- Crown width
- Valley width
- Rib width
- Web

Figure 7 below identifies where each of these dimensions are measured and helps demonstrate how the adjustment of one particular dimension (or angle of the rib/web) will affect the other dimensions within any given width of coil.

Figure 7



For greater load bearing capabilities profiles may be designed with additional stiffening ribs again, the placement and size of these ribs will vary from one manufacturer to another.

It should be noted that each manufacturer publishes its load span tables based upon the manufacture of its profiles with material of nominal thickness.

Where any doubt exists with regard to safe load bearing capability for any particular design then advice should be sought from the manufacturer or a qualified design engineer.

Clearly where profiles are potentially manufactured from metal that is incorrectly specified with regard to its thickness and has the potential to be out of tolerance then the load span tables are not applicable and appropriate expert advice should be taken.

13.0 Fixing regime

Warranties or guarantees of performance received from manufacturers are generally explicit with regard to the need for fixing in accordance with their own specific methods, type of fixing, frequency, maximum spacing and so on.

These fixing requirements are made based upon the use of nominal thickness material.

The use of materials that are thinner than the tolerance limits will tend to ripple (see section 7.3 on flashings) and deliver impaired performance regardless of whether the appropriate fixing regime has been applied.

As with all fixings it is necessary that the correct fastener is used with regard to the application and that the fasteners are fixed with the correct torque setting – any over-tightening will tend to cause distortion around the fastener and this will become emphasised where lighter gauge material is used.

The potential for failure in fasteners is highlighted in areas of maximum loading where thinner/lighter gauge materials are used. Important issues to be aware of in these circumstances may be summarised as: -

- Potential for fasteners tearing or pulling through lighter gauge cladding sheet.
- The need for torque control when fixing to avoid thread stripping.
- Local distortion which may lead to pooling on roofs and increased potential for corrosion and failure.

14.0 Fire performance

The fire performance of roofing and walling systems are considered separately.

14.1 Roofing applications

The generic performance of steel and aluminium systems in roofing applications has been assessed according to EN 1187 and allocated as follows under relevant Commission Decisions related to the calorific value of the material as summarised below: -

Table 4

Commission Decision	Coating Calorific Value	Classification	Notes
2000/553/EC	< 4 MJ/m^2	Satisfies without the need for testing	
2005/403/EC	< 8 MJ/m^2	$B_{ROOF}(1)$; $B_{ROOF}(2)$, $B_{ROOF}(3)$	Max Dry Mass of 330g/m^2

Both of the above decisions have a specific requirement that the thickness of the material be greater than 0.4mm.

14.2 Walling applications

As with load bearing capability it is perhaps intuitive that material thickness has an effect on the fire performance of pre-finished steel in walling applications with regard to reaction to fire; this is supported by research through the European technical committees.

The reaction to fire performance which is normally quoted is for steel which has greater thickness than the material which was tested.

Most steel sheeting for wall cladding is 0.5mm or greater. For the classification to be valid the testing must have been conducted on material of at least 0.5mm.

Where the material does not meet the requirements of BS EN 10143:2006 it may not claim the classification.

15.0 Interaction with other building components

Other MCRMA documents deal more specifically with issues relating to interactions between various components within any building system but it is worthy of note in this context that where nominal thickness and the potential to be out of tolerance is a possibility then further impacts will need to be considered.

From a material selection point of view this paper has identified the reduction in safe working load for a given span as being significant as material thickness reduces.

Reductions in safe working load of circa 20% will, towards the limits of loading, compromise the structure.

What should also be borne in mind is that under the continuous stresses and strains of normal life a building and its envelope (wall or roof) is subject to load and re-load over time, whether positive (gravity) or negative (suction). It is sensible to consider that where a material is below its tolerance limit then it is less able to sustain the rigours of constant change.

It is conceivable that such changes are most likely to be recognised early (if not through catastrophic failure) at those points where the cumulative effects of any tolerance variation are magnified, i.e. at fixed points.

In the case of cladding or roofing this will be where the system is fixed either by purlin or other support structure to the main structure and through the fixings.

16.0 Conclusions

The fact that manufacturers require tolerances against which they manufacture demonstrates that within any process there is the potential for a range of outcomes regardless of the control exerted during the process.

In order to ensure that the appropriate levels of safety are met and adhered to, it is imperative that in the specification, manufacture and use of metal in walling and roofing applications all due care is taken and that the materials supplied and used are within the tolerances allowed by the relevant standards whether for steel or aluminium.

It is possible to specify materials and special tolerances that are not necessarily addressed within the standards but that these must be capable of being achieved by the manufacturer and agreed between the parties – it then becomes the responsibility of the manufacturer/ supplier (mill) to meet the agreed specification.

The potential for adverse impact with regard to safe working load is significant in the case of materials supplied and used below the minimum tolerances allowed; the importance of appropriate professional advice on the validity of load span tables and specific loading conditions cannot be overstated.

The MCRMA, its members and associates remain committed at all times to the continuing development and safe use of metal cladding and walling systems.

17.0 Bibliography

BS EN 10143:2006 –Continuously hot-dip coated steel sheet and strip: Tolerances on dimensions and shape

BS EN 485: Aluminium and aluminium alloys, sheet, strip and plate. Part 4: Tolerances on shape and dimensions for cold-rolled products

BS EN 573:3

BS EN 14782:2006 Self supporting metal sheet for roofing, external cladding and internal lining. Product specification and requirements

EC3 – Eurocode 3: Design of steel structures (EN 1993)

ACR (CP)001:2007: Recommended practice for work on profiled sheet roofs.

ACR (M)001:2005: Test for Non-Fragility of profiled sheet roof assemblies

EN 1187:2002: Test methods for external fire exposure to roofs

2000/553/EC: External fire performance of roof coverings

2005/403/EC: External fire performance of roofs and roof coverings

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