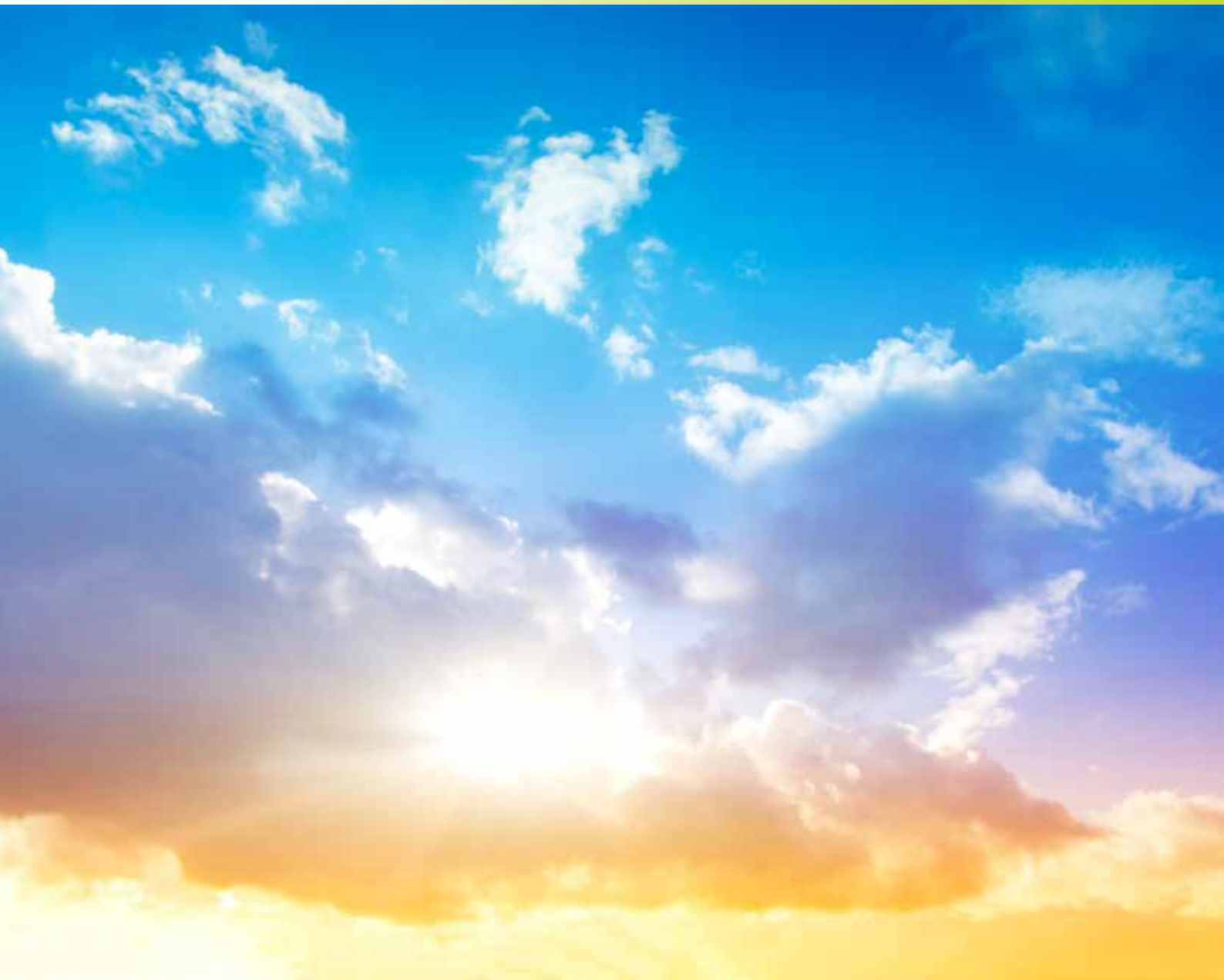


An introduction to natural daylight design through rooflighting



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Introduction

Daylight is a freely available natural resource that will significantly improve the environment within any building.

Rooflights provide three times more light than the same area of vertical glazing. They can also provide a much more even distribution of light, particularly in larger structures. Where vertical glazing exists, the effective area for natural lighting will only be within 6m of the wall containing the window. These facts are well understood by most people involved in building design. However the huge potential of rooflights to provide exactly the amount, type and distribution of natural light required to meet any given specification is not always appreciated. Rooflights can help to provide natural light with qualities appropriate to the use of the building.

The National Association of Rooflight Manufacturers (NARM) represents manufacturers offering a complete cross section of rooflight types, including modular domes, pyramids and flat glass rooflights: in-plane profiled rooflights; continuous barrel vaults, panel glazing systems and architectural glazing systems for skylights, lantern lights and atria.

Together, through NARM, they are able to provide a knowledge base second to none on matters relating to the provision of high quality natural daylight into all types of buildings.

Daylight design will be influenced by the building size and its usage. For smaller buildings vertical glazing will generally be adequate but only for areas within 6m of a window. For larger buildings, rooflighting or a combination of both roof and wall glazing will be needed.

This document provides an overview of factors to consider in the design and specification of rooflights

Benefits of natural daylight in the built environment

Natural daylight improves internal environments and promotes wellbeing

For those of us living in temperate Northern climates, the beneficial effect of sunlight is easy to recognise; a couple of sunny days seem to lift everyone's spirits. Research also shows that suicide rates are considerably higher in parts of the world where daylight is very limited for significant parts of the year. On a slightly less dramatic but equally significant level, there is also a growing body of evidence to suggest that buildings enjoying high levels of natural light are literally more successful than those more reliant on artificial light. In all environments the eye and brain functions respond better to natural light, so people perform better, while passive solar gain can reduce energy costs.



In the education sector

Research demonstrates a clear correlation between classrooms with good natural light and improved student performance and even attendance. This is because in natural light children concentrate better so are more focused and less easily distracted. Some studies suggest that health is also enhanced helping to explain the improved attendance.



In the healthcare sector

In the UK we are used to hearing of SAD, Seasonal Affective Disorder, a clinically diagnosed condition in which the lack of sunlight in winter makes people feel ill. Natural light helps people to feel better but it can also aid the healing process. In hospitals, studies have proven that the recovery rate of patients is accelerated where levels of natural light are increased.



In public buildings and transport facilities

As a free, natural resource, daylight not only improves the environment in large public spaces: it helps to control energy costs and improves safety levels for building occupants.



In domestic properties and leisure facilities

People like bright naturally lit environments, evidenced by the huge popularity of domestic conservatories and sunrooms. It is therefore logical that in their leisure time people prefer facilities enjoying high levels of daylight. Many sporting and recreational facilities have been designed to maximise natural daylight in recognition of this.



In commercial and retail environments

Daylight improves concentration so that working environments, be they factories or offices with natural light, tend to achieve increased productivity. Research into retail environments suggests that in many situations sales tend to be better in naturally lit locations; colours are more vivid and true, making goods appear attractive and encouraging customers to spend more time in these areas. A number of the UK's leading retail organisations include large areas of rooflights in specifications for all new build projects to ensure a high percentage of evenly distributed natural light within the interior.

Natural daylight is a free and sustainable natural resource

Rooflights not only make a positive contribution to the internal environment in a building. Research has shown that they also reduce energy use and cost, and contribute to the external environment by reducing the carbon footprint, helping to meet the requirements of Part L Building Regulations. For further information see page 15.

Types of daylight

Rooflights are not only the most effective way of allowing natural light into a building; they can also determine the type and amount of light entering the building.

Direct Light

As the name suggests light passes through the rooflight without any disruption or interference, entering the structure as a straight beam. It therefore gives strong light in a given area but less general light in the surrounding area. It is useful where strong light is required in an area for close detailed work such as painting, or in situations where a very natural environment is desired, or the designer wants people in the building to see the sky through the roof. Direct light will result in shadows and glare on sunnier days. Polycarbonate, PVC and glass in clear and most tinted options provide direct light.

Diffused Light

As the light passes through the rooflight it is scattered giving a much more even distribution of light into the structure below. It is useful when the requirement is for ambient lighting over a large area with minimal shadows. Most industrial, commercial and sporting facilities prefer diffused light for these qualities. GRP in all forms, solid and multi-wall polycarbonate, PVC, and glass in patterned and opal tinted forms all provide diffused light.



Direct - poor light distribution & glare



Diffused - good light distribution

Recommended light levels

Different materials and different tints of materials provide varying amounts of light into the building. In clear format most single skin rooflight materials will have a light transmission of 80%-90%. This must however be checked for the specific rooflight being used; material thickness, diffusing or colour tints, and number of skins can all affect overall light transmission.

In some situations the amount of light entering the building needs to be controlled, usually to prevent overheating. Tinted materials will limit the light entering the building. It is impossible to give a general guide to the light transmission achieved through the various tinted options available, as these vary not only from material to material but also from manufacturer to manufacturer.

Workplace (Health Safety and Welfare) Regulations 1992 state, “Every workplace shall have suitable and sufficient lighting which shall, so far as is reasonably practicable, be by natural light”. These comments are restated in HSG 38 – Lighting at Work.

The most effective method of providing even, consistent daylight particularly in large buildings, is through rooflighting – up to three times more efficient than windows of similar area. Diffusing materials should be used wherever possible to provide even light distribution and avoid glare. Wall glazing is less effective and can create internal shadows and dark corners. However it does offer good psychological benefits and must not be ignored.

It is important that designers consider the use of a building when determining rooflight area, and ensure that daylight levels are sufficient for all likely future uses. Light is measured in lux; Table A below shows the recommended light levels required for different activities.

Table A: Examples of internal light levels required for various activities

Characteristics of activity/interior	Level of illuminance required (Lux)	Typical building/space
Continuously occupied interiors, with visual tasks not requiring perception of detail	200	Some warehousing & stores Reception spaces
Moderately difficult visual tasks	500	General retail areas General manufacturing areas
Difficult visual tasks requiring accurate colour judgement or perception of movement	1000	Clothing and furniture retail Sports halls
Precise detailed work requiring accurate perception of intricate detail	2000	Engineering facilities Craft & design studios (Good background lighting plus specialist task lighting)

Rooflight areas to achieve recommended light levels

Rooflights make a positive contribution to the internal environment in a building, but also reduce energy use and cost, and contribute to the external environment by reducing the carbon footprint, helping to meet the requirements of Part L Building Regulations (See page 15). As a general rule, the greater the rooflight area, the bigger the contribution the rooflights can make – although the potential for solar overheating must be taken into consideration.

For manufacturing environments and office spaces, the tasks being illuminated are usually in a horizontal plane, viewed from above, and it is usually more appropriate to measure light levels horizontally. For some applications (e.g. storage facilities and racking), the illumination of vertical surfaces may be more relevant, and light levels should then be analysed vertically. Note that inside any given building, the vertical illuminance levels are generally lower than horizontal - but lower light levels are often acceptable for tasks viewed vertically (such as storage facilities).

The possible shading effects of large obstructions inside the building should also be considered, as should rooflight layout to minimise this effect. Research commissioned by NARM and undertaken by De Montfort University has predicted the daylight levels in the horizontal and vertical planes inside typical large span buildings (assuming even rooflight layout, without any significant obstructions) using the latest computer modeling techniques.

This research does not define a definitive rooflight area for a particular application. Selection of exact rooflight area depends on the level of natural lighting desired, the percentage of a working year that lower natural light levels are acceptable, and the level of use of auxiliary lighting which is acceptable; these are more subjective, and should be determined by the building designer.

The research provides data on how often during a year rooflights of various area will provide any selected lighting level (and hence how often auxiliary lighting may be required). In general, if relatively small increases in rooflight area result in significant reduction in time that auxiliary lighting is required, they should be seriously considered; conversely, reductions in rooflight area can be justified where they do not result in significant increases in the time that auxiliary lighting is required. Tables B and C taken from this research, provide recommendations for rooflight area to achieve desired lighting levels, on this basis, assuming overall light transmission of 67%; for rooflights with lower or higher light transmission, the figures should be adjusted accordingly.

Table B: Recommended minimum rooflight area for desired illuminance level (horizontal)

illuminance level reqd in the horizontal plane (Lux)	Recommended min rooflight area (% of floor area)
100	10
200	10
300	13
500	15
750	17
1000+	20

Table C: Recommended minimum rooflight area for desired illuminance level (vertical)

illuminance level reqd in the vertical plane (Lux)	Recommended min rooflight area (% of floor area)
100	10
200	14
300	17
500+	20

Artificial lighting is essential during parts of the working day and particularly in the winter months, and specifically in working areas where light levels need to remain constant. In order to minimize the use of artificial lighting, thereby maximising the energy savings from natural daylight, artificial lighting should be, wherever possible controlled by automatic means that operate on “need” requirement. Designers need to bear in mind these key points: -

- The electric light is carbon inefficient in that power from the National Grid is largely generated from burning fossil fuels at modest generation efficiencies
- Where natural daylight levels are low, without lighting control, the lights in the work place get turned on in the morning and stay on all day, regardless of the need for them
- Natural daylight through rooflights is completely free, provides some useful solar gain and makes the work place a pleasant environment

The De Montfort University research highlights the importance of appropriate lighting controls to maximise the benefits of natural light via rooflights. The use of on/off photo-electric cells and proportional lighting controls will save considerably on energy usage. The options that are available should be obtained from a good artificial lighting specialist.

Read More For further information about integrating natural daylighting with artificial lighting controls, please refer to: *NARM Technical Document NTD05 - “Designing with Rooflights and Artificial Lighting to reduce CO₂ Emissions”*. This can be downloaded from the narm website: www.narm.org.uk.

Solar heat gain

Rooflight areas have a bearing on internal temperatures and a wide range of solar control options are available for rooflights, from advanced ‘active’ solar control glass to tints and blinds. Building orientation can also affect solar heat gain, so cases should be viewed on an individual basis and manufacturer recommendations sought.

NARM has commissioned research by Oxford Brookes University on this subject relative to factory rooflights. This indicates that in a large volume building, with evenly distributed rooflights and moderate internal heat gains a rooflight area up to 20% will not cause solar overheating.

Read More The full results of this research are available in *NARM Technical Document NTD 04 - ‘A dynamic thermal modelling study of a typical metal clad building to evaluate overheating in the UK’*. This can be downloaded from the NARM website: www.narm.org.uk.

Rooflight systems overview

A rooflight can be defined as a clear or translucent structure designed for use on flat or low-pitched roofs, to allow natural light into buildings whilst maintaining the integrity of the building envelope.

A huge variety of rooflights and rooflight systems are available in today's marketplace, offering a wide range of characteristics to suit different building types. In the UK, rooflights are subject to UK Building Regulations. Choosing rooflights from a NARM member company is your assurance of compliance.

Rooflight specification is affected by and can influence many factors, including:

- Light transmission
- Thermal insulation
- Required working lifespan
- Aesthetics
- Roof construction
- Health & Safety considerations
- Ventilation considerations
- Solar control
- and more

Types of rooflight available

The many different designs of rooflights available today, can be loosely categorised under their material/s of manufacture: glass; thermoplastic; or GRP (Glass Reinforced Polyester). Brief introductions to these materials as used in rooflight applications, are on the following pages of this document.

Read More The following documents can be downloaded from the NARM website: www.narm.org.uk

NARM Technical Document NTD 09 - "Rooflights: glass, polycarbonate or GRP?" This can be downloaded from the NARM website: www.narm.org.uk.

NARM Technical Document NTD 12 - "An introduction to natural daylight design in domestic properties"

Glass rooflights

Glass offers the rooflight specifier an extremely wide range of options in terms of performance, function and aesthetics. Glass is often the preferred material for domestic, commercial and retail applications, where aesthetics, high performance and long working life are key considerations.

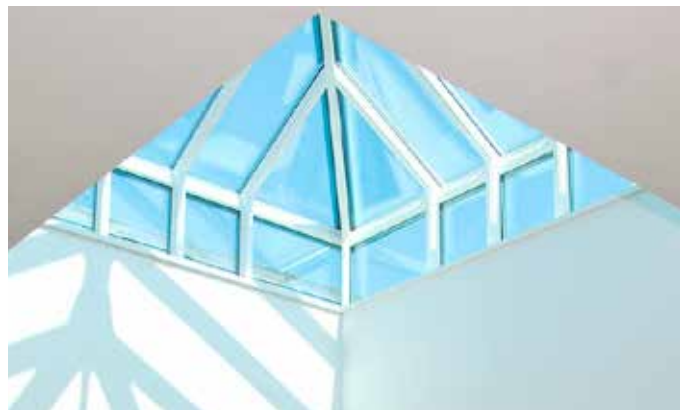
Glass manufacturers have developed products to satisfy the most demanding requirements, from sophisticated 'active' solar control, to self-cleaning properties and high impact resistance.

Glass has excellent fire properties, good impact performance, very high light transmission and provides the mark against which the optical clarity of all other glazing media is commonly compared. It is widely acknowledged as having a very long life expectancy with no discolouration from UV degradation, and laminated versions provide a good level of reduction in UV transmittance. Glass can also be curved for use

in barrel vault rooflights and supplied with various coatings, interlayers and surface treatments to provide coloured or textured surfaces to achieve obscure or diffused glazing, solar control and total UV protection to areas beneath the glazing.

NARM member companies offer a wide range of glass rooflights. Typical examples of glass rooflights are shown below.

Read More For specification details and contact information for glass rooflight manufacturers, visit: <http://www.narm.org.uk/products/glass/>



Thermoplastic rooflights

Modern thermoplastics like Polycarbonate, have been developed to provide excellent performance in rooflighting applications. Polycarbonate is a versatile material used extensively as a rooflight glazing. It has three sheet forms:

- Solid – flat, cold bent or formed
- Profiled
- Multiwall

The key properties of polycarbonate are common to all forms – exceptional impact resistance, high levels of light transmission, good workability and good fire rating. All are commonly available in clear and tinted options, with clear and most tints providing direct light, while clear patterned and opal tint provides diffused light and gives a soft quality to the light. Co-extruded UV protection eliminates up to 99% of UV radiation, protecting materials and people beneath it. Each form also has its own particular characteristics and properties.

Solid polycarbonate offers good optical clarity and superb workability. It can be cold curved on site and is suitable for use with a variety of glazing bar systems. Polycarbonate is a thermoplastic material, so it can be easily formed into 3D shapes, making it the ideal choice for domes, pyramids and barrel vaults.

Profiled polycarbonate matches profiled roof cladding and allows the sky above to be seen through a corrugated material, a feature popular with many designers. It has very good profile accuracy and is available in a growing profile range. Extrusion and vacuum forming techniques allow a huge variety of profiles to be produced.

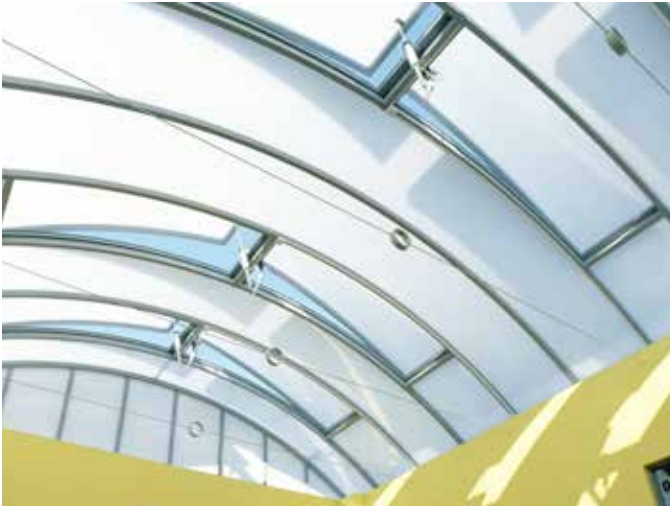
Multiwall polycarbonate is an insulating glazing material. Thicker sheets with more walls achieve the highest thermal performance, typically $1.6\text{W/m}^2\text{K}$ for a 25mm five wall sheet. Structured polycarbonate is most commonly used in most domestic and many commercial conservatories. Like solid polycarbonate it can be cold curved on site, although to a much lesser degree, it can be used in a variety of glazing bar systems, and has a very high strength to weight ratio making it ideal for the creation of glazing features.

Other thermoplastic glazing materials such as PVC are still available, although these are generally not recommended for use in building and construction and may not achieve compliance with standards and regulations.

Examples of typical polycarbonate rooflights are shown overleaf on page 13.

Read More For specification details and contact information for polycarbonate rooflight manufacturers, visit: <http://www.narm.org.uk/products/polycarbonate/>

NARM member companies offer a wide range of rooflight designs utilising solid and multiwall polycarbonate sheet. Typical examples are shown below.



GRP (Glass Reinforced Polyester) rooflights

GRP sheet is the material of choice for factory and warehouse rooflights. GRP remains the most versatile and commonly used profiled glazing material. Available to match virtually any metal or fibre cement sheet profile and ideal for barrel vault design. GRP offers excellent performance properties and provides high levels of diffused light into the building. In most industrial, sporting and commercial situations diffused light, which minimises glare and distracting shadows, is preferable. GRP sheets are produced in almost all profiles, and modern high quality GRP sheets incorporate UV absorbing surface protection which can virtually eliminate long term discolouration. In a very budget conscious world GRP is a very cost effective rooflight material.

Typical examples of GRP rooflights are shown below.

Read More For specification details and contact information for GRP rooflight manufacturers, visit: <http://www.narm.org.uk/products/grp/>



Daylight and energy efficiency

Independent research by the De Montfort University's Institute of Energy and Sustainable Development proves conclusively that rooflights can save energy in many applications, and the greater the rooflight area the greater the potential savings.



The amount of energy needed to light a building artificially is often much greater than the amount of energy used to heat it, and is often the greatest single energy use in operating the building.

When used in conjunction with automatic lighting controls to turn the electric lights down, or off, then rooflights can have a major impact on the overall energy consumption of a building, cutting energy costs by reducing the need for use of the electric lights.

Rooflights are usually less well insulated than the surrounding opaque areas of the roof, but have very little effect on the total energy required for heating, as the beneficial effects of passive solar gain compensates for the poorer insulation. Electricity used for lighting is much more expensive in terms of CO₂ than gas used for heating, so that including large areas of rooflights is one of the single most effective ways of improving the environment.

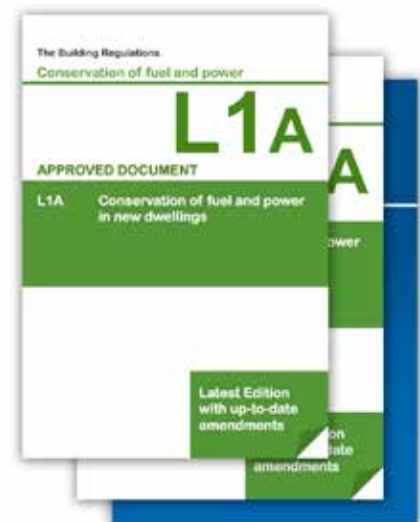
Using rooflights to provide a bright, naturally lit interior will save money, provide a more pleasant environment people want to spend time in and contribute to the government's target to reduce emissions of CO₂.

Legal requirements

The Building Regulations Part L not only consider the fabric of the building elements but also the energy consumption and efficiency of all the mechanical services such as boilers, hot water and artificial lighting.

The total energy requirement of a building is calculated with government approved National Calculation Tool software such as SBEM (Simplified Building Energy Model).

The appropriate rooflight specification and area parameters may be loaded into SBEM which then uses the data as part of the overall building calculation. Independent research proves that an appropriate use of rooflighting, usually 15 to 20% of the roof area, coupled with well designed controlled artificial lighting, will assist in reducing the carbon footprint of a building when considered under Building Regulations Part L.



Read More The following documents can be downloaded from the NARM website: www.narm.org.uk

NARM Technical Document NTD 06 - 'Designing with Rooflights, Supporting the Guidance in AD L2A & AD L2B'.

NARM Technical Document NTD 05 - 'Designing with Rooflights and Artificial Lighting to reduce CO₂ Emissions'.

Rooflights and non-fragility

When specifying rooflights, designers should consider carefully the potential to eliminate or reduce known or predictable hazards. The decision on how best to specify rooflights should take account of the risks during construction, and the ongoing risks when access to the roof is needed later e.g. during maintenance or cleaning.

As in all building work good safety standards are essential to prevent accidents. In accordance with the Health and Safety at Work Act and the Construction (Design and Management) or CDM Regulations 2007, the building should now be designed with safety in mind, not only for the construction period but throughout the normal life of the building. This must include considering the safety of people involved in maintenance and repair, and even demolition. It might mean providing permanent access to the roof, walkways and parapets, for example.

The Red Book

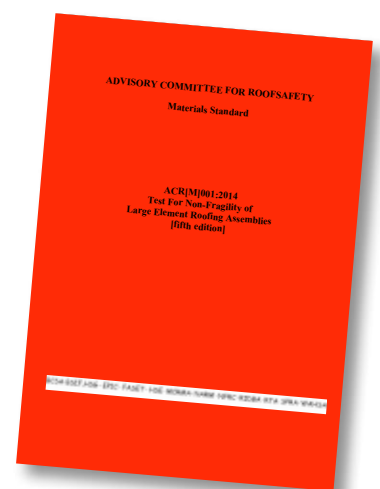
'The Red Book' ACR[M]001 defines a test for non-fragility which can be applied to any roof assembly, intended to indicate whether the roof can support the instantaneous loads imposed on it by a person falling or stumbling on it. It is not a product test but products such as rooflights can be tested as part of a roof assembly.

The test defines 3 Classes of non-fragility (A, B or C). Most roof constructions (without rooflights) are Class B or C; very few achieve Class A. Generally a rooflight should match the performance of the roof (eg if the surrounding roof without rooflights achieves Class B, so should a roof assembly including rooflights).

Read More The Red Book and the following documents can all be downloaded from the NARM website: www.narm.org.uk

NARM Technical Document NTD 03 - Application of ACR[M]001 'Test For Non-Fragility of Large Element Roofing Assemblies' to GRP Profiled Rooflight Sheetting

NARM Technical Document NTD 08 - 'Guidance on non-fragility for specifiers of in-plane rooflights'



NARM Technical Document NTD 11 - 'Understanding the differences between 'non-fragile' rooflights and 'walk-on' rooflights for deliberate foot traffic

NARM Quickguide 01: 'Non-fragility: key points from the Red Book ACR[M] 001

Rooflights and fire safety

Fire safety rules are set out in the Building Regulations Approved Document B (2006 Edition, updated 2007). Within this, the key aspects affecting rooflights are:

Escape of building occupants in the event of a fire

It is incumbent on the building designer to ensure that if rooflights form any part of the escape route (in the ceiling above the route or, indeed, if the route is across a roof featuring rooflights) then the rooflights must meet the appropriate standards. The only specification that will satisfy this situation is a rooflight with a 30 minute or one hour fire rating. Glass glazing is the main material to achieve this.

Inhibition of the spread of fire

Modern rooflights are usually double or triple skinned in thermoplastic or double glazed in glass. The internal skin and the inside faces of the rooflight upstand are internal linings and therefore within the scope of section B2. This states that the internal linings shall inhibit the spread of fire within a building and resist the flame over their surfaces. It also states that 'they shall if ignited have a rate of energy release which does not significantly contribute to the fire'.

Structural integrity - containing fire and aiding emergency services

Correctly made and fitted rooflights do not impact on the structural integrity of a building. However, in the event of a fire, the number and position of rooflights and flammability of rooflight materials all play a role in fire safety. The flammability classification of rooflight materials in the UK is defined by the following tests:

BS 476 part 7: Test for surface spread of flame

This tests the flammability of a material and its ability to spread a fire and so endanger life. Materials are classified class 1, class 2, class 3 or class 4 with class 4 being the worst and class 1 the best.

BS 476 part 6: Test for fire propagation

This measures the contribution that the tested material will make to a fire in the event of it burning. The material performance is calibrated into sub-indices of i1 and i2. An acceptable result gives an i1 rating of less than 6 and an i2 rating of less than 12.

Read More ▶ The following document can be downloaded from the NARM website: www.narm.org.uk

NARM Quickguide 02: Fire safety and rooflights: a summary of the regulations

Other reference material

In addition to this introduction to natural daylight design, NARM has published a series of Technical Documents for specifiers, covering specific topics relating to rooflights.

NARM NTD02 – Assessment of thermal performance of out-of-plane rooflights

NARM NTD03 – Application of ACR[M]001 ‘Test For Non-Fragility of Large Element Roofing Assemblies’ to GRP Profiled Rooflight Sheeting

NARM NTD04 – Thermal Modelling Study of Metal Clad Building – A dynamic thermal modelling study of a typical metal clad building to evaluate overheating in the UK – a report by Oxford Brookes University’s Oxford Institute for Sustainable Development (OISD)

NARM NTD05 – Designing with Rooflights and Artificial Lighting to reduce CO2 Emissions – supporting the requirements of Building Regulations L

NARM NTD06 – Designing with Rooflights – Supporting the Guidance in AD L2A & AD L2B

NARM NTD07 – NARM Statement on CE Marking

NARM NTD08 – Guidance on non-fragility for specifiers of in-plane rooflights

NARM NTD09 – Rooflights: Glass, Polycarbonate or GRP? – Guidance on non-fragility for specifiers of in-plane rooflights

NARM NTD10 – Analysis of Improving Daylighting and Lighting Controls on a Number of Existing Non-Domestic Buildings – An independent report by Elmhurst Energy

NARM NTD11 – Understanding the differences between ‘non-fragile’ rooflights and ‘walk-on’ rooflights for deliberate foot traffic

NARM NTD12 – An introduction to natural daylight design in domestic properties

These documents can all be downloaded free of charge from www.narm.org.uk

Other documents are available in this website, including ‘The Red Book’ ACR[M]001 Test For Non-Fragility of Large Element Roofing Assemblies

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