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CPD APPROVED

GD39 SUSTAINABILITY AND DURABILITY OF METAL ROOFING AND CLADDING SYSTEMS

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SECTION 5: METALS – STEEL AND ALUMINIUM

5.1 Metals

The two most common metals used for manufacturing profiled roofing and cladding sheets are mild steel, especially in a colour coated format, and aluminium. Other metals are used occasionally such as metallic coated steel, stainless steel, copper, zinc and bi-metallic materials and these will be briefly commented on. These other metals will be discussed in Section 6.

5.2 Mild steel

Mild steel will rust when exposed to air and water so requires protecting by coating with a sacrificial metal (i.e., hot-dip galvanising (HDG) with zinc) and/or organic paint coatings. In roofing and cladding materials both protective methods are usually used together but there are instances where profiled sheets are available without a paint coating.

As well as hot-dip galvanising with zinc there are a few variations to create metallic protection coating by adding aluminium and other metals (e.g., magnesium) to zinc, these are often under proprietary brand names e.g., Galvalloy (95% zinc and 5% aluminium), Aluzinc/ Zincalume/Galvalume (55% aluminium and 45% zinc).

These protective coatings claim to offer greater durability than 100% HDG zinc coatings especially at cut edges which are more vulnerable to accelerated rates of corrosion. Where a protective paint system has also been used with HDG this can result in premature paint peeling and delamination at the cut edge. The protective mechanism for these metallic coating variations is a combination of sacrificial protection provided by the zinc and barrier protection provided by the aluminium (or other metal) forming an oxide on the surface.

The durability of mild steel protected by metallic coatings is generally based on the thickness of the zinc layer. Damage to or partial removal of the protective metallic coating can accelerate the corrosion of the steel substrate.

Galvanised steel can suffer from inverse corrosion at temperatures above approximately 70°C and where there is moisture present. In this instance the steel becomes sacrificial to the zinc and corrodes. This can occur at end lap positions with dark coloured sheets laid to low pitches.

5.2.1 Colour coated steel

Paint coatings applied to galvanised (or other protective coating) steel comprise multiple layers, see figure 5.1, and generally consist of a pre-treatment layer, a primer, the coloured paint layer and sometimes a clear protective layer to the outer weathering side. The reverse side consists of a pre-treatment layer and a backing coat. In some environmental conditions there may be the requirement for a double-sided coating where the external weathering side coating is also applied to the reverse side.

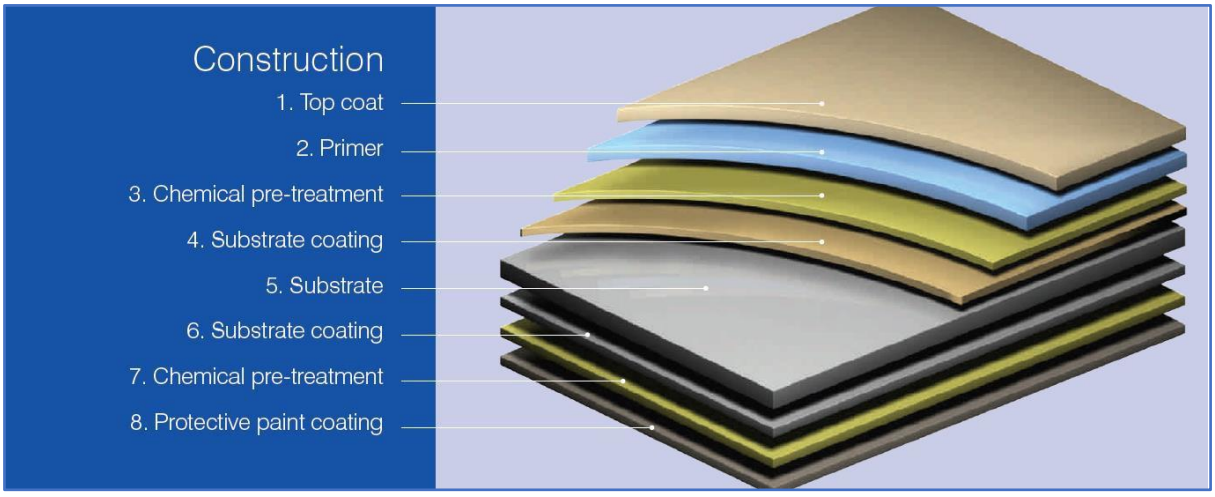

Figure 5.1 – Typical multi-layer coating system on steel

There are a several types of organic paint finishes that can be applied to steel such as plastisol, polyester, polyurethane and polyvinylidene fluoride (PVDF also known as PVF_2). Reverse side coatings will usually be polyester or epoxy unless a double-sided coating is specified. Thicknesses of finishes will vary from approximately 25 µm (e.g., polyester) to 200 µm (e.g., plastisol). Reverse side coatings will typically be between 5 and 12 µm.

Surface finish varies from one paint system to another with the thicker paints (e.g., plastisol) having an embossed or leather grain effect, see figure 5.2, and thinner paints (e.g., polyurethane, PVDF and polyester) having a smoother finish. An embossed or leather grain surface can conceal minor scratches and blemishes but can trap dirt and is aesthetically considered more suitable for use on roofs.

Figure 5.2 – Embossed effect surface finish

A smooth surface can provide a more aesthetically better finish and may be considered more acceptable for use as wall cladding; however, the smooth surface does not conceal minor scratches and blemishes so greater care must be taken when handling and installing the cladding sheets.

Surface colour can have an impact on the durability of paint finishes. Lighter colours reflect thermal radiation better than darker colours, keeping the surface temperature lower in warmer conditions and higher in colder conditions which can reduce the pace of degradation of the paint system. It is normally recommended that light coloured coated steel sheets are used on roofs.

British Board of Agrément (BBA) certificates for pre-finished steel coil will give an indication as to the minimum appearance or decorative life (usually the period before first maintenance painting is considered) for the coating. This will be less than the expected design life of the coating in protecting the steel substrate against corrosion. Table 5.1 gives an overview of the typical minimum appearance or decorative life of various generic coating systems based on information from pre-finished coil BBA certificates from several manufacturers. These typical life expectancies may differ from an individual manufacturer's BBA certificates, and it is therefore advisable that the manufacturer is consulted to obtain a more definitive indication of their coating system's durability performance.

Coating System	Typical minimum decorative/appearance life (years) of coating for various atmospheric atmospheres				Typical minimum design life (years)
	Rural or Urban	Coastal	Normal Industrial	Severe Industrial	
High Performance Plastisol	25	20	25	20	>40
Plastisol	10 – 25[1]	10 – 25[1]	10 – 25[1]	10 – 25[1]	10 – 25[1]
Multiple layer polyamide modified coating	25 – 30	15 – 20	25 – 30	15 – 20	>40
Polyurethane	15	10	15	10	20
PVDF	15	10	15	10	20
PE	5 - 15[1]	-	-	-	15

Notes 1. Life expectancies differ for different colours and manufacturers

2. Life expectancies will be dependent upon location, aspect and use (roof or wall)

Table 5.1 – Overview of typical steel coating system life expectancies based on BBA certificates

Actual product warranties offered for coating systems are dependent upon many different factors such as material supplier, coating, surface colour, location, application etc. The warranty will also vary depending upon an existing application involving weathered material and the future development of enhanced systems which may improve with ongoing R&D. Performance warranties should be discussed with individual suppliers at the time of product specification and the warranty should be agreed in writing at the design stage.

The degradation hierarchy of the breakdown of a paint system can be taken as chalking, cracking and blistering, in order of increasing seriousness. If maintenance painting is then not undertaken after the last stage, there is a likelihood that there will be a development of rust or corrosion products and/or flaking of the paint.

Where there are areas of colour coated profiled sheet with exposed eaves and soffit areas there maybe the need for the reverse side coating of the sheet to be improved with a similar coating as the top weathering layer.

The thickness of the paint system can usually provide good protection from minor scratches and abrasion but deep scratches which fully penetrate or remove the paint system can lead to premature corrosion of the steel substrate and should be repaired with a compatible anti-corrosive paint.

Surfaces which are not subject to natural washing by rain, e.g., soffit areas, below framed PV panels etc. may have an increased risk of corrosion and degradation of the material and/or its coating, which may negate any material/coating warranty. The surfaces should be cleaned with a greater frequency than other areas in order to restore the paint systems appearance and remove any corrosive deposits. This can usually be done by hosing with water and a neutral detergent, although it is advised that written approval and any further maintenance requirement is sought from the roof system manufacturer/supplier prior to specification and installation.

At cut edges of the profiled sheet edge corrosion is inhibited by the sacrificial action of the protective metallic coating. Factory cut edges are usually a clean cut; site cut edges though may lead to a rougher edge which is more susceptible to corrosion and should be kept to a minimum and would benefit from being coated with an anti-corrosion paint to delay the formation of edge corrosion.

Cut edge corrosion issues leading to premature breakdown of the protective paint system often occur at end lap positions on roofs, see figure 5.3, even after a period of time much less than the expected durability of the paint system.

Figure 5.3 – Cut edge corrosion and premature breakdown of paint system at roof end lap detail

This can be a result of a combination of an incorrect choice of the paint system for the environmental location and/or the type of metallic coating protection used on the steel substrate.

It is therefore advisable that the roof sheet manufacturer and/or metal manufacturer is consulted as to the correct choice of paint system and steel substrate protection that is required for a given application, location and atmospheric environment. Advice should also be sought if additional protective measures are required at end laps, such as the on-site application of an anti-corrosive paint to the cut edge at roof end laps.

Further information on the correct sealing of end laps can be found in MCRMA Guidance Document GD19 *Effective sealing of end laps in metal roofing constructions*.

5.2.2 Unpainted metallic coated steel

Profiled roofing and cladding sheets roll-formed from hot dipped galvanised (HDG) zinc and zinc-aluminium alloy metallic coatings, in their natural unpainted state are used in some non-aggressive environments and where the durability requirement is relatively short.

In polluted and coastal environments, the durability of the metallic coatings can be considerably reduced with the zinc-aluminium alloy coating offering a slightly better performance than the HDG coating. Acidic and alkaline environments can cause severe corrosion as will run-off from or contact with highly acidic or highly alkaline materials, e.g., high acidic timber, concrete and mortar etc.

Both forms of metallic coating offer good resistance against minor scratches due to the sacrificial action of zinc but deep scratches resulting in damage to, or partial removal of the protective metallic coating can accelerate the corrosion of the steel substrate.

5.3 Aluminium

In the UK, aluminium roof and wall cladding sheets are most commonly produced from uncoated aluminium alloy. Aluminium is a very durable material and generally does not require any coating for protection purposes except in some particularly aggressive environments where additional protection would be beneficial.

Colour coated aluminium is predominately used where there is an aesthetic requirement on a project e.g., planning requirements, matching existing buildings, company's brand colour (see figure 5.4), etc.

Figure 5.4 – Colour coated aluminium in company's brand colour

5.3.1 Uncoated aluminium

Uncoated aluminium used for roofing and cladding sheets will invariably have a stucco-embossed finish, see figure 5.5, rather than being plain mill finish. The stucco-embossed finish is adopted as it diffuses incident light and helps reduce reflections and glare. The appearance of minor marks and scratches from the production, handling and installation process which would be visible if using a mill finish uncoated material are also negated when using a stucco embossed finish.

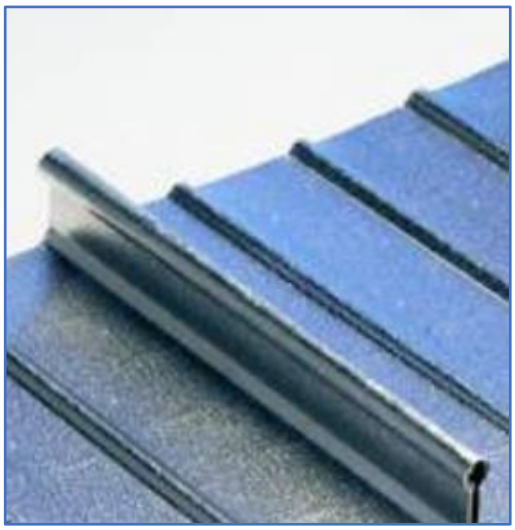

Figure 5.5 – Aluminium standing seam sheet with stucco embossed finish

With uncoated aluminium it is the naturally forming oxide layer that provides an ever-present barrier to atmosphere attack. Inert and hard, the oxide layer is an integral part of the metal reforming spontaneously if cut or scratched. This layer thickens very slowly with age and darkens in time from its original highly reflective surface according to the amount of atmospheric pollution, typically to a dull grey in rural and urban environments and a darker grey in coastal and industrial environments.

Aluminium is highly resistant to chemical attack from pollutants typically found in various atmospheric environments as shown in table 5.2, is also unaffected by petrol, oil and modern greases.

Atmospheric environment and corrosion category	Typical pollutants	Effect on uncoated aluminium
Rural and suburban (C2)	The level of atmospheric pollution is generally very low	Pollutants have little effect on aluminium.
Urban (C3)	Carbon monoxide (CO) and carbon dioxide (CO_2)	These pollutants have little effect on aluminium.
Industrial (C3, C4, C5-I)	Sulphur dioxide (SO_2) and hydrogen chloride (HC). In the presence of moisture, these gases can form acids	The acids may penetrate the protective aluminium oxide layer and attack the underlying metal. Such pitting attack, has shown to reduce over time.
	Ammonia, carbon monoxide and carbon dioxide	These pollutants have little effect on aluminium.
Coastal/marine (C3, C4, C5-M)	Sodium chloride (NaCl)	Very little effect on exposed rain-washed areas, sheltered areas might suffer only superficial attack, but less so than that of industrial pollutants

Table 5.2 – Effect of atmospheric pollutants on uncoated aluminium

Performance data collected over long periods of time show that the rate of pitting reduces with time and that the rate of attack becomes negligible after a few years.
BS 5427 states that "*plain mill finish, including stucco embossed aluminium, is normally expected to last the design life of the building without maintenance. In certain exceptional conditions pitting and/or the formation of a loose deposit, particularly on the internal surface, can occur. Evidence of this normally appears shortly after commissioning".*

Rainwater has a beneficial washing effect on exposed aluminium surfaces by diluting any pollutants resting on the metal and washing them away. Surfaces which are not subject to natural washing by rain, e.g., soffit areas, below framed PV panels etc. should be cleaned periodically to restore the appearance and remove any corrosive deposits. This can usually be done by hosing with water and a neutral detergent.

The durability of uncoated aluminium sheets can be impacted upon by other construction materials as listed below and contact should be avoided where possible or protective measures should be taken to isolate them, such as paints, bi-metallic separation tapes or pads etc. appropriate to the materials and environment.

- Any environment or condition
    - ungalvanised mild steel,
    - brass
    - copper and its alloys
    - timber treated with fire retardants
    - mortar
    - alkali-bearing materials
- Damp conditions
    - timber preserved with copper or fluoride compounds
    - other metals (i.e., bi-metallic contact)
- Coastal/marine environments
    - lead
    - stainless steel (not fasteners)
- industrial environments
    - lead

Drainage from copper onto uncoated aluminium should be avoided but drainage from the aluminium onto copper is acceptable.

5.3.2 Coated aluminium

There are a several types of organic paint finishes that can be applied to aluminium such as PVDF (polyvinylidene fluoride, also known as PVF_2), polyurethane, Abrasion Resistant System (ARS), polyamide modified polyurethane paint system) and polyester. Each coating system has different properties and offers various levels of durability.

The coating systems are multi-layer (see figure 5.6) consisting of a pre-treatment, a primer and a finish coat on the weathering side. The reverse side will consist of a pre-treatment and backing coat unless a double-sided coating is specified.

The coatings on aluminium are in a thickness range of between 20-40 µm and are applied as a uniform smooth film on a smooth surface (i.e. mill finish aluminium). A stucco embossed finish can be achieved with some paint systems by embossing the coated aluminium, but this is not recommended for corrosive environments as the embossing may cause micro-cracking in the coating.

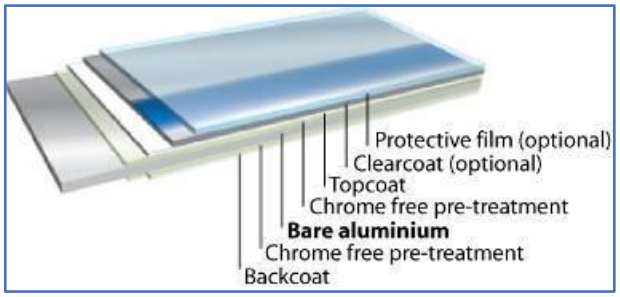

Figure 5.3 - Typical multi-layer coating system on aluminium

PVDF coating systems can be supplied as a Class 1 PVDF system that contains a minimum of 70% PVDF resin and a maximum of 30% of acrylic resin or as a Class 2 PVDF system that has a 50% to 50% PVDF to acrylic mix. Class 2 PVDF systems are not widely used in the UK due to their inferior performance to ultraviolet (UV) light.

The weathering side of the PVDF coating system is described as a 2-coat system consisting of the primer and the finish coat. PVDF coatings can be supplied as a 3-coat or 4-coat system as well when there may be the need to provide additional protection in aggressive atmospheric environments or may be due to the type of colour chosen. There are two types of 3-coat system which use either a clear lacquer layer (protecting the pigments used in forming the colour or to protect metallic coating systems) or an opaque layer (a grey PVDF layer is used on top of the primer protecting it from UV attack from sunlight and is mainly used on blue and dark green colours). A 4-coat system will use both additional layers.

BBA certificates for pre-finished aluminium coil will give an indication as to the minimum appearance or decorative life (usually the period before first maintenance painting is considered) for the coating. Table 5.3 gives an overview of the typical minimum appearance or decorative life of various generic coating systems based on information from pre-finished coil BBA certificates. These typical life expectancies may differ from an individual manufacturer's BBA certificates, and it is therefore advisable that the manufacturer is consulted to obtain a more definitive indication of their coating system's durability performance and any warranties offered.

Colour coated aluminium is generally only used where there is an aesthetic requirement on a project and maintenance painting is only necessary for appearance. Coated aluminium profiled roofing and cladding sheets will still offer the same long-term durability as uncoated profiled sheets.

Coating System	Typical minimum decorative/appearance life (years) of coating for various atmospheric atmospheres				Typical minimum design life (years)
	Rural or Urban	Coastal	Normal Industrial	Severe Industrial	
PVDF	20	15	20	15	>40
Polyurethane	15	10	15	10	>40
ARS	20	15	20	15	>40
Polyester	15	10	15	10	>40

Notes

1. The paint systems perform satisfactorily as per the atmospheric conditions above but excluding the immediate vicinity of, and downwind from, sources of abnormal corrosive contaminants, such as chemical works, cement works and copper foundries.
2. Decorative life expectancies will be dependent upon colour, location, aspect and use (roof or wall)

Table 5.4 – Overview of typical aluminium coating system decorative life expectancies based on BBA certificates

Actual product warranties offered for coating systems are dependent upon many different factors such as material supplier, coating, surface colour, location, application etc. The warranty will also vary depending upon an existing application involving weathered material and the future development of enhanced systems which may improve with ongoing R&D. Performance warranties should be discussed with individual suppliers at the time of product specification and the warranty should be agreed in writing at the design stage.

Where there are areas of colour coated profiled sheet with exposed eaves and soffit areas there maybe the need for the reverse side coating of the sheet to be improved with a similar coating as the top weathering layer.

Resistance to scratching and abrasion is dependent upon the coating system. An ARS paint system has excellent scratch and abrasion resistance whilst a PVDF paint system has only moderate resistant and should be handled with care. Polyurethane and polyester paint systems have scratch and abrasion resistances between these two extremes. Scratches and abrasions to the paint system will not affect the overall durability of the roofing and cladding sheets and repair is generally only considered from an appearance point of view.

Surfaces which are not subject to natural washing by rain, e.g., soffit areas, below framed PV panels etc. should be cleaned periodically to restore the paint system's appearance and remove any corrosive deposits. This can usually be done by hosing with water and a neutral detergent.

Surfaces which are not subject to natural washing by rain, e.g. soffit areas, below framed PV panels etc. may have an increased risk of corrosion and degradation of the material and/or its coating, which may negate any material/coating warranty. The surfaces should be cleaned with a greater frequency than other areas in order to restore the paint systems appearance and remove any corrosive deposits. This can usually be done by hosing with water and a neutral detergent, although it is advised that written approval and any further maintenance requirement is sought from the roof system manufacturer/supplier prior to specification and installation.

MCRMA ONLINE CPD PROGRAMME

This guidance document is available as an online CPD and is accredited by the CPD Certification Service. MCRMA's online CPD programme is open to anyone seeking to develop their knowledge and skills within the metal building envelope sector. Each module also offers members of professional institutions an opportunity to earn credit toward their annual CPD requirement.

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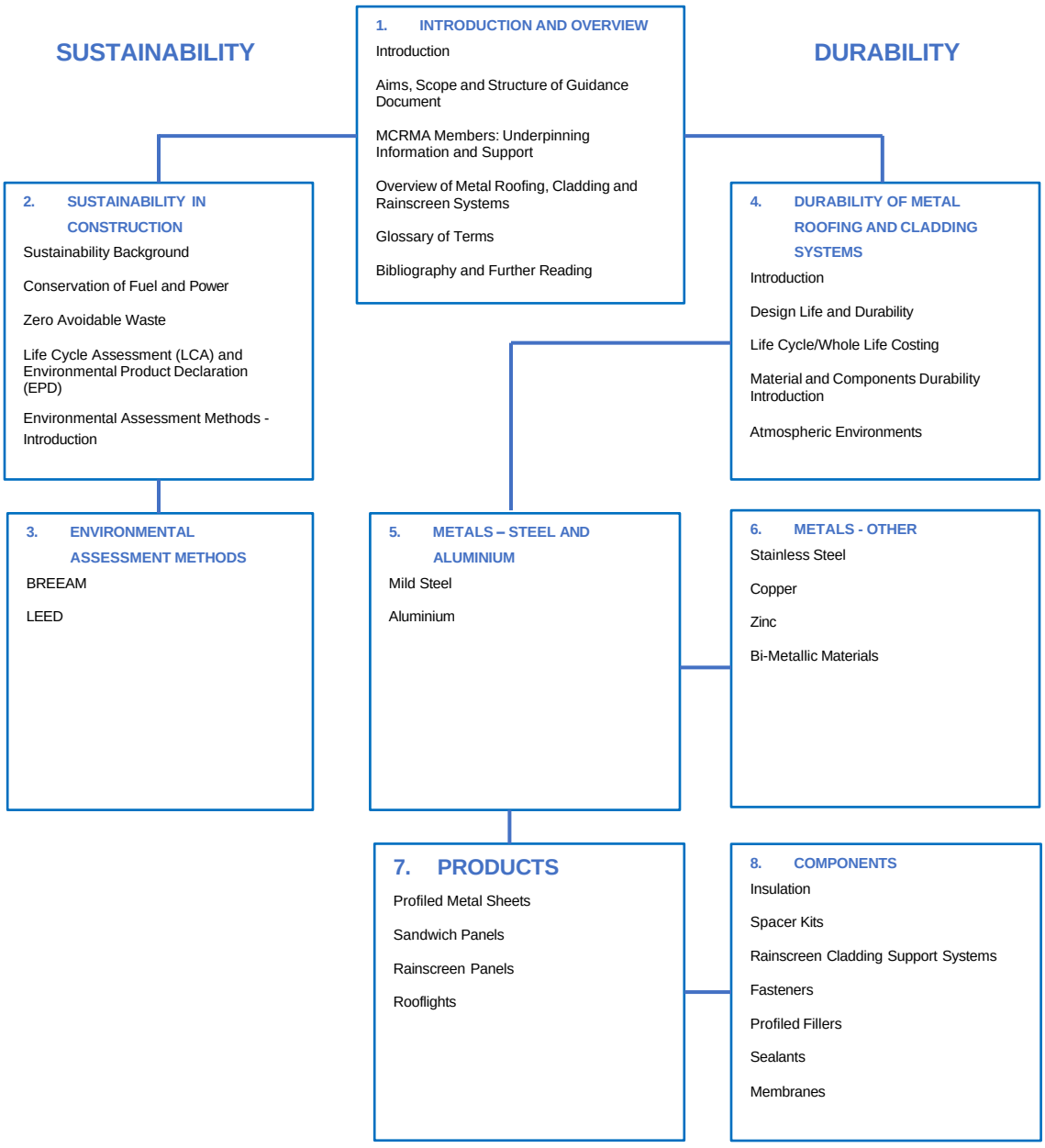
This module has an anticipated CPD value of 60 minutes or equivalent.

You can take the module at GD39-5 CPD Test

5.4 STRUCTURE OF GD 39



Pictorial overview of MCRMA guidance document GD39: Sustainability and durability of metal roofing and cladding systems

5.5 GLOSSARY OF TERMS

BRE Green Guide to Specification Generic product LCAs and EPDs form the basis of the BRE (Building Research Establishment) Green Guide to Specification (Green Guide). Initially published as a simple to use 'green guide' to the environmental impacts of common building materials and products. It has undergone regular updates and expansion as an online version which provides guidance for specifiers, designers and their clients on the relative environmental impacts of many elemental specifications for roofs, walls, floors etc.

BREEAM (Building Research Establishment Environmental Assessment Method) A voluntary scheme which can be used to assess the environmental performance of most types of building (new and existing). Developed by BRE (Building Research Establishment) it is the world's longest established environmental assessment system and is used internationally as well as in the UK.

COP (Conference of the Parties) 26 The 26th Meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The COP26 conference was held in Glasgow in November 2021 hosted in partnership by UK and Italy. Previous notable COP conferences took place at Kyoto (COP3) in 1997 and Paris (COP21) in 2015. These and other conferences have led to commitments to climate change, reduction of greenhouse gases and keeping global temperature rise this century below 2°C (preferably 1.5°C) above pre-industrial levels have been agreed.

CSR (Corporate Social Responsibility) The self-regulated responsibility of companies to society in areas such as the environment, the economy, employee well-being etc. Most companies, especially larger ones, now report on their CSR, a major element of which is the carbon footprint of a company's activities and their efforts to reduce it.

Environmental assessment method/rating system A methodology and/or rating system where various environmental impact factors are assessed against given criteria and points/credits are awarded. The total number of points/credits obtained will provide an indication of the environmental friendliness of a building design and its operation. The use of environmental assessment methods and rating systems can help encourage clients, developers and design teams to design and construct more sustainable buildings which are more energy efficient, climatic responsive, material and resource efficient, have healthier indoor environments for occupants and limit waste emissions and pollution.

EPD (Environment Profile Declaration) The results of an LCA are published in an EPD which is developed to a common format e.g., to the principles and procedures given in ISO 14025. The overall goal of an EPD is to communicate verifiable and accurate information on the environmental aspects of products that are not misleading. An EPD also provides the basis of a fair comparison of the environmental performance of products.

Greenhouse Gases Greenhouse gas emissions from human activities strengthen the greenhouse effect, causing climate change. Some of the gases occur naturally in the atmosphere, while others result from human activities. The seven greenhouse gases which contribute directly to climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The largest contributor to global warming is carbon dioxide (CO_2) which makes it the focus of many climate change initiatives.

LCA (Life Cycle Assessment) An assessment of the environment impacts of a product over its life cycle to a given methodology e.g., compliance with ISO 21930, considering several environmental issues. This life cycle of the product is often referred to as '*cradle to grave'*, where the *'cradle'* is the extraction of raw materials and the *'grave'* is the product's disposal and will consider the product's use over the building's life expectancy. A variation is a '*cradle to cradle'* life cycle where the disposal stage is replaced with a recycling process that produces material suitable for manufacturing a new product. LCAs are often broken down further into '*cradle to gate*' and '*gate to gate*' life cycles which can be useful for a manufacturer as a means of identifying internal processes for environmental improvements.

LCC (Life Cycle Costing) An LCC will consider all relevant costs over the defined life of a building covering construction costs, operation and occupancy costs, maintenance costs, renewal costs, and end of life costs as well as any environmental costs.

LEED (Leadership in Energy and Environmental Design) Green Building Rating System A voluntary, standard for developing high-performance, sustainable buildings developed by the US Green Building Council (USGBC). Although developed in and for the USA it is used internationally including the UK.

NDC – Nationally Determined Contributions National action plans on how countries will meet their commitments to climate change, reduction of greenhouse gases and rise in global temperature.

Net Zero Carbon/Net Zero Total greenhouse gas emissions going into the atmosphere e.g., from a particular process are equal to (or less) than the removal of greenhouse gases out of the atmosphere.

WLC (Whole Life Costing) A WLC will cover all the costs in an LCC as well as non-construction costs and incomes.

ZAW (Zero Avoidable Waste) The prevention of waste being generated at every stage of a project's lifecycle, from the manufacture of materials and products, the design, specification, procurement and assembly of buildings and infrastructure through to deconstruction. At the end of life, products, components and materials should be recovered at the highest possible level of the waste hierarchy, whilst ensuring minimal environmental impact.

5.6 BIBLIOGRAPHY AND FURTHER READING

The following is a list of support documents and publications that were used in the development of this guidance document, and which will provide further reading on the subject.

Approved Document B Volume 2 – *Buildings other than dwellinghouses – Fire Safety (for use in England)*

Aurubis – *Copper Book for Architecture*

BES 6001 – *BRE Framework Standard for Responsible Sourcing*

BRE BR502 – *Sustainability in the built environment: An introduction to its definition and measurement*

BRE Digest 489 – *Wind loads on roof-based photovoltaic systems*

BRE Information Paper IP 13/10 – *Cool roofs and their application in the UK*

BREEAM – *BREEAM UK New Construction – Non-domestic Building (United Kingdom) – Technical Manual – 2014*

BREEAM – *BREEAM UK New Construction – Non-domestic Building (United Kingdom) – Technical Manual - 2018*

BS ISO 15686-5:2017 – *Buildings and constructed assets. Service life planning. Life-cycle costing*

BS 7543:2015: *Guide to durability of buildings and building elements, products and components*

BS EN 1990: 2002+A1: 2005 (incorporating corrigenda December 2008 and April 2010) – *Eurocode – Basis of structural design*
NA to BS EN 1990: 2002+A1: 2005 (Incorporating National Amendments No.1) – *UK National Annex for Eurocode – Basis of structural design*
BS EN 15804: 2012+A2:2019 (incorporating corrigenda February 2014 and July 2020) – *Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products*
BS EN ISO 14001:2015 – *Environmental management systems. Requirements with guidance for use*
BS EN ISO 9001:2015 – *Quality management systems. Requirements*
BS EN 14782:2006 – *Self-supporting metal sheet for roofing, external cladding and internal lining. Product specification and requirements*
BS 5427:2016+A1:2017: *Code of practice for the use of profiled sheet for roof and wall cladding on buildings*
BS EN ISO 12944-2 *Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments*
BS 476-22:1987 – *Fire tests on building materials and structures. Part 22: Method for determination of the fire resistance of non-loadbearing elements of construction*
BS EN 506:2008 – *Roofing products of metal sheet. Specification for self-supporting products of copper or zinc sheet*
BS EN 1172:2011 – *Copper and copper alloys. Sheet and strip for building purposes*
BS EN 988:1997 – *Zinc and zinc alloys. Specification for rolled flat products for building*
BRE – *BRE Building Elements: Roofs and roofing: Performance, diagnosis, maintenance, repair and the avoidance of defects - Third Edition*
BSSA – *Stainless Steel and Sustainable Construction*
CAB – *Aluminium & sustainability: a 'cradle to cradle' approach*
CLC/GBC – *Zero Avoidable Waste in Construction*
CLC/GBC – *The Routemap for Zero Avoidable Waste in Construction*
Constructing Excellence – *Sustainable Construction: An Introduction*
Constructing Excellence – *Whole Life Costing*
CP 143-5:1964 – *Code of practice for sheet roof and wall coverings. Code of practice for sheet roof and wall coverings. Zinc*
CPA – *COP26 – An Introduction*
CPA – *Net Zero Carbon – What on Earth does it mean?*
CPA - *A guide to understanding the embodied impacts of construction products*

CWCT Technical Note 33 - *Breather membranes and vapour control layers in walls*
CWCT – *Guidance on built-up walls*
Euro-Inox – *Technical Guide to Stainless Steel Roofing*
Euro-Inox – *Cleaning Architectural Stainless Steel*
Hydro – *Circular economy – the design perspective. From theory to implementation*
International Molybdenum Association (IMOA) – Which *stainless steel should be specified for exterior applications?*
ISO 21930:2017 - *Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services*
ISO 14025:2006 - *Environmental labels and declarations — Type III environmental declarations — Principles and procedures*
MCRMA Article – The factors to consider when installing PV panels
MCRMA Membership Charter
MCRMA Guidance Document GD01 – *Built up systems and spacer stability*
MCRMA Guidance Document GD08 – *An introductory guide to rainscreen support systems*
MCRMA Guidance Document GD11 – *Fixings and fastenings for rainscreen systems*
MCRMA Guidance Document GD12 - *Composite flooring systems: Sustainable construction solutions*
MCRMA Guidance Document GD17 – *A guide to site installation of insulated roof panels*
MCRMA Guidance Document GD19 – *Effective sealing of end laps in metal roofing constructions*
MCRMA Guidance Document GD21- *Thermal performance of buildings: non-domestic construction*
MCRMA Guidance Document GD22 – *Installing renewables on metal roofs: A checklist*
MCRMA Guidance Document GD28 – *Mineral wool insulation installation: Best practice guide*
MCRMA Guidance Document GD 33 – *Fasteners for metal roofing and wall cladding: design, detailing and installation guide*
MCRMA Guidance Document GD 34 – *The definition of cladding within the construction sector*
NARM Technical Document NTD09 2014 - *Rooflights: glass, polycarbonate or GRP?*
NARM Technical Document NTD15 2018 - *A guide to rooflights for profiled sheeted roofs*
NFRC – *Profiled sheet roofing and cladding – The NFRC guide to design and best practice (Blue Book)*
NFRC Technical Bulletin 36 – *Performance standards of building strip sealants in metal clad buildings*

RICS NMM3 - *New rules of measurement: Order of cost estimating and cost planning for building maintenance works*

RICS Guidance Note – *Life cycle costing*

UK Government – *COP26 Explained*

USGBC – *LEED v4 for Building Design and Construction*

USGBC – *LEED v4.1 for Building Design and Construction*

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