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GD39 SUSTAINABILITY AND DURABILITY OF METAL ROOFING AND CLADDING SYSTEMS

SECTION 6: METALS – OTHER METALS

6.1 Stainless steel

Stainless steel can provide a durable, long-lasting surface for roofing and cladding applications and requires little maintenance, other than cleaning and no protective coatings are usually necessary. The durability of stainless steel though is dependent on grade, environment and surface finish.

The alloying elements in stainless steel form a thin, transparent protective 'passive layer' on the surface which instantaneously reforms in the presence of oxygen from air or water, so even if the material is scratched or damaged, it continues to protect the surface from corrosion.

The passive layer consists mainly of a chromium oxide that forms in reaction with oxygen in the air. For spontaneous development of the passive layer, the steel must contain at least 12% chromium (Cr). The passive layer can be broken down completely or partly with corrosion as a result but has the ability of re-passivation in an environment containing oxygen, such as air or aerated solutions. This environment is sufficient for both the creation and maintenance of the passive layer of stainless steels.

Pollutants in coastal/marine and industrial environments may cause permanent breakdown of the passive layer. Under circumstances where the passive layer cannot be rebuilt, corrosion occurs on the unprotected surface. Chloride ions impact on the durability of stainless steel the most and are typically found in coastal/marine environments and internally where chlorine is used e.g., swimming pools. Industrial environments where pollutants such as sulphur dioxide (SO_2) and hydrogen chloride (HC) in the presence of moisture, can form acid conditions which can also impact on stainless steel's durability.

Chromium (Cr) provides the basic corrosion resistance of stainless steels while nickel (Ni) improves ductility, corrosion resistance and workability. The addition of other alloy elements, for example molybdenum (Mo) and nitrogen (N), can improve the corrosion resistance to surface pitting in more corrosive coastal/marine and industrial environments
.
Molybdenum-alloyed grades of stainless steel are normally specified for industrial and coastal/marine atmospheres.

Stainless steel can be supplied in several finishes with smooth, textured, reflective and dull finishes. As a general rule, the brighter and smoother the finish is the better the corrosion resistance and the easier the maintenance is.

Euro-Inox publication *Technical Guide for Stainless Steel Roofing* (available via British Stainless-Steel Association (BSSA) gives advice on the selection of stainless-steel grades and finishes for roofing systems.

Regular washing to keep the surface clean and free from dust collection should be carried out as dirt and salt deposits may cause some localised pitting if left in-situ for long periods under wet conditions. Surfaces which are not subject to natural washing by rain, e.g., soffit areas, below framed PV panels etc. should also 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 use of bleaches, etc., silver cleaners, and acids such as sulphuric and hydrochloric should be avoided.

Figure 6.1 shows a standing seam roof system produced from stainless steel coil

Figure 6.1 shows a standing seam roof system produced from stainless steel coil

6.2 Copper

Roofs and facades made of copper are very durable and can normally be expected to last the design life of the building without maintenance. Copper used for roofing and cladding use phosphorus deoxidised copper, designated Cu-DHP and complying with BS EN 1172:2011 *Copper and copper alloys. Sheet and strip for building purposes.*

Copper initially has a bright appearance that weathers gradually to bronze tones through to a green patina. This patination process by means of the atmospheric corrosion of the copper forms a lasting, very adherent and naturally reforming protective film which gives the material durability and anti-corrosion properties in all atmospheric conditions.

Once installed, copper's initial bright finish quickly starts to have a dark mottled effect which after one or two years will develop into a more even, dark brown colour which will not appear to change over the next few years. Gradually the green patina starts to appear, dependent upon the orientation of the material and the atmospheric environment. The green patina (potentially a blue patina in coastal areas) would firstly start to develop on roofs and other horizontal or pitched surfaces then more slowly on vertical surfaces. In some environments with little or no air pollution the vertical surfaces may fail to develop the patina and remain brown coloured.

The appearance of copper changes over time in response to local atmospheric conditions the ‘colour’ of the copper at any one time may be difficult to predict or may never fully develop. As well as the standard bright mill finish material, copper sheeting is available in a range of factory applied surface treatments to provide instantly the various stages of oxidisation and patination, e.g., brown pre-oxidisation, blue/green pre-patination. The processes involved in forming these variations are similar to those taking place over time in the environment utilising copper mineral compounds, rather than chemical treatments and organic coatings. Once installed the surface of the pre-treated copper will still change naturally.

Copper sheeting is also available alloyed with other metals such as aluminium, zinc and tin, to provide different coloured surface finishes.

Although a very durable material there are conditions which can cause corrosion attack of the copper and interference with the development of its protective patina. Copper can also be problematical to other metals and construction materials.

Copper undergoes corrosion of the surface in order to form its protective patina in normal conditions. The surface can be affected by corrosion damage under unfavourable conditions, such as acidic water (< 4 pH). Corrosion damage can occur over time where water runs down, or drips onto copper surfaces where the point of contact is constantly being abraded by the running water so that no protective oxide layer can form. Greater abrasion of the material will occur if the water also contains granules of sand. Standing water caused by poor drainage can also lead to local corrosion and should be avoided by correct detailing to avoid undrained horizontal surfaces. The internal face of copper gutters may need to have a protective paint coating applied.

Rainwater run-off from timber can be highly acidic and any leeching of the timber can cause corrosion to copper sheeting.

Copper should not be placed in direct contact with bituminous surfaces. Acid rainwater in concentrated form from a bituminous surface will prevent the development of the patina and lead to discoloration and damage to the copper sheeting.

Copper can also be attacked by flue gases containing sulphur dioxide. Copper is corroded by ammonia and some metal acids.

Copper can cause galvanic corrosion to occur when it is in contact with other less nobler metals, such as aluminium, zinc, galvanised steel etc. 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. Water which has been in contact with copper should not be permitted to run down onto other metal surfaces. Facades constructed from non-water repellent materials such as brick, sandstone, plaster, wood, etc. will need to be protected against rainwater containing copper to prevent discoloration. Flashings on plastered walls should be terminated with drip details which run a minimum of 40 mm beyond the finished wall.

Figure 6.2 shows a standing seam roof system produced from copper coil.

Figure 6.2 – Copper standing seam roof system

6.3 Zinc

Roofs and facades made of zinc can be very durable and would normally be expected to last the design life of the building without maintenance. Zinc for roofing and cladding use a zinc-copper-titanium alloy (typically Z1 zinc (99.995% pure zinc), to which titanium and copper are added) to BS EN 988:1997 *Zinc and zinc alloys. Specification for rolled flat products for building.*

Zinc develops a protective patina layer on its surface, typically blue-grey in colour, which offers high corrosion resistance. The patina is developed chemically through several stages:

- Zinc oxide is formed on the surface through oxygen in the atmosphere
- Zinc hydroxide is then formed due to exposure to water and moisture
- Zinc carbonate, the patina, is formed by the reaction of the zinc hydroxide with carbon dioxide in the atmosphere

The patina is alkaline zinc carbonate that will also contain additional substances from the local atmosphere with the colour differing slightly from one environmental location to another. The time required for formation of the patina will be dependent upon the amount of exposure to water. A low-pitched roof may become fully patinated within three years whereas a sheltered soffit may require over 10 years.

The appearance of zinc changes over time in response to local atmospheric conditions, the ‘colour’ of the zinc at any one time may be difficult to predict and will have different shades on a building depending on the orientation and degree of exposure. As well as the standard bright zinc material, zinc sheeting is available in a range of phosphate pre-weathering surface treatments to provide duller pre-weathered and darker effects. Non-painted coloured finishes are also available.

Some BBA certificates for roof systems with zinc in its natural, phosphate treated and coloured forms with a 60 μm thick composite polyurethane-polyamide lacquer protective layer on the bottom face indicate a minimum service life of 60 years in rural and urban environments, with a shorter service life if local environment conditions are chemically corrosive, e.g. in the immediate vicinity of and downwind from coastal areas, manufacturing facilities such as chemical works, cement works, copper foundries or coal mines.
Although a very durable material there are conditions which can cause corrosion attack of the zinc and interference with the development of its protective patina. Zinc is not resistant to acids or strong alkalis.

If there is an inadequate supply of carbon dioxide from the atmosphere, which can also happen when poor storage and handling methods are adopted prior to sheet installation and after installation if the sheets are covered up, the development of the patina remains at the zinc hydroxide stage and when in contact with moisture grows in volume and appears as ‘white rust’. If the zinc hydroxide (white rust) is allowed to continue then the zinc will start to corrode.

Condensed water, if trapped against the underside of zinc roof coverings, is liable to attack the zinc and lead to underside corrosion. The risk of this occurring can be reduced by the application of a protective coating to the underside of the zinc (see above), and/or provision of adequate ventilation to the underside of the zinc sheet.

Zinc is susceptible to galvanic corrosion and contact with metals such as copper, unprotected or ungalvanized steel and natural lead must be avoided. Water which has been in contact with copper should not be permitted to run down onto zinc surfaces.

Direct contact with alkali bearing materials such as fresh concrete, plaster, bitumen or mortar should also be avoided.

Zinc should not be in direct contact or receive rainwater run-off from some timbers which can be highly acidic, and any leeching of the timber can cause corrosion to zinc materials. Zinc is incompatible with timbers with a $pH < 5$ including red cedar, white cedar, larch, oak, chestnut and Douglas fir. Zinc is compatible with pine, spruce, Scots pine and poplar.

Sulphur acids in polluted industrial and coastal environments can attack zinc more rapidly than in other environments. The degree of attack can be less on steeper pitched roof as dirt and corrosive deposits are more effectively washed away by rain. In industrial and coastal environments, it may be necessary to clean the zinc surface periodically to restore its appearance and to remove any dirt debris. Surfaces which are not subject to natural washing by rain, e.g., soffit areas, below framed PV panels etc., in all environments, 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.

6.4 Bi-metallic materials

A bi-metallic material or bi-metal is where two separate metals are joined usually in the form of a thicker substrate material and a thinner weathering layer. This will not generally be for the purposes of protection as in galvanised steel sheeting but to create a material which has the main properties (e.g., strength) of the substrate material and the decorative appearance of the outer weathering layer.

A common example of this type of material is zinc plated aluminium. This can give a material which has a lighter weight and potentially more economical alternative to traditional zinc roofing and cladding whilst still retaining the decorative appearance of zinc.

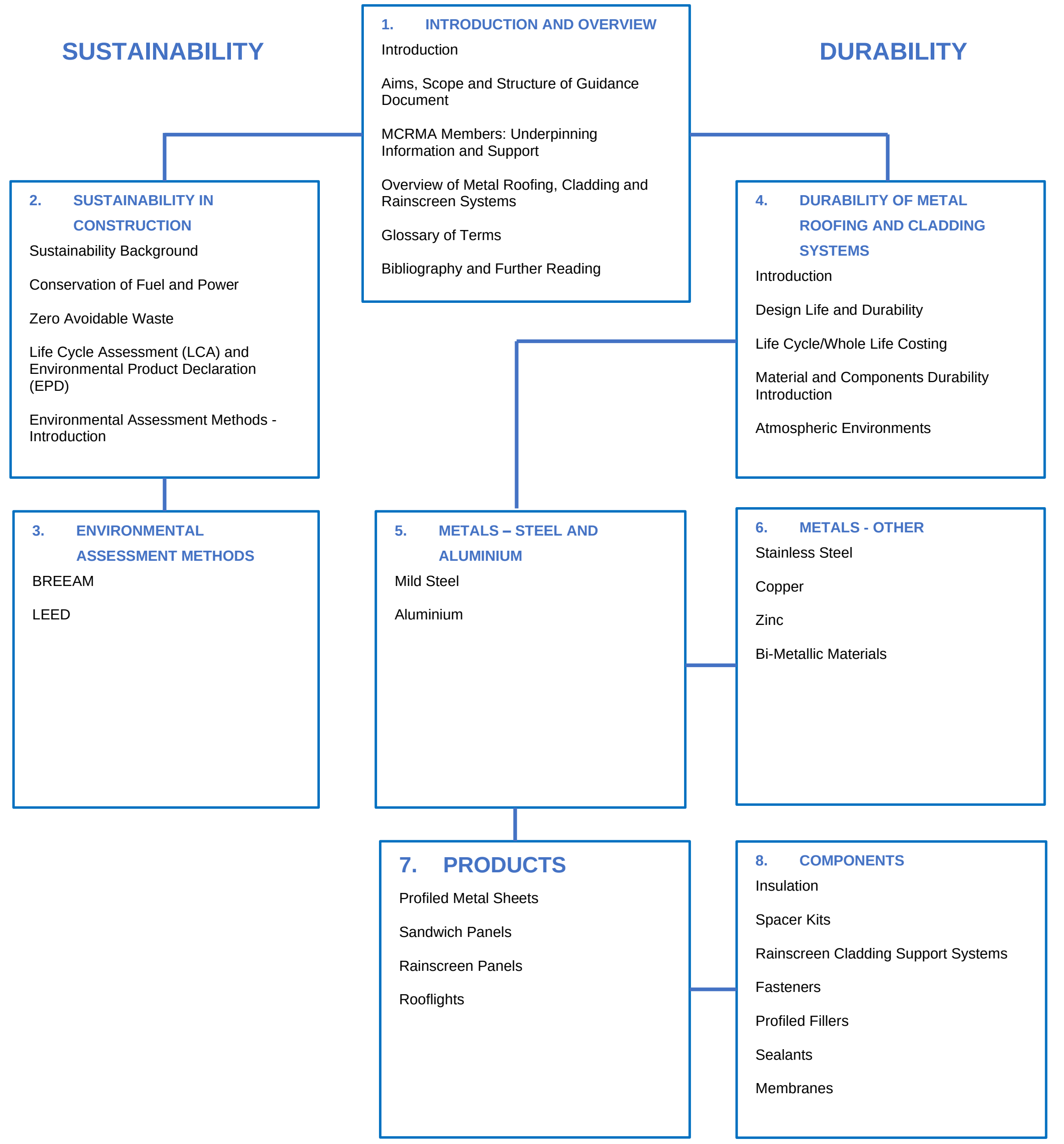
From a durability point of view the thicker substrate material will usually provide the overall service life of the material with a lesser decorative life for the thinner outer layer. As an example, a BBA certificates for this type of materials indicates that it will perform effectively as a cladding with an ultimate life of at least 40 years (i.e., as per aluminium) and the decorative surface layer can be expected to be retained for at least 10 years.

Limitations in use in various atmospheric environments and avoidance of contact with other metals and materials would generally be as per the individual metals of the bi-metallic material.

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.

Each variation of bi-metallic material would be expected to have durability depending upon the metals used. The manufacturer of the material should be consulted as to its performance and any specific limitations in its use for a particular application.

6.5 STRUCTURE OF GD 39



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

6.6 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.

6.7 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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