Design Manual
NR/GN/CIV/200/08

NetworkRail

Lighting Design in Stations

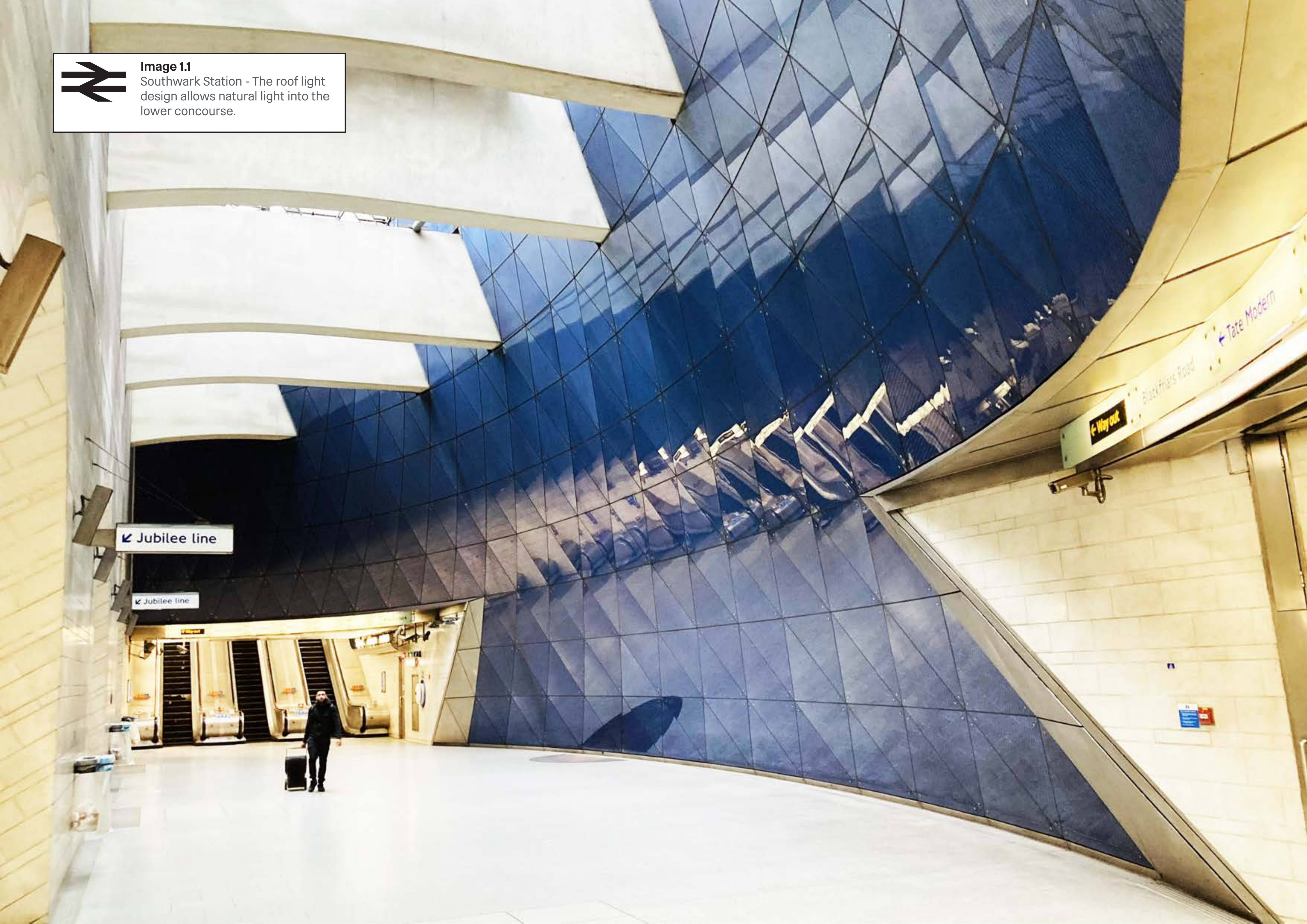

Image 1.1
Southwark Station - The roof light design allows natural light into the lower concourse.

Document verification

Verification

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Disclaimer

How to use the guidance suite

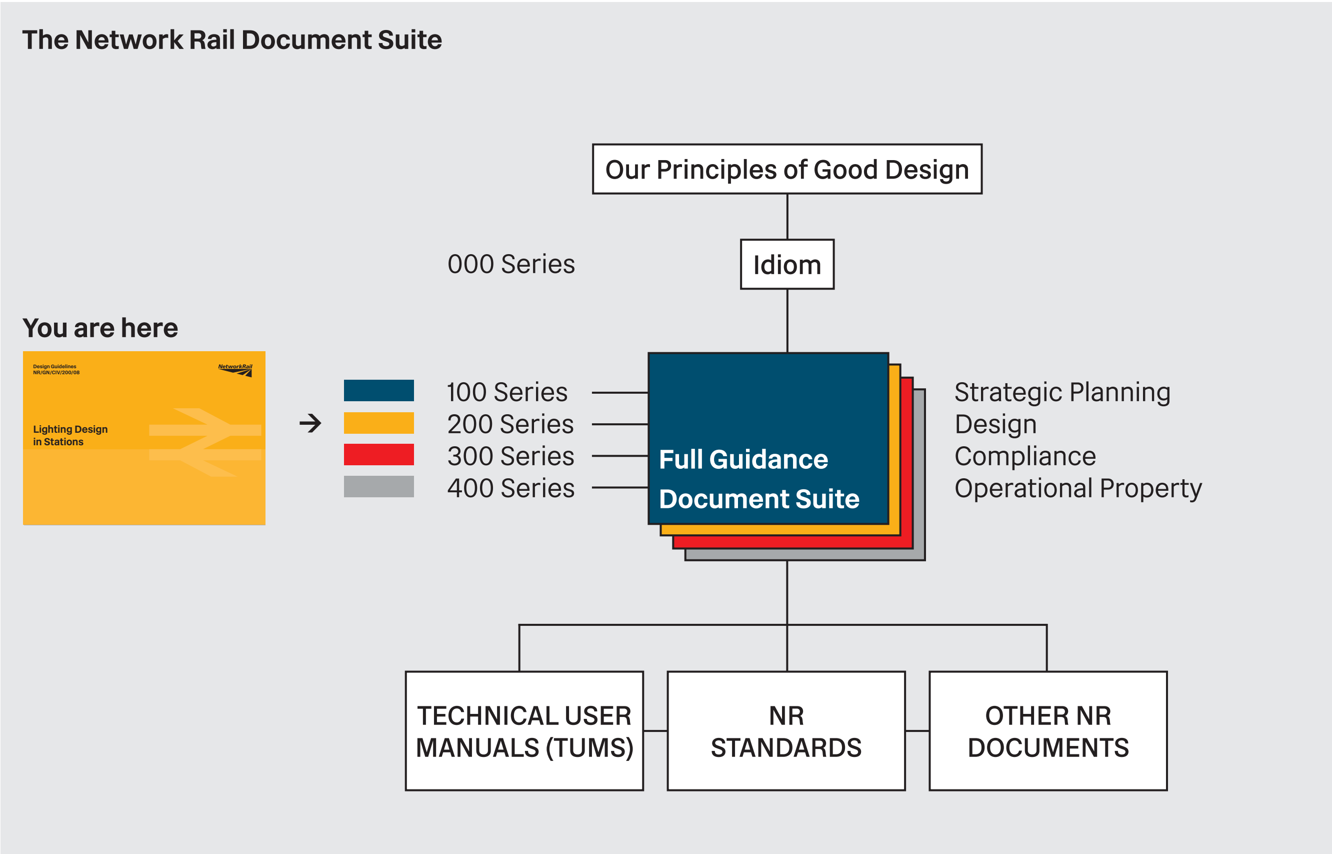

Figure 0.1 Network Rail Document Suite Summary

References to other documents

- Code of Practice Guidance
- National Standard
- Network Rail document
- European Standard

Example

European Standard

PRM TSI: 4.4.1
Information regarding the level of accessibility of all stations must be freely available. Operating rules should be made to ensure that information regarding the level of accessibility of all stations is available.

A full list of relevant documents, and other guidance suite documents is contained in the appendix.

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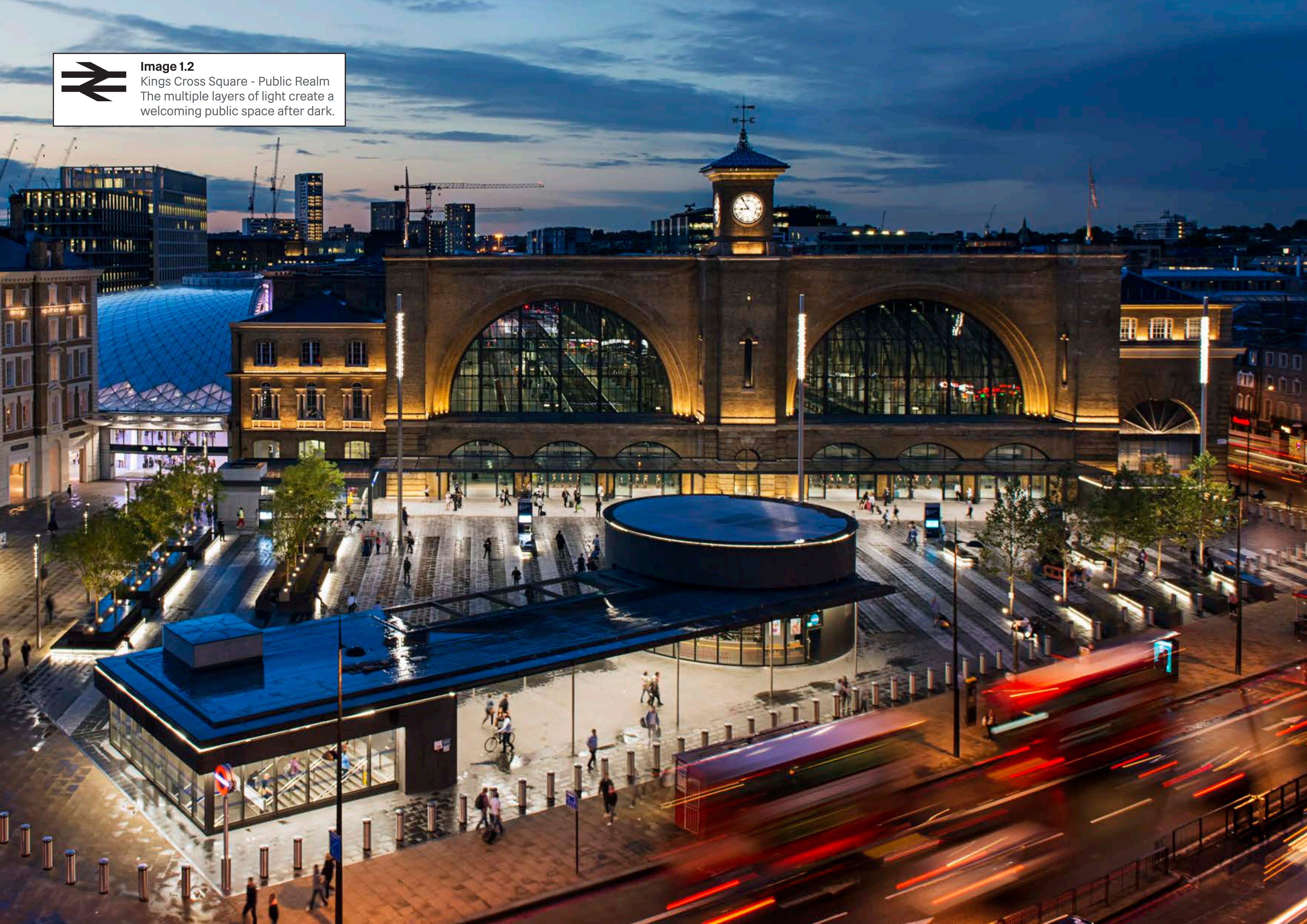


Image 1.2
Kings Cross Square - Public Realm
The multiple layers of light create a welcoming public space after dark.

Lighting Design in Stations

Introduction

1

1.1 Purpose

The Network Rail *"Lighting In Stations"* Design Manual provides the framework for a consistent approach to lighting design and specification for the publicly accessible parts of Network Rail stations.

This design guide contains comprehensive and structured quality guidelines for lighting design illustrating good practice lighting design principles, benchmarking standards of design and signposting ways to deliver optimum outcomes.

The aim of the document is to establish a legible and consistent Network Rail design identity using standardised elements, materials and detailing which is supported by a consistent lighting design methodology applied across all project types whether for lighting replacement at the end of service life, station refurbishment, restoration or new-build projects.

This lighting design manual for stations seeks to encourage all stakeholders responsible for the delivery of lighting installations on the railway to implement lighting design strategies that go beyond basic compliance with the numeric lighting engineering values stipulated in each project design prepared under NR/L2/CIV/003 (Engineering and Architectural Assurance of Building and Civil Engineering Works) and the subsequent Employer's Requirements at the procurement stage of the project.

The Network Rail Strategic Business Plan (SBP) for England and Wales, and our SBP for Scotland's Railway sets out to deliver the best railway for the funding available for the next Control Period (CP7).

A key part of Network Rail's CP7 plans for enhancing the passenger experience is the improvement of lighting in stations. The objective is to develop lighting solutions which put user experience and aesthetic considerations at the forefront, without compromising on the Network Rail Project Delivery Guidance and the Technical Lighting Standards. Strategies for improvement to lighting in Stations are directly linked to the measures of success defined in the Network Rail Buildings and Architecture Strategy 2021. Good lighting design can help to achieve greater:

- Sustainability
- Satisfaction
- Safety
- Stewardship

Measurable improvements to lighting in stations can also assist Network Rail delivering their Environment Sustainability Strategy 2020 -2050 by contributing to:

- A low-emission railway
- A reliable railway service that is resilient to climate change
- Improved biodiversity of plants and wildlife
- Minimal waste and sustainable use of materials

Images 1.3 and 1.4: Lyon-Saint Exupéry Airport Railway Station
The sculptural form of the station canopy is transformed at night with indirect lighting to create an iconic 'gateway to the city at night.

Introduction

1.2 Scope

The scope of the guidance includes covered and open platforms, concourses and ticket offices, waiting rooms, staircases, ramps and footbridges, tunnels and underpasses, station forecourts and car parks.

The typical spatial typologies considered within the design guide are generally consistent across all Network Rail properties. This guide signposts examples of good lighting design which can be used as reference points for the provision of new lighting or the renewal of existing lighting including emergency lighting to enable the safe use and enjoyment of railway stations by passengers and users at all times.

The all-embracing vision and aims of Network Rail "Principles of Good Design" publication have been used as a reference point for the development of the Lighting Design in Stations Guide

The project examples and case studies contained in the appendices of this design guide are examples of good lighting design practice in stations. The designs frequently adopt a multi-layered approach to the lighting of stations and signpost the way for future Network Rail projects to achieve a significant step-change in the quality of lighting design within station environments for everyone.

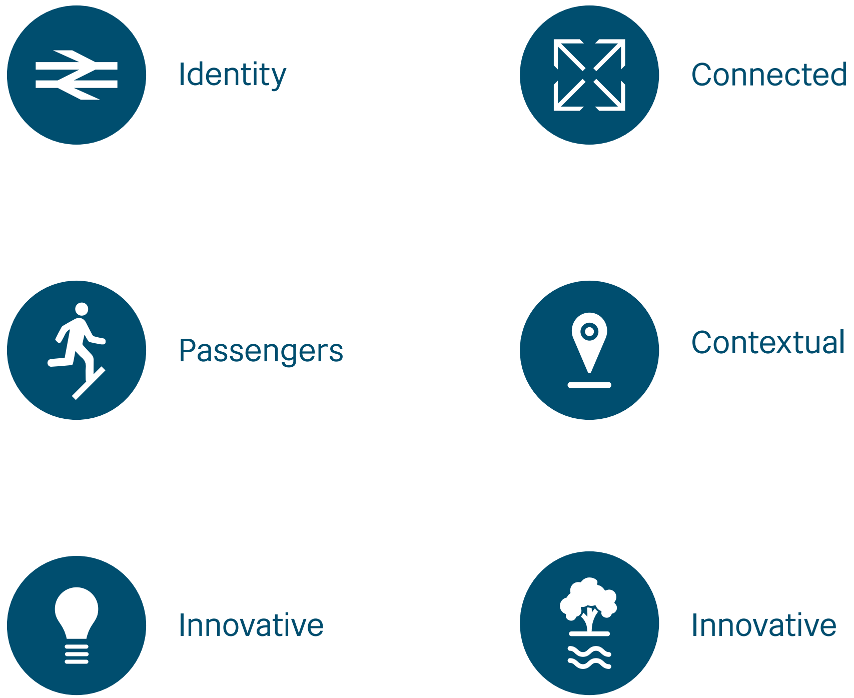


Figure 1.1
Network Rail Principles of Good Design

1.3 Benefits of Good Lighting Design

Light is a potent and immediate sensory stimulus that connects everyone with their surroundings. It communicates with people very directly and can evoke powerful thoughts and emotions.

In the built environment, both natural light and electric light are powerful design tools.

"We first assess our environment according to how well that environment is structured, organised and illuminated to satisfy all of our needs for visual information….in the relevant, appropriate luminous environment, those things which we want or need to see are clearly visible and emphasised and those which are distracting or unpleasant are de-emphasised or hidden from sight."
William M.C. Lam

Natural light is a constantly changing resource, never the same from one moment to the next. Historically, the architectural forms of buildings and structures evolved in an environment shaped by a single source of light, the sun. The later development of "artificial" sources of light presented a greater range of opportunities for architects, artisans, and designers to reveal and enhance both interior and exterior spaces in the built environment.

Light reveals three-dimensional space and the forms, textures, and colour of the world around us. Light provides the visual cues that enable people to perceive, appreciate and interact with their environment. It can amplify the design intent of those responsible for the design of the built environment both within and around railway stations and create an ordered visual hierarchy which is legible for all users.

Exposure to visible light serves the fundamental psychological human need of being able to clearly perceive the nature and structure of the environment that presents itself to us during every moment of the day. People always feel comfortable when they can clearly see what they want or need to see in any given situation. Psychological discomfort will increase as visual noise, and irrelevant or conflicting visual signals dominate the scene and interfere with a person's ability to perceive important information or visual cues as they pass through the station.

Good lighting can create the optimal environment for processing essential wayfinding information. Clear visual cues for passengers can also promote intuitive elements of wayfinding to assist the flow of passengers through the station.

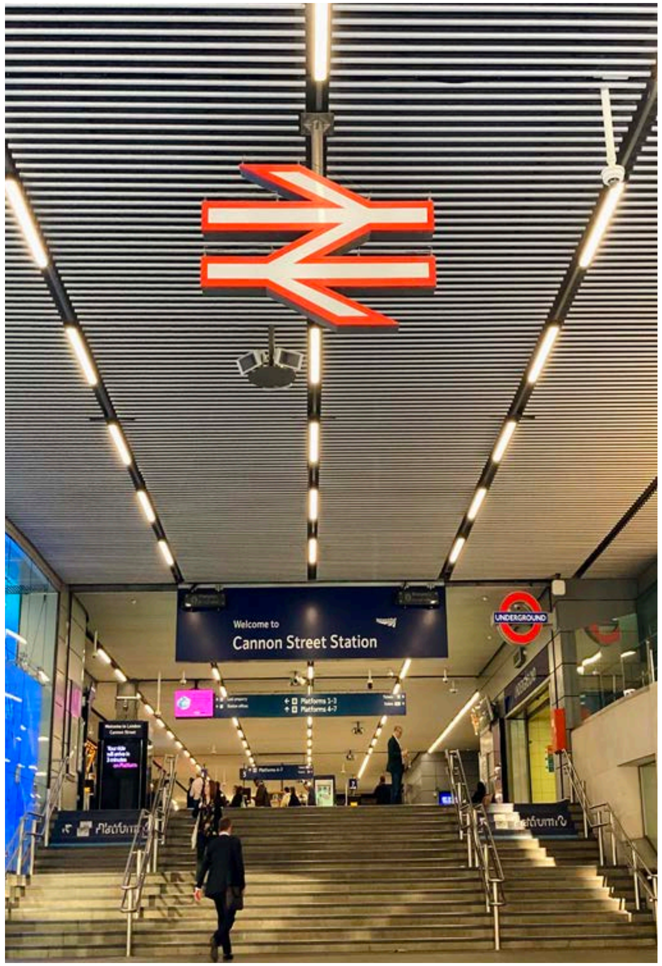


Image 1.5: Cannon Street Station:
Network Rail logo and linear lighting elements support wayfinding

1.3 Benefits of Good Lighting Design

"Railway stations have the power to be modern day cathedrals; grand, inspiring and memorable at any scale. They are the gateways to our cities, towns and communities and can hold centre stage in the public realm."
Sir Nicholas Grimshaw CBE, PRA, RIBA, AIA

The development of modern lighting engineering principles in the early 20th Century led to a greater and greater reliance on quantifying the *"measurable"* metrics of illuminance and uniformity for specific visual tasks. This led to the increased focus on providing functional task lighting, engineered to comply with the published lighting design codes and standards to the detriment of the perceived subjective quality of the illuminated environment.

Over the past fifty years, an alternative approach to architectural lighting design has evolved which puts perception of the space, aesthetic design considerations and subjective user-experience at the forefront, alongside the pure lighting engineering aspects of the design. On the railway, lighting is used for many different purposes; to support visual tasks of all users accurately, quickly, and safely; to make stations and their surrounding environments pleasant and attractive places to be; to generate business for retailers both inside the station and in the local community; to enhance passenger safety and security and promote intuitive wayfinding.

Image 1.6: London Bridge Station
Multi-service channels with Cable Management System (CMS), Closed Circuit Television (CCTV) and lighting flush recessed into canopy soffit panels

1.3 Benefits of Good Lighting Design

The interplay of natural light and electric light is an integral part of everyone's experience of the railway.

Lighting is an aspect of the day-to-day operation of a station. Good lighting design can assist in the differentiation of spaces inside and outside the station and create an ordered visual environment in which all user groups can feel comfortable.

Lighting can add presence to external public spaces creating a unique character and ambience which contributes to a clearly defined sense of place. It can highlight elements of the station architecture both externally and internally, defining the essential character of a building by day and night. Moreover, lighting can be used strategically to guide passengers through the station at key decision points on their journey from the wider community, into the immediate external station environment, through busy concourses and gatelines onto platforms and boarding and alighting from trains.

Good lighting can work alongside station signage to support wayfinding by creating intuitive spaces for everyone. It can work alongside station signage to support wayfinding by creating intuitive spaces. Conversely, bad lighting design can cause visual discomfort and glare, create confusion and be hazardous to all station users.

Image 1.7: London Bridge Station
Daylit concourse with Illuminated Passenger Information Displays and Illuminated Advertising Displays

1.3 Benefits of Good Lighting Design

The benefits that creative, welcoming, and uplifting lighting designs and light-art features can bring to railway stations cannot be over-estimated.

In the images on the right, one can see the effects of good lighting design compared to poor lighting. In the image 1.8, safety and welcoming ambiance are lacking. The use of luminaires in different colour temperatures create a lack of uniformity on the platforms while the dark canopies are not illuminated which creates a gloomy ambience after dark. The platform's edge, seating and station signage are relatively dark, impacting safety. This ill-considered lighting design results in glare, harsh shadows, and dark spots, creating the impression of an unsafe and unwelcoming environment.

In contrast, canopy lighting at Birkenhead North (Image 1.9) provides uniform, bright illumination, enhancing safety and ambiance. Lighting creates a bright, safe and welcoming environment whilst enhancing the architectural elements of the cast-iron canopy structure.

These two examples illustrate how passenger experience can be measurably improved, and vandalism, anti-social behaviour, littering, graffiti and tagging substantially reduced.

Well lit spaces will enhance the prominence, visibility and legibility of station signage and wayfinding elements.

Public art displays of sub-letting retail spaces and the subtle use of interactive light features as media assets for Network Rail can have significant direct and indirect revenue-earning potential.

The Network Rail minimum viable product (MVP) methodology can be directly applied to the measurable value that well-designed and well-implemented lighting design brings to railway stations both in terms of enhanced passenger experience and the creation sustainable lighting schemes for both new construction and the renewal, refurbishment, repair, maintenance and enhancement of existing assets.

Image 1.8: Poor lighting design can create an unwelcoming environment with harsh shadows and dark spots

Image 1.9: Canopy lighting that enhances the sense of safety and a welcoming environment

Image 2.1
Helsingborg Central Station
Uplight on the wooden ceiling reflects warm lighting while creating an organic pattern

2

Lighting Design in Stations

Lighting Strategies

2.1 Identifying Visual Tasks

At the outset of each project, it is important to clearly define the objectives for the lighting design. This is equally true whether the project consists of the replacement and renewal of existing lighting or the provision of completely new lighting as part of a station refurbishment or a new-build design.

Most technical lighting design parameters are defined in published design guidance and recommendations which specify minimum levels of maintained illuminance and lighting uniformity for common visual tasks within specific environments. For example, British Standard BS EN 12464 Parts 1 & 2 “Lighting of Workplaces” specifies the requirement to provide adequate and appropriate lighting in terms of the quantity and quality of illumination for specific visual tasks in railways. The Lighting Design in Stations guide advocates a more subtle approach to the design of lighting for stations which is multi-layered and considers the lighting of each internal and external space holistically, incorporating the strongly advised levels of task illuminance but proposing ways in which the lighting in stations can be enhanced to provide an improved aesthetic visual experience for all users.

National Standard

Lighting of Workplaces, Indoor and Outdoor Workplaces
BS EN 12464- Part 1 and BS EN 12464-Part 2 [1]

[1] Note the work on the revision of EN 12464-2 is at an advanced stage it is likely to be published before the end of 2024.

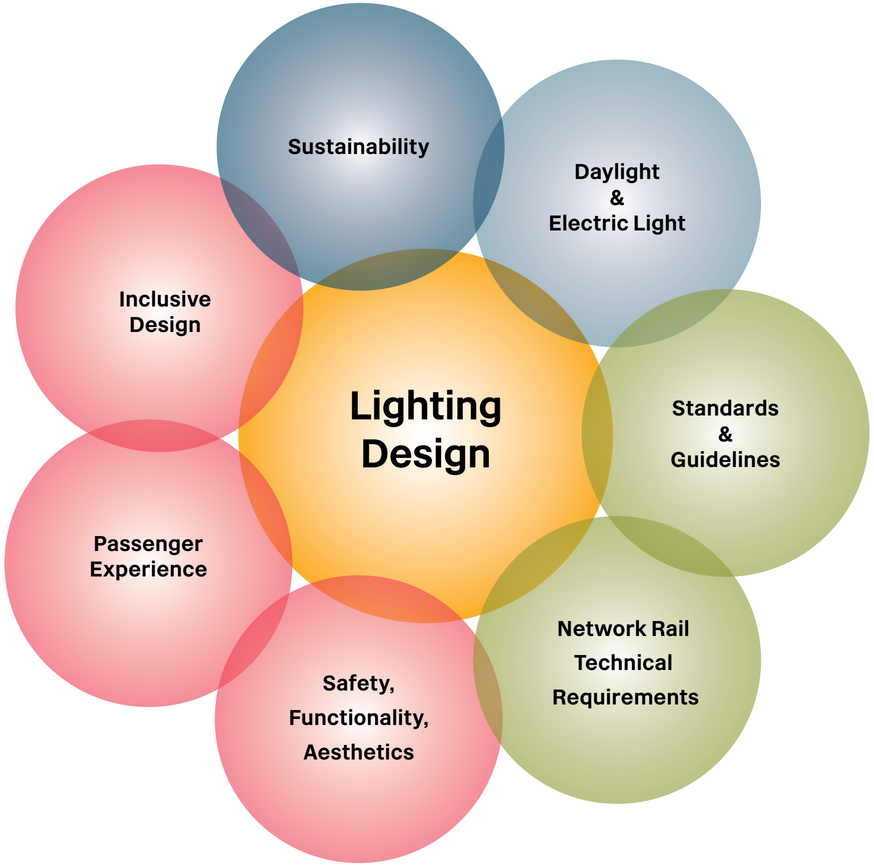


Figure 2.1
Aspects of Lighting Design

2.2 Developing the Lighting Concept

The lighting designer should create a synthesis which combines the lighting of identified visual tasks with the illumination of each interior space or external environment to achieve the optimum end results.

Passenger safety and passenger experience should be put at the forefront, whilst balancing this consideration with the operational requirements of the railway and other project stakeholders.

The lighting designer should begin by conceptualising the lighting of each aspect of a space when revealed by light. What a lighting designer chooses to light or not to light can affect each user's perception of the station environment according to decisions made at the design stages of each project.

The three tenets of lighting first conceptualised by Richard Kelly in 1952 remain an essential theoretical statement on lighting design. No other lighting design practitioner had previously articulated abstract lighting concepts in such a poetic way:

- Ambient Luminescence
- Focal Glow.
- Play of Brilliants.

Richard Kelly understood the ability of light to shape three-dimensional space and create a sense of visual awareness, evoking a range of human emotions

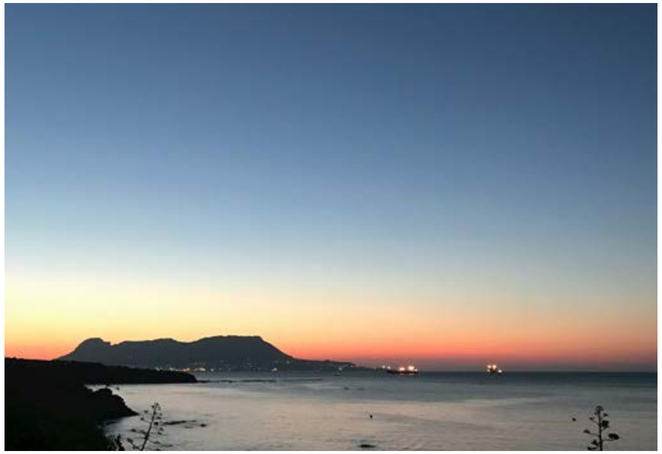


Image 2.2: Ambient Luminescence
The warm glow of a sunset

Image 2.3: Focal glow
Narrow beam spotlight highlighting an object of interest

Image 2.4: Play of Brilliants
Sparkling reflections of sunlight on the surface of the sea

2.2 Developing the Lighting Concept

For daylit spaces the role of natural light is a fundamental aspect of the building design and strategies for the control of both daylight and electric light in harmony with each other should be embedded in the design.

The appearance of both internal and external spaces in a station environment may be radically different during the day and after dark. These extreme variations should be taken into account when developing a lighting design.

There are several conceptual terms that can be used as a framework when developing a robust lighting strategy for each project, as described on the following pages.

Image 2.5: London Bridge Concourse area during daytime.
A translucent frit on the glazed roof creates diffused daylight during the day providing ambient illumination for the circulation spaces.

Image 2.6: London Bridge Concourse area after dark .
A variety of luminaire types and lighting elements create a different experience at night. The windows are dark but the translucent frit on the glazed roof reflects light back onto the circulation space below. The glazed roof appears more opaque at night than it does during the day.

2.3.1 Lighting Hierarchy:

The distribution of illuminance and luminance within a space and the colour appearance of the light sources should create an ordered sense of the visual significance of different objects and surfaces within the station.

2.3.2 Ambient Illumination:

The overall impression of brightness within the space, whether bright or dim. This may vary over the course of a day, for example. The colour temperature of light sources may subjectively influence a user's impression of the overall ambience with cooler light sources being associated with more active spaces and warmer light sources promoting a feeling of restfulness and relaxation.

2.3.3 Visual Discrimination:

The lighting of identified visual tasks considering the complexity of the task, visual performance and clarity should be a priority. Consideration should be given to avoiding disability glare and veiling reflections which adversely affect visual performance of all user groups (See section 2.10 for further guidance).

Image 2.7: London Bridge Concourse
Multiple lighting elements create lighting hierarchy

Image 2.8: London Bridge Concourse
Regular arrangement of luminaires creates uniform illumination

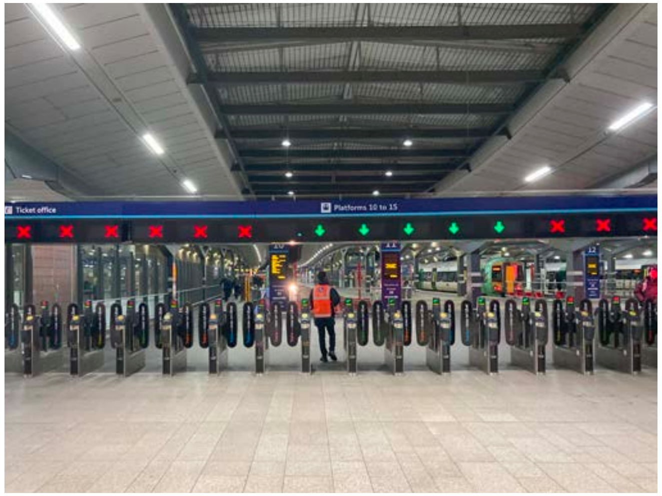


Image 2.9: London Bridge Gateline
Digital signage and glare-free lighting assist passenger flow.

2.3 Conceptual Principles

2.3.4 Flow of Light:

Considering the direction of light, which can be used to create shadow patterns or reveal the form and texture of objects within the space.

2.3.5 Sharpness of Lighting:

The degree to which light sources can cast defined shadows or create high contrasts within the visual field. When considering the needs of all users of the station environment, it is advisable to avoid high contrasts and pronounced shadows which may cause discomfort glare or confusing shadows.

2.3.6 Luminous Elements:

Considering illuminated elements within the field of view, which are perceived as sources of light. These could include luminaires with prismatic or opalescent diffusers, decorative lighting elements, internally illuminated directional signage, illuminated retail and advertising elements in the station environment.

Image 2.10: London Bridge - Undercroft
Suspended multi-service lighting trough supports wayfinding

Image 2.11: London Bridge - Train Platform
Platform edge lighting avoids high contrast and shadows

Image 2.12: London Bridge - Entrance
Information Point with backlit LED screen

2.4 Lighting The Space

When illuminating spaces within a station, lighting designers should create a series of layers rather than a single functional element being used. Task lighting elements should be supported by additional layers of ambient lighting and architectural accent lighting.

Illuminating architecture of the space in this way creates additional visual interest which is part of the overall passenger experience and contributes to the unique identity of each location.

The lighting designer can choose to reveal and enhance certain aspects of the architecture or to not light other elements to create an ordered visual environment and a legible space in which passengers can safely navigate. Visual ambient cues can assist with intuitive wayfinding, alongside more specific task based lighting to illuminate signage elements.

Sometimes the purpose of the lighting can be to celebrate the architecture itself to create a pleasant and memorable experience for passengers. Lighting then becomes an integral part of the design of the station identity.

Most railway station buildings and structures have a clearly defined building module, whether this is clearly expressed or not. The lighting design should always respond to this module, with luminaires set out in harmony with the rhythm of the structural grid.

Image 2.13: Elizabeth Line cross passage
Lighting as an integral part of the architecture

Structures where the lighting of selected elements is in harmony with the architecture creates illumination which is visually pleasing.

Consideration should be given as to whether luminaires are visible design elements within the space or concealed and visually discreet.

Uplighting can create the sense of an elevated ceiling making large, enclosed volumes like station concourses appear even more generous. Smaller non-daylight spaces such as pedestrian underpasses feel more welcoming by creating the impression of an elevated ceiling. Enhancing visual acuity can be provided with good levels of diffused illumination without harsh directional lighting and shadowing.

The use of free-standing totems and post mounted signs perhaps with integrated lighting elements could be used at Managed Stations where the high ceilings and listed structures make the use of suspended signage elements challenging.

Image 2.14: Elizabeth Line concourse
Lighting integrated in architectural elements. Uplighting creates a sense of elevated ceiling

2.5 Task Lighting

When considering how a space should be lit, it is important to first define the visual tasks and how the lighting should address them.

One of the principal tasks in station is to facilitate the safe movement of arriving or departing passengers.

Identified obstructions along walking routes should be highlighted to enable safe movement.

Where passenger density increases in hazardous locations such as escalators or platform edges the provision of higher illuminance values may be necessary. Therefore, points of emphasis should be illuminated.

Lighting should be layered and task-specific, rather than generic and undifferentiated. It is widely accepted that human visual perception and processing of visual information is based on photo-tropic behaviour using a brightness and contrast hierarchy within the visual field.

Horizontal illuminance and lighting uniformity should never be the sole consideration for lighting designers since the way in which the eye responds to light does not correspond with linear illuminance scales where a range of visual step changes should be applied.

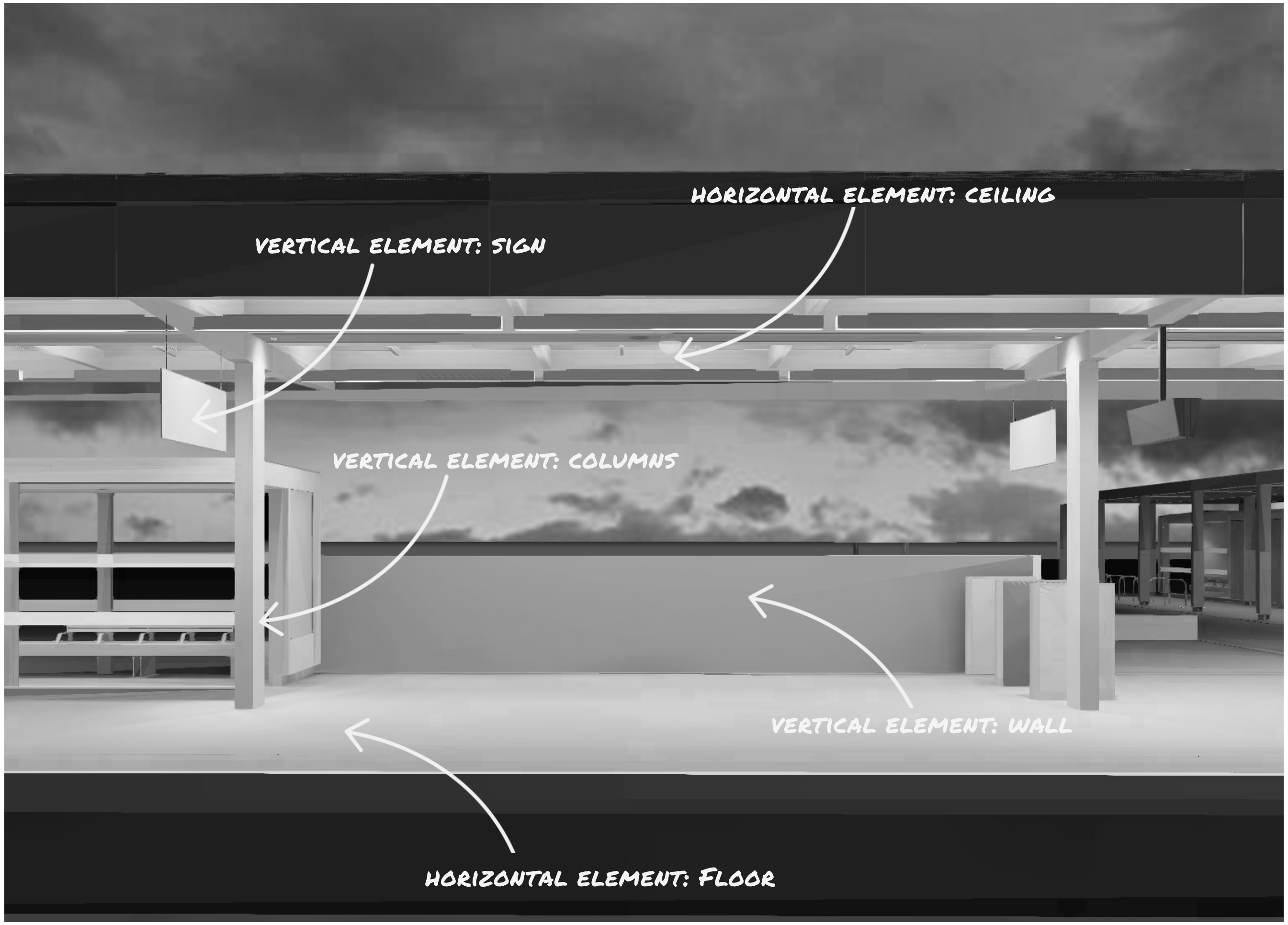


Figure 2.2: Hub Station platform
Horizontal and Vertical elements in Hub Station

2.5 Task Lighting

When standing or walking through a station, the visual field includes more vertical surfaces than horizontal ones. In transport environments, passengers are naturally drawn to brighter backdrops rather than brighter floors or table surfaces, while either moving or standing. Indirect lighting and wall washing may therefore place greater emphasis on the ceiling and vertical surfaces rather than the floor.

The plane in which tasks take place should therefore be given careful consideration, as many tasks in a station environment may occur in vertical planes rather than horizontally.

If high volumes of passengers are expected then consider the following strategies for the lighting:

- Specifying a greater number of lower output luminaires, rather than fewer high output luminaires, to provide improved lighting uniformity overall;
- Ascertain that the passenger destination points are clearly visible in crowded stations;
- Ascertain that all signage and wayfinding elements clearly visible. It is important that signage is legible when closer, but also clearly visible and conspicuous from greater distances to assist passenger flow through busy spaces.

Figure 2.3: Hub Station platform lighting
Night time scene - illumination of key aspects of the platform environment

2.6 Passenger Safety

2.6.1 Passenger Safety and Security:

Appropriate illuminance levels should be provided, both internally and externally with the correct levels of lighting uniformity. It is important that good facial recognition is achieved, particularly in the external environment since passengers may feel comfortable with others approaching them only after they have been recognised.

2.6.2 Hazard identification:

Obvious hazards may include changes in level, junctions, platform edges, the platform train interface and areas where there are moving vehicles or equipment. Local accent lighting can assist passengers to identify a hazard. The process of wayfinding consists of four stages: orientation, route decision, route monitoring and destination recognition. Passenger flow through the station consists of fast zones such as primary access routes and slow zone such as ticket offices, information boards and retail units where passenger dwell for longer. The lighting design can promote intuitive wayfinding by considering ways in which light can assist each of these stages in every passenger's journey through the station. In addition to checking that signs, directory panels, maps and information are adequately illuminated the lighting designer can aid intuitive wayfinding by highlighting decision-making areas and destination points.

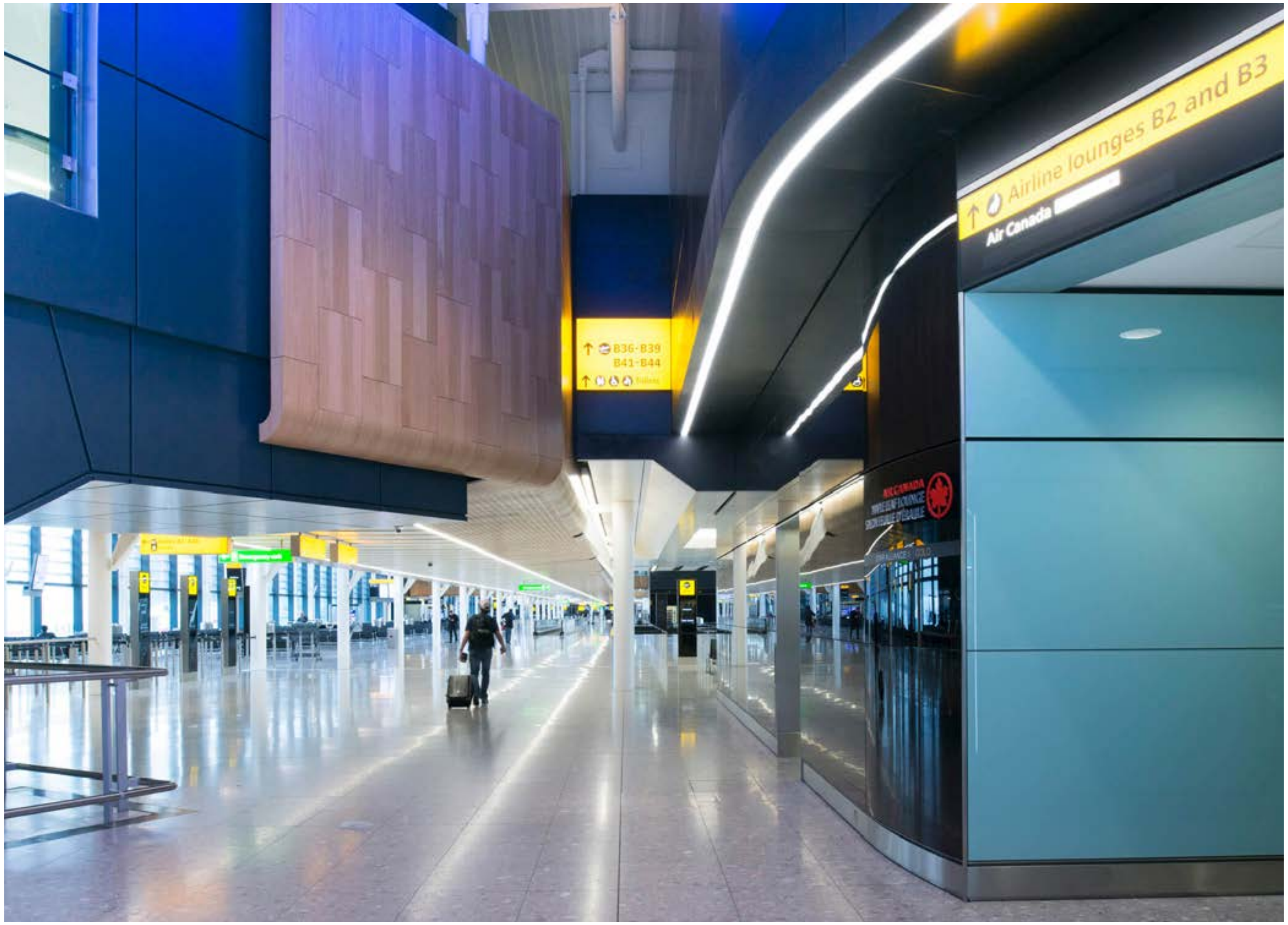


Image 2.15: London Heathrow Airport, Terminal Two Concourse B
Lighting follows passengers pathway and supports wayfinding

2.7 Wayfinding

Allowing passengers to move quickly and efficiently through the station areas requires a legible, cohesive and consistent wayfinding system.

Physical wayfinding elements may include signage, information boards and maps and free-standing totems. These are often large-scale elements within the station environment which are sometimes internally illuminated. In terms of passenger wayfinding, lighting can be used to assist visual communication, to provide visual clarity in terms of colour and contrast, avoid excessive reflections, glare, and shadowing. Good lighting can also enhance the clarity of text and symbols. An appropriate and well-conceived lighting design should work in support of the station wayfinding strategy by allowing passengers to see and interpret visual information clearly and correctly while they negotiate a safe route through the station.

Lighting and signs can help to define paths and routes but may also create unnecessary obstructions to passenger movement. Where possible, signs and associated lighting elements should be suspended or wall mounted to minimise the need for additional free-standing structures within the space.

NR Guidance Suite Reference

Wayfinding Design Manual
NR/GN/CIV/300/01

Internally illuminated displays with static and dynamic information should have non-reflective surfaces. Station signs and displays should not be located adjacent to external glazing or luminaires and light sources where there is a risk of veiling reflections causing glare and reduced legibility of important directional signage and passenger information. It is important to consider the visual balance of wayfinding with advertising (often illuminated / digital and competing for attention). Lighting can be used a visual cue to promote intuitive wayfinding for passengers by highlighting a preferred route or lighting the end of a vista to guide passengers to a particular destination point in the station.

Image 2.16:
Birmingham New Street
Bespoke finger post design

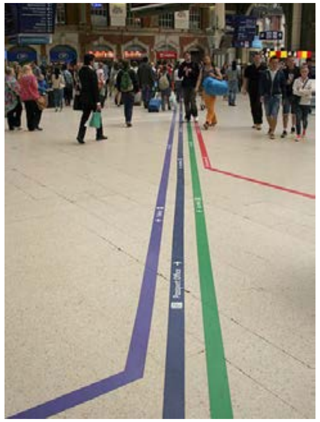


Image 2.17: Victoria Station
Graphic lines on concourse floor guide passengers through the station

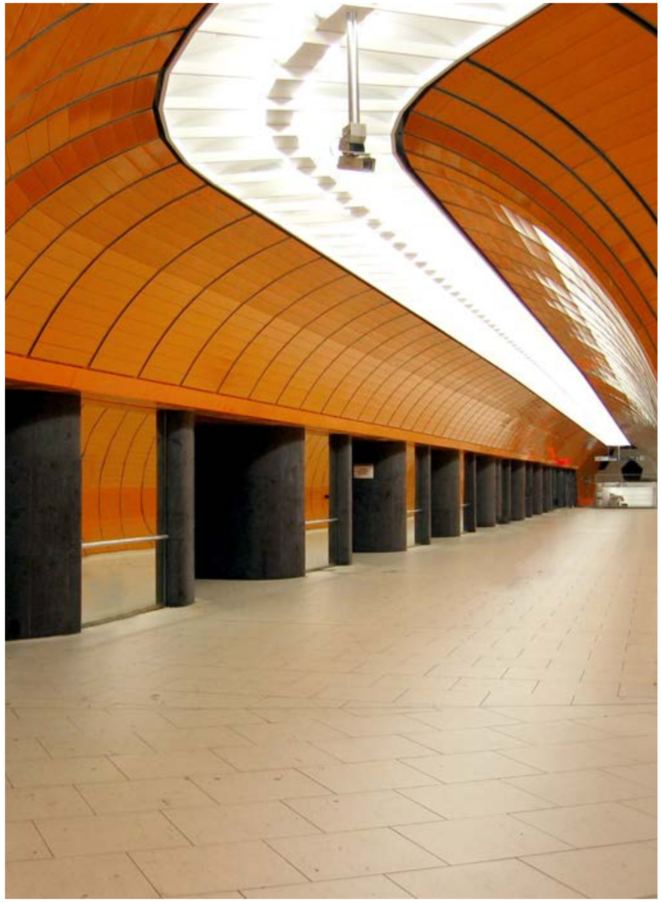


Image 2.18: Marienplatz, Munich,Germany
Lighting follows the directionality of the architecture supporting wayfinding

2.8 Inclusive Design

"Inclusive design is about making places everyone can use...it aims to remove the barriers that create undue effort and separation. It enables everyone to participate equally, confidently and independently in everyday activities." Commission for Architecture and the Built Environment (CABE). Principles of Inclusive Design - 2006

It is necessary to place all users of the railway at the heart of the design process in every railway station to enable passengers to use the railway safely, easily and with dignity.

BS 8300 Parts 1 & 2 provides comprehensive guidance on the design of exterior and interior environments. Lighting designers should therefore carry out a risk assessment when determining the technical parameters for the lighting design, taking into account Sponsor and Asset Management requirements.

Network Rail document
Inclusive Design Manual **NR/GN/CIV/300/04**

National Standard
Design of an accessible and inclusive built environment **BS 8300-Parts 1 and 2**

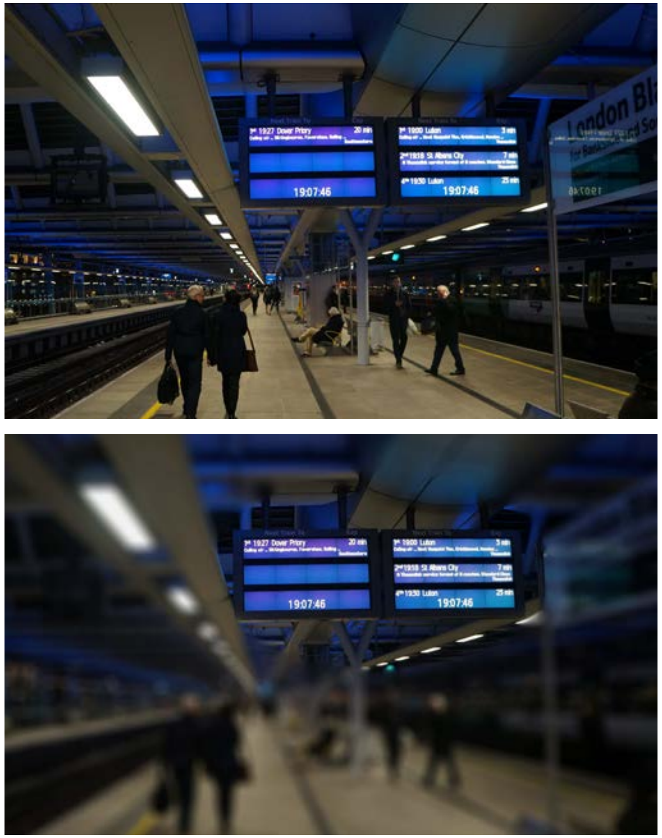


Image 2.19
Passengers with visual impairment may have difficulty reading Customer Information Displays. Platform surfaces with high reflectance values and good levels of illuminance with high levels of lighting uniformity can assist all user groups in the station environment.

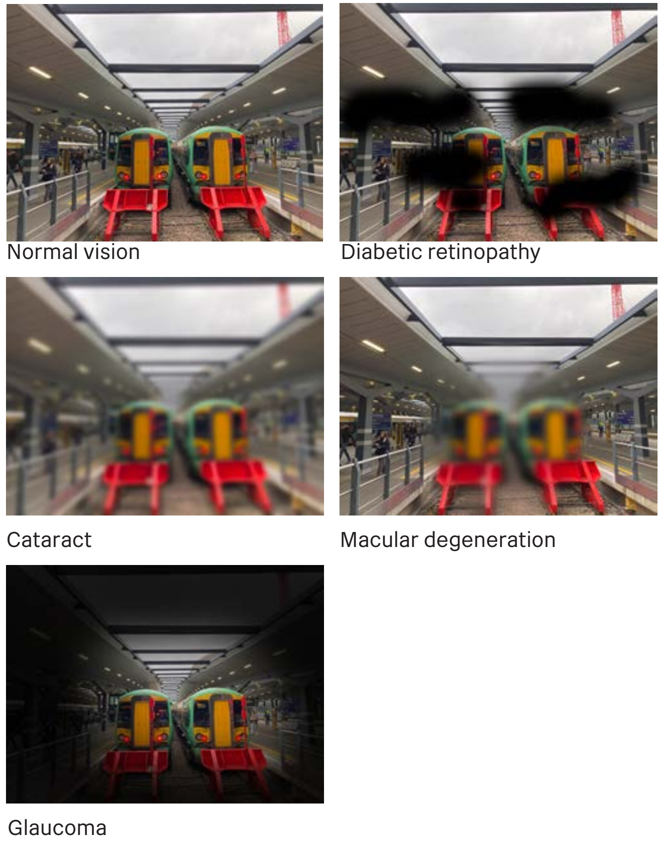


Image 2.20
Photographs illustrating the potential impact of common types of visual impairment compared to normal vision

2.8 Inclusive Design

The illuminance on interior surfaces, the quality of the lighting, good colour rendering and the avoidance of glare are key factors to be considered.

The general lighting design advice in BS8300 is for lighting to maintain a level of illumination that is comfortable and provides a safe environment which is suitable for people who are blind or partially sighted. In addition, the lighting should avoid any perception of flicker and not give rise to light pollution.

Glare from bright patches of light within the field of view can be misleading and cause confusion for those who are blind and partially sighted and people with sensory/neurological processing difficulties. An even illuminance across a room or space is preferred.

At building entrances, the code of practice highlights the requirement for designers to create transition zones to allow for visual adaptation at ingress and egress points.

Both natural light and electric lighting should be designed to avoid creating glare, pools of bright light and strong shadows.

Where one-to-one communication is important, e.g. between a station staff and a member of the public, lighting should illuminate the face of the person speaking to make it easier for a person to lip read.

Activities that involve precise hand movement, e.g. keypad and entry phone controls, might require specific task lighting.

Uplighters with exposed light source at floor or low level should not be used as they may cause glare and obscure vision. If luminaires are used for uplighting they may include anti glare characteristics and accessories.

BS8300 also recommends avoiding the prominent use of strong colours, either in light sources or on surfaces, can lead to sensory overload for some persons with sensory/ neurological processing difficulties.

Where a lighting design has been determined for a specific feature, it should be used consistently wherever that feature appears to avoid potential confusion for users of the space. BS 8300 has specific design recommendations for typical building areas, such as stairs, ramps, corridors etc. Designers should refer directly to the standard for specific guidance.

Note: Illuminance and uniformity levels stipulated within BS 8300-1 and within the Department for Transport's Design Standards for Accessible Railway Stations should be agreed with the Sponsor and/or Asset Management.

Application	Average illuminance	Minimum illuminance
Pedestrian routes in the external environment	5	-
Pedestrian routes adjacent to the entrances/exits of buildings	-	100
Subways (open)(night)	50	25
Subways (enclose)(night)	100	50
Subways (enclosed)(day)	350	150
Footbridges (open)(night)	30	15
Footbridges (enclosed)(night)	100	50
Footbridges (enclosed)(day)	350	150
Stairways and ramps (open) in external environment	30	15
Stairways and ramps (open) adjacent to the entrances/ exits of buildings	-	100
Reading Signs	50	-
Pedestrian Crossing	-	10 to 15

NOTE 1: Values in this table are drawn from CIBSE publication LG06/16 and the SLL Code for Lighting.
NOTE 2: The values given for reading signs would be adequate for the illumination of entry barrier controls and car park ticket machines.

Table 2.1: Maintained illuminance lux values - BS8300

Application of the PRM NTSN

Lighting (PRM NTSN 4.2.1.9):

- The illuminance level of the external areas of the station should be sufficient to facilitate wayfinding and to highlight the changes of level, doors and entrances.
- The illumination level along obstacle-free routes should be adapted to the visual task of the passenger. Particular attention should be paid to the changes of levels, tickets vending offices and machines, information desks and information displays.
- The platforms should be illuminated according to the specification standards referenced in the design manual.
- Emergency lighting should provide sufficient visibility for evacuation and for identification of fire-fighting and safety equipment.

The minimal light levels and uniformity along the platform, necessary for safe circulations, should take into account the foreseen passenger density. The table on the following page summarizes the advised light levels for the different types of platforms.

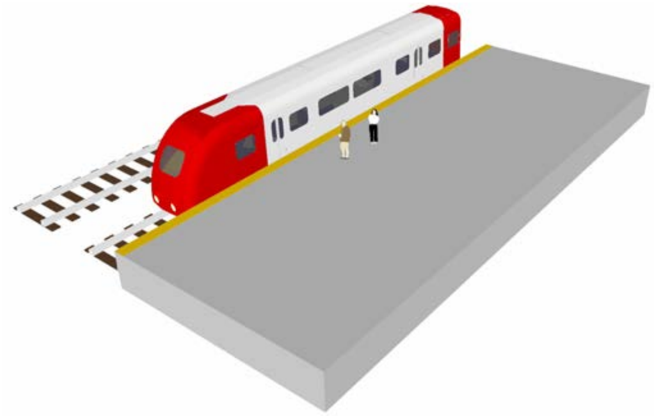


Figure 2.4 Schematic visual of an open platform with fewer passengers

Figure 2.5 Schematic visual of open platform with a greater number of passengers

Ref. no	Type of area, task or activity	E_m lux		U_o	R_{GL}	R_a	Specific Requirements
		Required[a]	Modified[b]				
General	Railway areas including light railways, monorails, miniature rails, metro etc.						Avoid glare for vehicle drives
23.1	Open part of platform, very small number of passengers [f]	5	-	0.20	50	40	1) Special attention to the edge of the platform. 2) $U_d \geq 1/10$
23.2	Open part of platform, small number of passengers [f]	10 [c]	-	0.25	50	40	1) Special attention to the edge of the platform. 2) $U_d \geq 1/8$
23.3	Open platform, medium number of passengers [f]	20[c]	-	0.30	50	40	1) Special attention to the edge of the platform. 2) $U_d \geq 1/6$
23.4	Open platform, large number of passengers [f]	50[c]	-	0.40	50	40	1) Special attention to the edge of the platform. 2) $U_d \geq 1/5$
23.5	Covered part of platform, very small number of passengers [f]	20[c]	-	0.25	50	70	1) Special attention to the edge of the platform. 2) $U_d \geq 1/5$
23.6	Covered part of platform, medium number of passengers [f]	50[c]	-	0.40	50	70	1) Special attention to the edge of the platform. 2) $U_d \geq 1/4$
23.7	Covered part of platform, larga number of passengers [f]	100[c]	-	0.50	50	70	1) Special attention to the edge of the platform. 2) $U_d \geq 1/3$
23.8	Stairs [e], ramps, very small number of passengers [f]	10	-	0.40	-[d]	40	
23.9	stairs [e], ramps small amount of passengers [f]	20[c]	-	0.40	-	40	
23.10	Stairs [e], ramps medium amount of passengers [f]	50[c]	-	0.40	-	40	
23.11	Stairs[e], ramps large amount of passengers [f]	100[c]	-	0.50	-	40	

Table 2.2: Lighting requirement for areas, tasks and activities. Section 5.3 on BS EN 12464-2

National Standard

Light and lighting. Lighting of work places - Outdoor work places

BS EN 12464-Part 2

Note:
Illuminance and uniformity levels should be provided in accordance with the requirements of BS 12464 whilst noting these are minimum requirements. Where enhanced values are detailed in the Rail Industry Standards such as RIS 7702-INS or the Department for Transport's *"Design Standards for Accessible Railway Stations"*, these should be provided.

Composition of the Table:

-Column 1 lists the reference number for each area, task or activity.

-Columns 2 lists those areas, tasks or activities for which specific requirements are given. If the particular area, task or activity is not limited, the values given for similar, comparable situation should be adopted.

-Column 3 gives the maintained illuminance E_m of the reference surface for the area, task or activity given in column 2.

-Column 4 gives the minimum illuminance uniformity U_o on the reference surface for the area task or activity given in column 2.

-Column 5 gives the Glare Rating limits (R_{GL}) where these are applicable to the situations listed in column 2.

-Column 6 gives the minimum rendering indices (R_a) for the situation listed in column 2.

-Column 7, contains advice and footnotes for exceptions and special applications for the situations listed in column 2.

Notes:

a. required: minimum value.

b. modified: considers common context modifiers - refer to BS EN 12464

c. The lighting level can be reduced post curfew by two of the recommended steps in the scale of illuminance. See Figure 2.6 on Page 35.

d. For stairs the glare rating cannot be applied due to viewing direction not considered by the glare rating method. It is recommended instead to limit the luminaire luminances.

e. The requirements specified for the lighting of stairs are to be applied to the individual steps of a flight.

f . The classification of the number of passengers is determined by national regulations.

g. Illuminance levels for platform are horizontal values measured on the platform surface.

2.9 Visual Adaptation

Human vision can operate over a wide range of luminances (0.04 to 40,000 cdm^2). However, to cope with this range, vision needs to adapt as the range of luminance changes.

In some circumstances the adaptation process may take some time, so it is recommended that dramatic changes in luminance are avoided where possible.

There are many fast-moving transition spaces for both passengers and vehicles in a railway station where visual acuity and hazard recognition are important to achieve.

Initial impressions of the user may be influenced by the person's previous state. As people enter an illuminated room from another space, it takes time for the eyes to adapt to the new surroundings. Visual adaptation can be assisted by providing enhanced levels of illuminance at building thresholds during the day to assist in daylight adaptation.

For passengers entering a station, any changes in illuminance values should be gradual, no greater than 10% per 5 linear metres. For example, increasing average illuminance values from 50 lux to 100 lux at ground level would require a minimum travel distance of 25 metres on foot.

Image 2.21: Station Triangeln, Malmö, Sweden - South Entrance
Appropriate lighting levels in the station entrance support visual adaptation at night whilst the narrow beam downlights at the threshold entrance assist passenger wayfinding and orientation when entering the station both during the day and after dark.

2.9 Visual Adaptation

The human eye can detect objects easily when they have a strong contrast. This can be created either with strong saturated colours, accent lighting, or both. However, the illuminated objects should have a difference in luminance or colour to the background area to be effective. The use of coloured light only works where it is different to the background colour and accent light is only effective where the object being lit achieves a sufficiently different luminance to the background.

It is also possible to use relative darkness and contrasts to make objects appear more conspicuous in a busy station environment. Entrances and exits, passenger help points, boarding and alighting thresholds, signage and seating areas should be highlighted with accent or direct lighting stand out from the background. To give a perceptual difference with ambient illuminance levels within the station environment the recommended step changes in illuminance (in lux) are as shown in figure 2.6 below. Dimmable lighting control systems allow lighting designers to programme pre-set lighting scenes in each environment which respond automatically to ambient light levels, passenger density and the time of day.

National Standard

Light And Lighting. Basic Terms And Criteria For Specifying Lighting Requirements

BS EN 12665:2018

Image 2.22: Kings Cross Station
Ambient lighting levels in the concourse area are carefully balanced with exterior daylight conditions, facilitating a smooth transition from the external public realm to the interior spaces of the station.

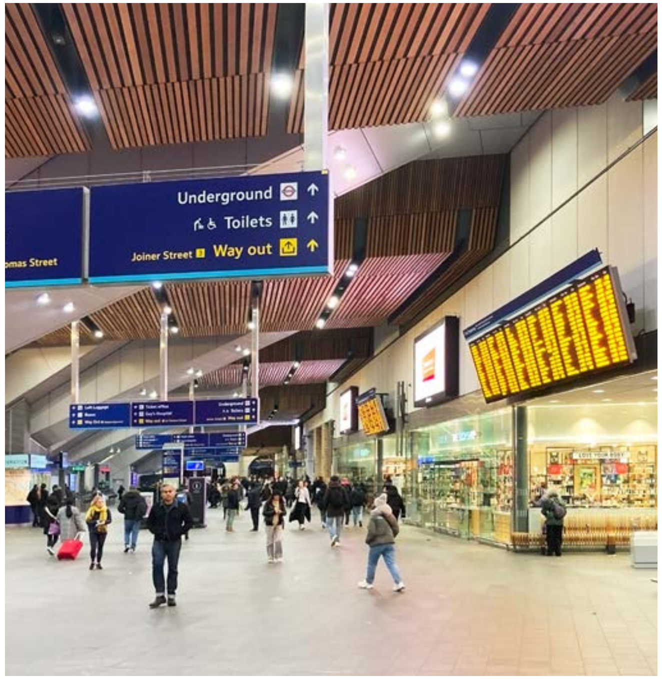


Image 2.23: London Bridge Station
Clear and legible wayfinding and passenger information displays on the concourse should not visually compete with active retail frontages.

Figure 2.6
Visual perception of the lux different values according to BS EN 12665

2.10.1 Glare

Glare from light sources is defined as either 'discomfort glare' or 'disability glare'. Both are instances of the same phenomenon, because the human visual system can deal with only a limited range of luminance at any given time.

Discomfort glare is caused by light from a bright source being scattered within the eye and creating a luminous veil on the retina. Discomfort glare does not affect a person's ability to carry out a visual task but may cause fatigue.

Disability glare reduces contrast to the extent that the ability to carry out a visual task is significantly impaired. Older people are more affected by disability glare and can take longer to recover due to the greater absorption of light on its passage through the eye. Disability glare is a measure of the extreme difficulty caused by this scattered light and discomfort glare is a measure of subjective discomfort people may feel even though the visual task not be significantly impacted.

The creation of visual comfort and the avoidance of both types of glare should therefore be of equal importance to the provision of appropriate levels of illuminance. Light sources should be concealed from direct view or filtered with louvres, reflectors or diffusers to minimise glare for passengers, staff and train drivers. Visible LEDs are extremely bright point sources, which require some form of optical control within the luminaire, i.e. lenses, reflectors, diffusers or refractors. The intensity of the light source can also affect glare. As such lower power light sources should be considered. It is also important for designers to be aware that shiny or glossy elements within the field of view may also cause excessive brightness within the visual field and are potential sources of glare.

Practical guidance to mitigate glare can be found in RIS-7702-INS clause G3.4.2.4 and G3.4.2.5

2.10.2 Veiling Reflections

Other sources of visual discomfort which should be avoided in the station environment are veiling reflections.

Veiling reflections are an example of disability glare reflected from a surface. Veiling reflections occur where specular reflections from a surface, such as a back-painted signage panel, ticket office computer screens or CIS screens on platforms which obscure the information being conveyed to passengers.

Care should be taken when locating luminaires and light sources adjacent to specular surfaces to avoid glancing light reflections from surfaces being directed towards passengers and other users of the space.

Image 2.24:
Disability Glare from visible light sources on high masts.

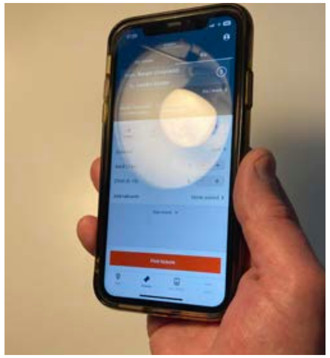


Image 2.25:
Veiling Reflections

Network Rail document

Rail Industry Standard for Lighting at Stations

RIS-7702-INS

2.10 Managing Glare

2.10.3 Solar Glare

Solar glare, dazzle or glint can be caused by the reflection of sunlight frequently from glazed building facades. This type of disability glare is of particular concern in situations where it may affect train drivers by impairing the visibility of signals putting the driver, passengers or third parties at risk.

Potential solar glare should be assessed and studied for proposed developments in close proximity to the railway. The severity of potential glare can be calculated as the equivalent veiling luminance which is caused by the excess light being scattered in the eye thereby creating a 'veil' through which objects are seen. As the figures opposite illustrate, light reflected from a building façade varies considerably throughout the day and at different times of the year. Whether or not a sun reflection will cause an instance of glare depends upon several factors:

- The location of the observer and viewing angle
- The position of the sun in the sky
- The reflective qualities of the building façade
- The location and orientation of these surfaces relative to the viewing direction
- The pathological condition of the observer's eyesight
- The background brightness defining the state of adaptation in the observer's eye

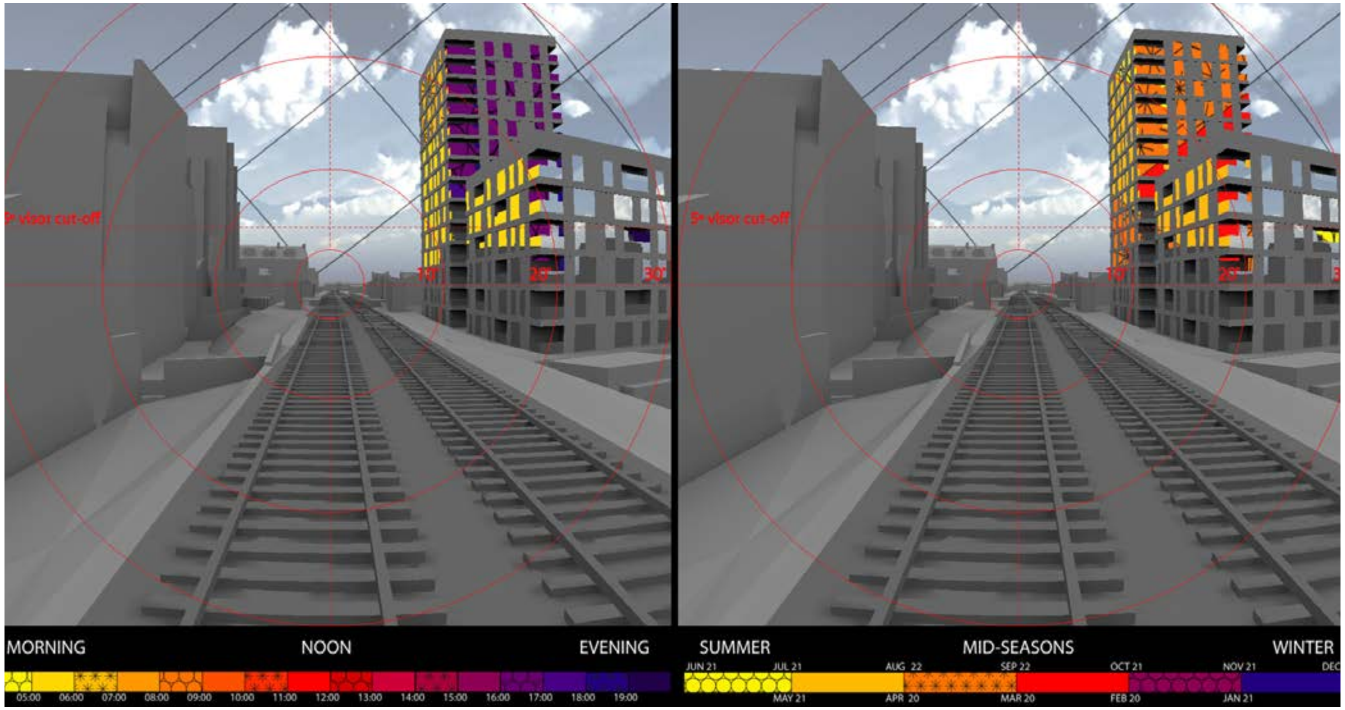


Figure 2.7: 3D computer modelling of solar glare to assess sunlight reflected from a glazed facade at different times of the day and over several months.

"For vertical façades this problem usually occurs only when the sun is low in the sky; but some types of modern design incorporate sloping glazed façades which can, under certain circumstances, reflect unwanted high altitude sunlight into the eyes of motorists, pedestrians and people in nearby buildings."
Source: BRE Information Paper 3/87 - "Solar dazzle reflected from sloping glazed facades" 1987

2.11 Managing The Effects of Obtrusive Light

There is an increasing awareness of the potential adverse effects of electric lighting in the night-time environment. The harmful effects of electric lighting are usually categorised as follows:

- Sky Glow
- Light Spill or Intrusive Light
- Glare

Network Rail has over 2,500 stations ranging from "Category A" major termini in our major cities to "Category F" small unmanned stations often in rural areas which account for more than half of the stations on the railway network.

Exterior lighting is at stations for reasons of passenger safety and visual amenity. However, those responsible for the lighting design in stations should be mindful of the potential adverse effects when developing lighting schemes for both interior and exterior spaces.

Image 2.26:
Obtrusive light from a floodlighting installation in a dark landscape

There are many good practice lighting design strategies that should be followed to verify that station lighting reduces the impact of electric lighting in and around the railway after dark.

- New lighting installations should not measurably increase sky glow or the sky quality beyond the immediate task area being illuminated.
- Luminaires and light sources should be directed downwards with no light spill above the horizontal plane.
- In instances where building façades or station canopies are being illuminated with indirect light, care should be taken to avoid light spill beyond the surface that is being illuminated.
- Avoid light spill and glare into neighbouring properties.
- Light areas to appropriate levels of illuminance and uniformity and should not over-light.
- Switch off or dim the lighting when not needed.
- Consider potential impacts on flora and fauna (See following page).

Code of Practice Guidance

"The Reduction of Obtrusive Light"
Institution of Lighting Professionals Guidance Note
GN01/21: 2021

The Institution of Lighting Professionals has detailed guidelines for mitigating and managing potential adverse affects of electric lighting based on original Commission Internationale De L'Eclairage (CIE) technical documents: (CIE 150: 2017 *"Guide on the Limitation of the Effects of Obtrusive and Light from Outdoor Lighting Installations"* and CIE 126: 1997 *"Guidelines for Minimizing Sky Glow")*

The obtrusive effects of outdoor lighting are best controlled initially by appropriate design, the published guidance is primarily applicable to new installations; however, some advice is also provided on remedial measures which may be taken for existing installations.

Those responsible for the lighting of station premises should note that the Clean Neighbourhoods and Environment Act 2005, Section 102 makes reference to "artificial light emitted from premises so as to be prejudicial to health or a nuisance;" noting that this clause does not apply to artificial light emitted from: *"...railway premises, not being relevant separate railway premises;"*

However, designers should consider that car parking, the public realm outside stations and adjacent external areas are not exempted. Therefore, it is good practice to always follow the guidance published by the Institution of Lighting Professionals.

2.12 Mitigating Impacts on Flora and Fauna

The use of electric light at night has potential adverse effects for all natural ecosystems, including amphibians, birds, mammals, insects, plans and people.

The potential adverse effects of electric light on human circadian system are widely discussed, however animals experience similar effects. A wide range of nocturnal species can have their circadian cycle interrupted by electric light after dark, causing disruption to foraging, breeding migration and communication.

There are many instances of birds colliding with tall floodlit buildings as they try to orient their flight. Many insect species are attracted to electric light. A fixation or captivity effect often occurs when insects fly directly into or follow a circular or elliptical path around a luminaire either becoming exhausted or eaten by predators. Electric light can also interfere with the nocturnal navigation of insects, drawing them towards the illuminated area and away from their natural habitats.

All bat species and their roosts are legally protected in the UK. Electric lighting can adversely influence the foraging, commuting and roosting habits of bats.

No bat roost (including access points) should be directly illuminated.

Image 2.27:
Big-Eared Bat in flight

Image 2.28:
Bats typically use tree canopies as foraging routes. Designers should avoid direct illumination of identified foraging and commuting routes.

Network Rail document

Climate Action Design Manual for Buildings and Architecture
NR/GN/CIV/100/04

2.12 Mitigating Impacts on Flora and Fauna

The type of lamp (light source) specified can have an adverse impact on bats foraging and commuting. Warm white light sources of 2,700K or less should be used in environmentally sensitive zones. Lighting should be directed to where it is needed and light spill avoided. Levels of illuminance should be as low as guidelines permit. If lighting is not needed externally for safety and operational reasons at a railway station, it is best not to light an area.

The times during which the lighting is operational should be limited to provide some dark periods. Mitigation measures for bat populations are often used in combination for best results:

- Creating dark buffers, illuminance limits and defined zones.
- Specifying appropriate luminaire and light sources.
- Providing physical screening through soft landscape and the installation of walls, fences and building.

Code of Practice Guidance

"Bats And Artificial Lighting At Night"
Institution of Lighting Professionals Guidance Note
GN08/23: 2023

Network Rail document

Environmental & Sustainability Strategy 2020-2050

Image 2.29:
Sky glow from electric lighting installations in the United Kingdom with the northern lights visible on the horizon. Photograph taken from International Space Station

Image 3.1
Fulton Centre - NYC
Skylight in an organic structure.
Reflective materials suspended in the oculus distribute natural light to the concourse below.

3

Lighting Design in Stations

Daylight and the Non-Visual Effects of Light

3.1 Daylighting Strategies

Access to daylight is fundamental to our health, well-being and cognitive capabilities. Natural light reveals the form of station buildings both inside and outside, allows passengers to safely navigate their way through the building, it supports visual task performance and can create pleasant and stimulating environments for everyone.

Windows allow light into the interior spaces, create views both into and out of the station and can enable natural ventilation to take place. However, care should be taken to avoid potential glare from excess levels of daylight and direct sunlight within the station. Both natural light and electric lighting should be harnessed to work together in the design of stations, with daylight design given priority, whilst avoiding glare to all building users.

Decisions may be taken at an early stage in the station design process regarding building orientation and massing, which may in turn influence the architecture and daylight design strategies. Daylight design strategies may also influence the form of the building, plan and section details, building orientation, fenestration details and roof light design.

Most importantly, window design, internal materials and finishes may also directly influence the electric lighting strategies, so those responsible for the lighting design in stations should be notified.

Image 3.2: Woolwich Elizabeth Line Station
Combination of ceiling openings with integrated luminaires creating a welcoming passenger experience

3.2 Optimising Natural Light

Once daylighting decisions are made, they may have implications for other, interrelated aspects of building performance such as solar heat gain, winter heat loss, provision of view, acoustic performance, privacy, security and protection from fire. Designers working on railway stations should address these interrelated factors and to determine priorities within the context of each project.

Optimising the use of natural light is a fundamental aspect of station design. In urban environments there may be constraints such as the 'Rights to Light' of neighbouring properties which may influence the form and massing of the station building itself.

The location and orientation of existing railway tracks and adjacent infrastructure may have an impact on daylight design opportunities, affecting daylight availability and influencing the design of windows and roof lights to optimise sunlight ingress, whilst avoiding potential solar glare.

Even in smaller station schemes there is significant scope to use daylight to enhance the environment during the hours of daylight and reduce energy consumption.

Code of Practice Guidance

SLL LG10-2014 Daylight

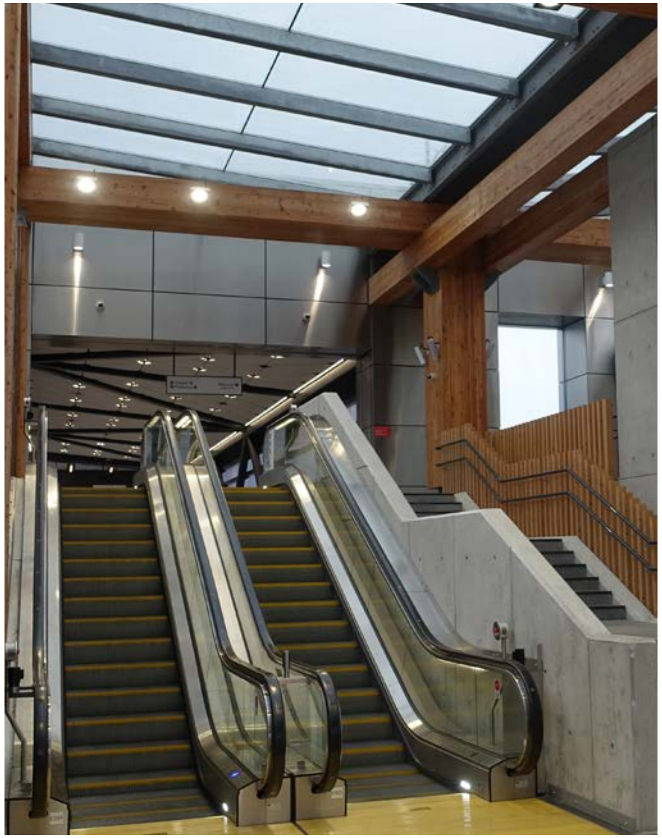


Image 3.3: Brent Cross West Station
Concourse with diffused ceiling openings allowing daylight in the space

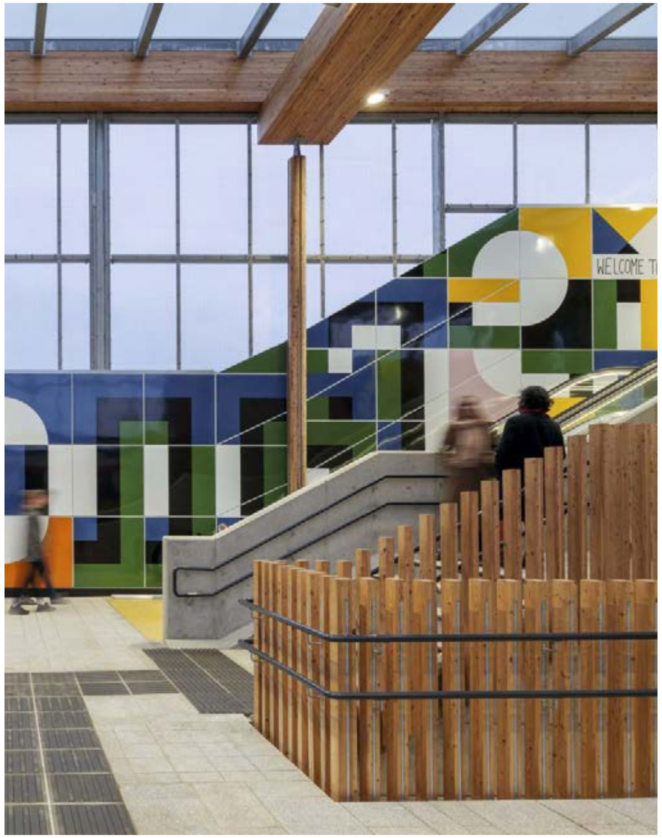


Image 3.4: Brent Cross West Station
Natural Light is an integral part of the passenger experience at Brent Cross West Station

3.3 Non-Visual Effects of Light

There has been a significant amount of research regarding the non-visual effects of light since the discovery of melanopsin-containing Intrinsically Photosensitive Retinal Ganglion Cells (iPRGC) in 1998. Most research has focused on the effects of light on the circadian timing system including the sleep/wake cycle, the impact on alertness, mood memory recall and cognitive functions relative to task performance.

Most commercial luminaire manufacturers now actively promote the use of dynamic tuneable white lighting systems which may subjectively affect health wellbeing and visual performance. Human Centric Lighting (HCL) refers to a holistic lighting design approach focused on enhancing human performance, comfort, health, and well-being. The International Commission on Illumination (CIE) has recently coined the term Integrative Lighting, which describes Human Centric Lighting as lighting that "specifically integrates both visual and non-visual effects and provides physiological and/or psychological benefits to humans."
Which is now replacing the previously used term Circadian Lighting within the lighting industry.

Optimising the use of natural light and integrating daylight with electric light using intelligent lighting controls. Electric lighting systems connected with daylight sensors to minimize the use of electric light or control the intensity and colour temperature of luminaires within the station according to daylight conditions outside.

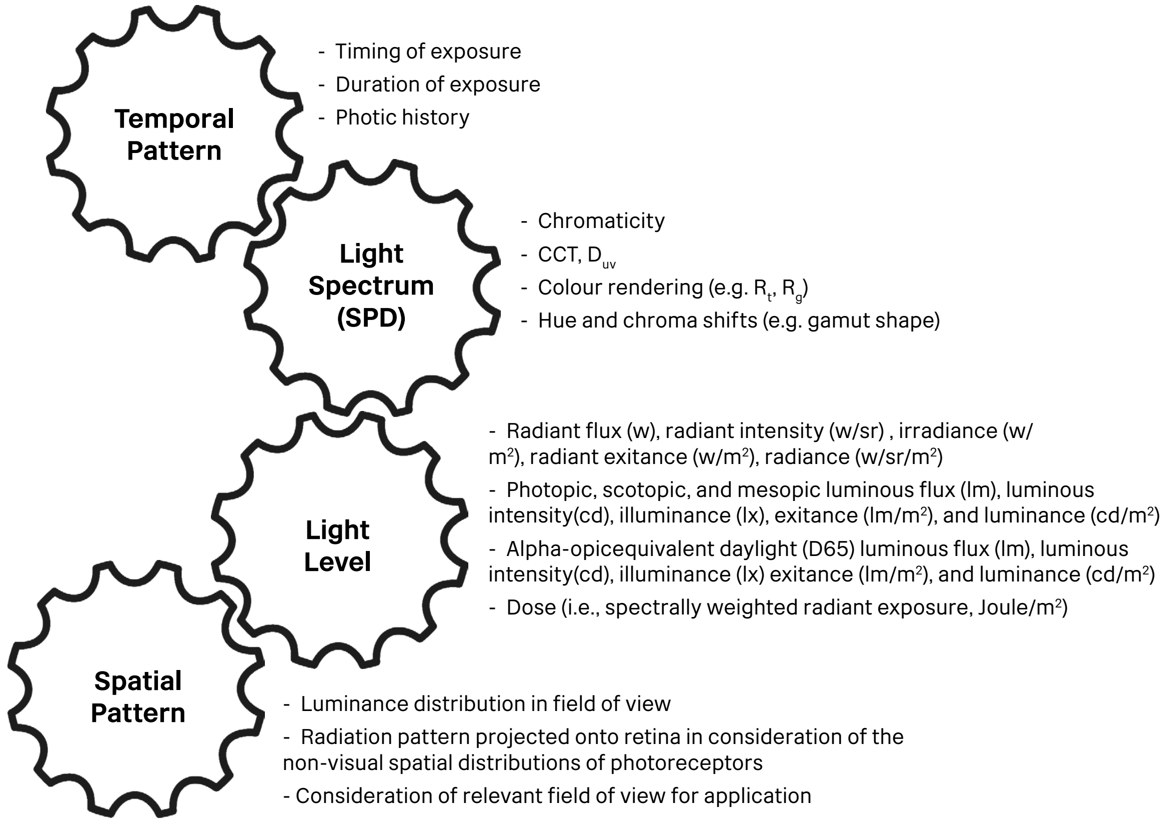


Figure 3.1: A schematic of top-level light and lighting variables that can be independently manipulated by lighting designers (for the built environment). Some of the derived sub-factors that are operationalised from the top-level variables are shown in bulleted list. When supporting the needs of end users, designers often vary factors together as shown schematically with interlocking gears-though any of the four top-level factors can be designed from any other.
Source: KW Houser PhDa,b , PR Boyce PhDc, JM Zeitzer PhDd,e and M Herf BS
Human-centric lighting: Myth, magic or metaphor? Lighting Research & Technology 2021; 53: 97–118

3.4 Circadian Lighting

Circadian Lighting (CL) or Integrative Lighting is an aspect of Human Centric Lighting which refers to lighting systems designed to support the functions of the human circadian system. Circadian Lighting Systems typically utilise tunable white LED lighting that can be programmed to alter both the colour temperature and intensity of the lighting to "mimic" the natural daylight cycle. Generally, a pre-programmed lighting sequence may commence with a lower illuminance level and warm colour temperature early in the day, gradually increasing to higher illuminance values and cooler colour temperature at midday, gradually decreasing in intensity and transitioning to warmer colour temperature during the evening until sunset. Studies have found that lighting installations following this sequence which may provide psychological and physiological benefits as increased alertness.

Subjectively, Human Centric Lighting systems may be able to transform the perceived atmosphere of station environments, creating spaces that are calmer and welcoming for users. Whilst most station environments are places of transition with passengers moving rapidly from one mode to another, dynamic lighting conditions which adapt to the time of day may enhance the overall experience for all station users.

"Good outcomes are most likely when a knowledgeable design team prioritises and balances visual and non-visual design outcomes, such that clients and building occupants experience lighting solutions that are visually beautiful and easy to use. Rather than a feature of a lighting product, humancentric lighting is a feature of the built environment that should complement how environments are used by occupants."

Source: KW Houser PhDa,b , PR Boyce PhDc, JM Zeitzer PhDd,e and M Herf BS
Human-centric lighting: Myth, magic or metaphor? Lighting Research & Technology 2021; 53: 97–118

Image 3.5: Daylight is an infinitely variable natural resource always changing from the one moment to the next.

Image 4.1
MAAT Museum - Lisbon
Handrail lighting of this footbridge offers proper illumination and enhances its structure

4

Lighting Design in Stations

Station Categories & Spatial Typologies

4.1 Station Categories and Lighting Applications

4.1.1 Station Categories:

This design manual includes lighting recommendations and strategies applicable to projects in all Network Rail station categories:

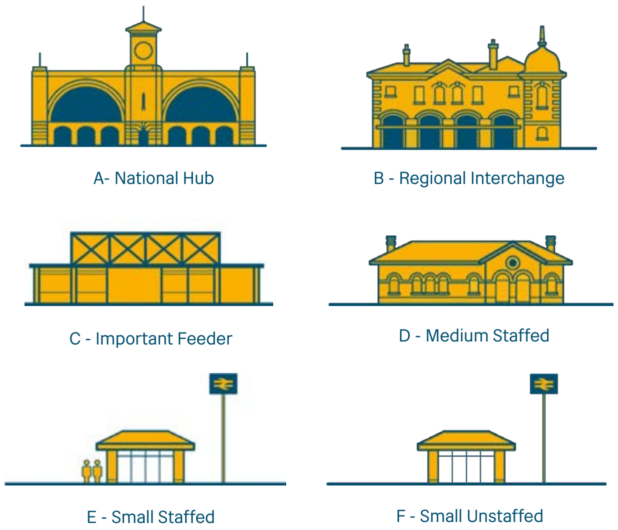


Figure 4.1: Stations Categories

Network Rail document

Network Rail "Station Design Guidance"

NR/GN/CIV/100/02

4.1.2 Lighting Applications

Network Rail stations often include multiple spatial typologies, each of which presents a different set of lighting opportunities.

Lighting design strategies will therefore vary according to the station architecture and the operational requirements. Bespoke lighting solutions should be developed for each project based on factors such as space layout, TOC, user and other stakeholder requirements, relevant standards and regulations and the unique architectural features within each station.

Consideration should be given to ingress of solid bodies to avoid excessive cleaning requirements due to presence of pollutants within the rail environment e.g. diesel fumes, smoke from coal fired trains, ballast dust from rail tamping etc. Minimum IP ratings should be suitable for the application and agreed with NR asset managers and project sponsors at the outset of each project.

This chapter considers lighting elements typically specified and installed in stations as either expressed or integrated lighting elements.

4.1.3 Enclosed Canopy or Station Shed:

Main stations and termini frequently have large, enclosed volumes with glazed vaulted ceilings or roofs with natural daylight ingress. Large internal spaces such as this can be illuminated by high output LED downlights or floodlights mounted onto the structure or suspended from the ceiling. Lighting should be conceived as a series of layers which provide task lighting for safe access combined with architectural lighting elements which reveal and enhance the station architecture and spatial envelope.

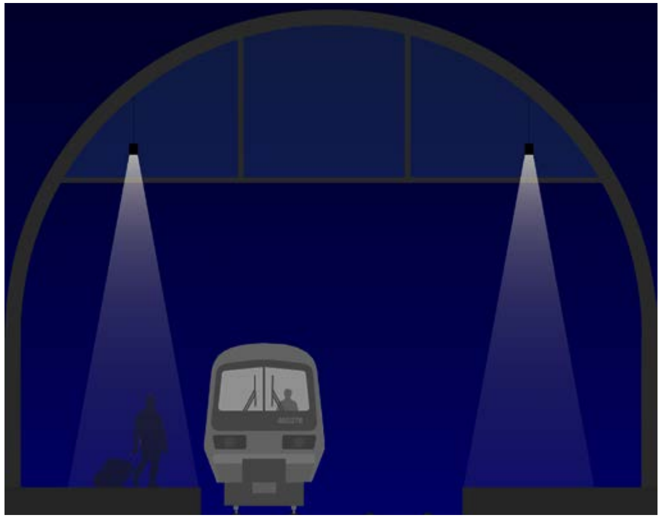


Figure 4.2
High efficacy downlights suspended from vaulted station canopy

4.1.4 Covered Platforms:

Luminaires should be securely attached to the structural elements of the canopy, to provide stability and durability in all weathers. Ideally, the mounting of luminares should be part of an integrated Cable management system (CMS). Care should be taken to provide appropriate levels of illuminance and uniformity across the entire platform area including the Platform Train Interface (PTI). The design of some station canopies may also allow architectural lighting elements to be incorporated to create visual interest or as part of the branding of the station.

Figure 4.3
Linear luminaires mounted on continuous CMS beneath canopy

4.1.5 Column Mounted Lighting:

Luminaires are fixed to a vertical support structure, typically a pole or column. This configuration is commonly used for outdoor lighting in various settings such as open platforms, streets, parks, walkways or public spaces. The column-mounted luminaires can provide task lighting, enhance visibility and improve safety in outdoor environments. Columns can be strategically placed to illuminate specific areas or pathways, providing ambient illumination and good levels of semi-cylindrical illuminance for enhanced facial recognition after dark.

Figure 4.4
Column mounted luminaires illuminate open platform surfaces

4.1.6 Building Mounted Lighting:

Luminaires contribute to both the functional and aesthetic aspects of station lighting. Typically fixed to walls, façades or other structural elements, building-mounted luminaires can be strategically placed to illuminate entrances, walkways, and architectural features, enhancing visibility and emphasising the station architecture. Building-mounted luminaires play a crucial role in creating a visually appealing and well-lit environment around structures, contributing to safety, security, and the overall ambiance of the station and its surroundings.

Figure 4.5
Wall mounted luminaires illuminate station forecourt

4.1.7 Catenary Lighting:

Catenary lighting enables luminaires to be suspended from a system overhead tensile cables. Luminaires can provide area lighting for outdoor open spaces such as station forecourts, pedestrian areas or streets. This approach allows for flexibility in lighting design, enabling the creation of artistic and functional lighting installations in the public realm.

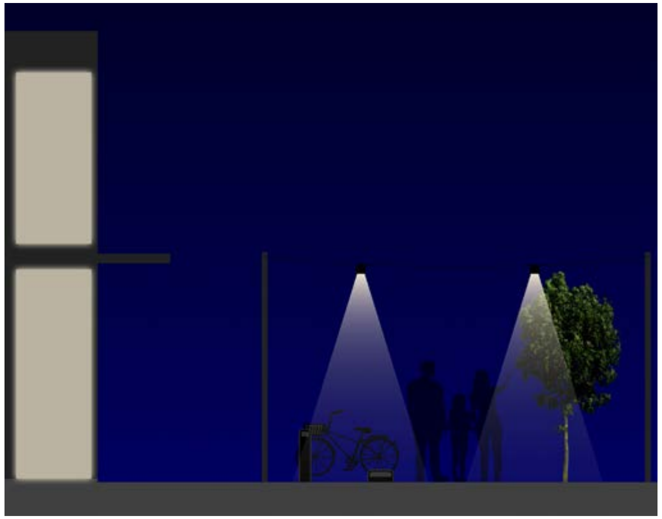


Figure 4.6
Catenary mounted area lighting in station forecourt.

4.1.8 Bollard Lighting:

Lighting bollards can be used to provide focused illumination to pathways externally. Luminaires with a low-glare shielded downward light distribution or directed optically efficient flat beam light distribution should be specified. Given that the light sources will be located below eye height for all user groups, supplementary lighting installed at greater mounting heights may be required to provide additional semi-cylindrical illuminance in areas of perceived greater risk. Care should be taken to specify appropriate IK ratings (see Section 6.3.2).

Figure 4.7
Illuminated bollard with shielded downward light distribution.

4.1.9 Canopy Integrated Lighting Elements:

Integrated lighting elements can be seamlessly incorporated into the design of a canopy or concourse, becoming part of intrinsic character of the station. Indirect lighting can create the impression of an elevated space. Accent lighting can reveal forms, materials and finishes. Lighting for identified visual tasks should be discreet and low-glare, recessed into ceilings where possible and coordinated with other building services to create an organised and visually pleasing environment that is easy to maintain.

Figure 4.8
Indirect lighting integrated into station canopy design.

4.1 Station Categories and Lighting Applications

4.1.10 Building Integrated Lighting:

Integrating the lighting and associated building services not only fulfils functional requirements but also elevates the overall passenger experience by creating a well-lit, aesthetically pleasing and efficiently designed station environment. Patterns of visual information created should be consistent in order to assist passenger orientation and wayfinding as they move from the public realm through the station interior, eventually boarding and alighting from trains.

4.1.11 Handrail Integrated Lighting:

Handrail integrated lighting in train stations is frequently used on staircases, ramps bridges and walkways. Whilst this type of lighting provides direct task illuminance for the staircase itself, the overall ambience of the space will depend on a combination of material, finishes and the form of the stair enclosure itself. Given that the integrated light sources are mounted at low level, some supplementary lighting may be required in and around the staircase to provide appropriate levels of semi-cylindrical illuminance.

4.1.12 Integrated Low Level Lighting:

In the public realm and in station forecourts, opportunities should be sought to integrate lighting into street furniture, such as benches, seating, planting boxes, bicycle rack and other elements of the landscape design, such as steps and changes in level. This multi-layered approach can highlight points of interest, amenities and potential hazards. Supplementary lighting may be required where facial recognition is needed for security purposes or percieved personal safety.

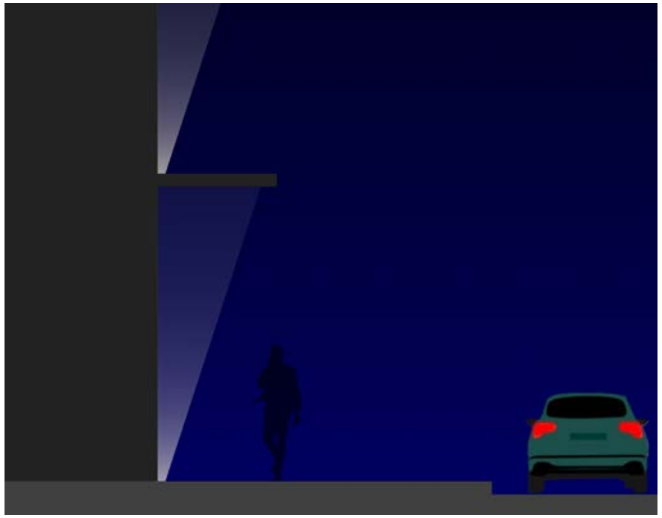


Figure 4.9
Integrated lighting elements reveal the form of the station at night.

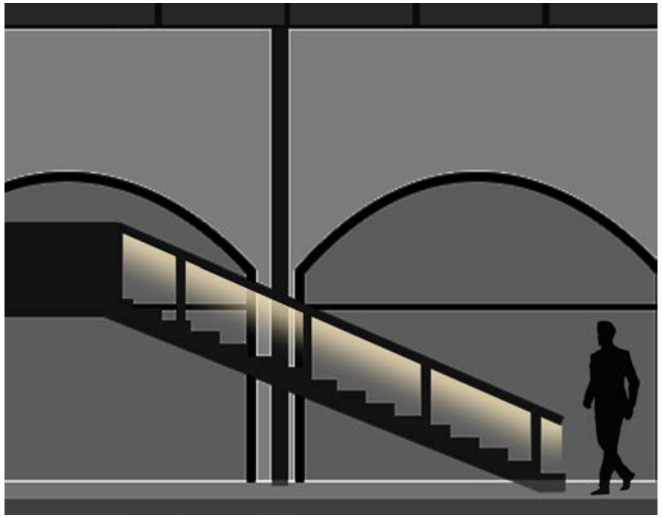


Figure 4.10
Handrail lighting provides direct task illuminance to a staircase.

Figure 4.11
Low level lighting integrated into street furniture assists orientation.

4.2 Public Realm

The public space outside stations presents many lighting design opportunities which should be used strategically to create legible public spaces after dark and assist passengers arriving and departing by many different modes of transport to continue their journey.

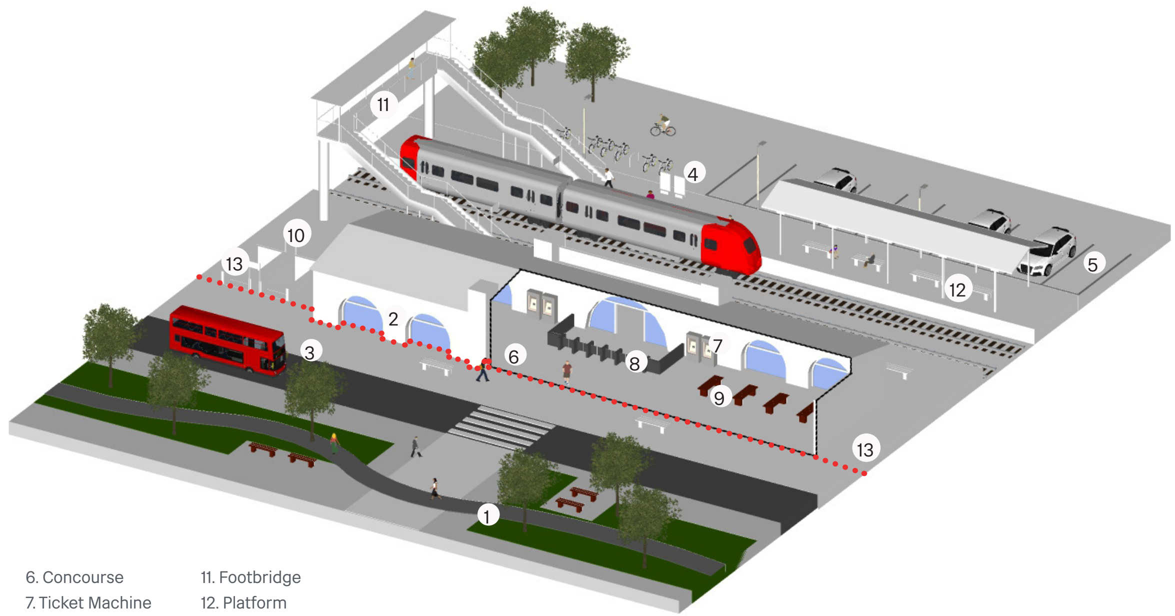
The lighting design should respond to the uses of the space and the local context.

There is likely to be an interface with public realm lighting provided by others such as the local authority and other commercial enterprises and residents in the vicinity.

The public realm outside the station may also be a privately-owned public space (POPS). It is important for those responsible for the lighting design in stations to clearly definer the boundaries between NWR and Public land, particularly for access roads and TOC leases.

Landscape lighting can be used to enhance selected landscape elements, architectural features and natural features of the space.

Lighting can create focal points, and guide passengers on the journey from the public realm into the station and onto platforms and trains. Good lighting design can contribute to the overall atmosphere after dark to create a unique sense of place.



1. Public Realm
2. Facade
3. Bus Stop
4. Cycle park
5. Car Park
6. Concourse
7. Ticket Machine
8. Gateline
9. Waiting Area
10. Underpass
11. Footbridge
12. Platform
13. NWR Boundary

Figure 4.12
Interface between NWR Station Facilities & Public Realm

Code of Practice Guidance

"Lighting Against Crime"
Institution of Lighting Professionals / Secured By Design
2011

Network Rail document

Parking & Mobility at Stations

NR/GN/CIV/200/11

4.3 Station Facades

Many railway station buildings may present exciting opportunities to implement facade accent lighting which can reveal and enhance elements of the station architecture after dark.

Lighting designers should consider the local context whilst avoiding sky glow, light spill, glare and the potential adverse impacts on local flora and fauna.

Older Victorian stations may have brick façades, cast iron columns and canopies typical of the architecture of the period. Elements of the station architecture can be selectively highlighted or accented as part of a coordinated lighting strategy for the public realm outside the station. Architectural elements such as clock towers and finials, columns and pilasters can be highlighted in subtle and imaginative ways.

Contemporary station buildings may have large areas of glazed curtain walling which may tend to reflect station surroundings during the day and which may become translucent at night revealing the interior spaces and activity within the station after dark.

Those responsible for the design of the exterior lighting outside the station should also consider the provision of security perimeter lighting particularly where the station building closes earlier than the last train or does not open before the first train departs in the morning.

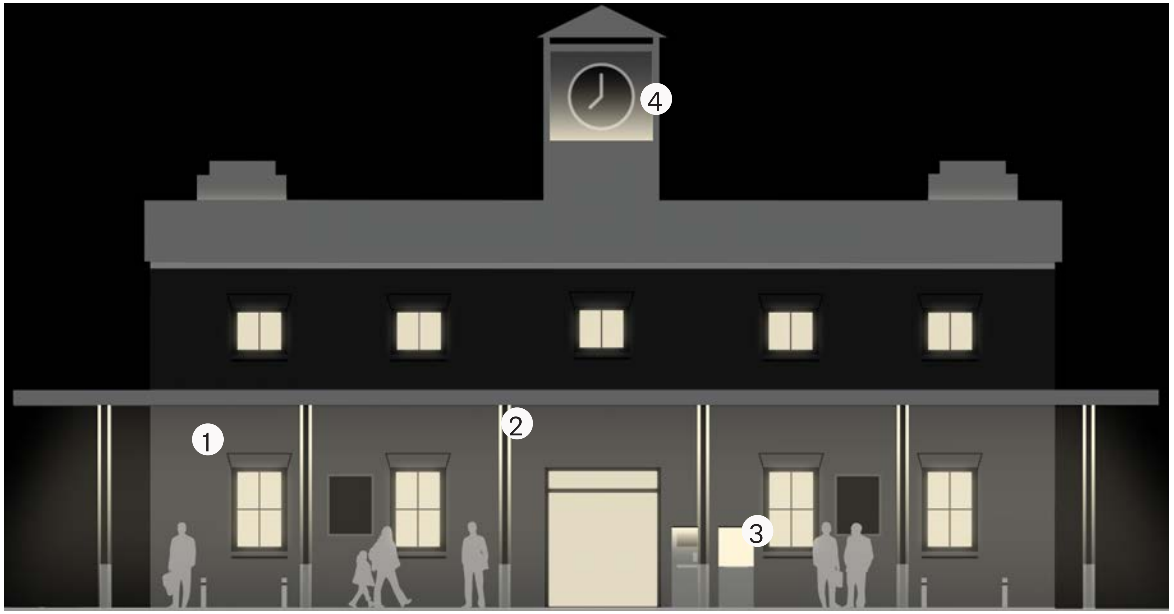


Figure 4.13:
Facade of Station

Image 4.2:
External Threshold:
Enhanced Illuminance levels

Image 4.3:
Accent Lighting - Visual
Interest / Highlights

Image 4.4:
Local Task Lighting
Customer Information Point

Image 4.5:
Vertical Illumination -
Enhancement of elements

4.3 Station Facades

An additional layer of lighting can be integrated into the station's building facade, specifically tailored for festive occasions and special events.

Celebration lighting can be achieved in various ways, either through dynamic lighting luminaires that are controllable or by additional luminaires specifically incorporated for a unique event like national days.

Celebration lighting serves as an additional layer enriching the station's character and seamlessly blending it into the festive atmosphere of the occasion, thus enhancing the overall experience.

Flinders Street Station in Melbourne, Australia is a good example of how lighting can transform the appearance of a station. In the top left image, one can observe the lighting elements of the facade of the Edwardian Baroque building, revealing its elegance with multiple layers of accent lighting in the window reveals and columns, linear lighting along the perimeter, and general flood lighting on the roofs. These multiple layers of light enhance the architecture of the station and underscore its importance as a Victorian heritage site. During social or cultural events, the dynamic lighting system changes in colour and intensity, transforming the appearance of the facade on special occasions.

Images 4.6 - 4.9: Flinders Street Station, Melbourne, Australia.
White light reveals the architectural elements of the facade and dynamic coloured light transforms its appearance for special events.

4.4 Intermodal and Interchange Facilities

4.4.1 Bus Stops, Bus Stations and Shelters

Depending on the scale of the railway station and the local context, passengers arriving and departing by bus, may arrive in an enclosed bus station, smaller bus stands with waiting rooms, simple bus shelters or open bus stops.

Good lighting design for bus stations is necessary for providing safety, security and overall functionality for all users.

The lighting of bus shelters and pavements should provide good visibility for bus drivers to observe passengers boarding and alighting from vehicles, staff, and security personnel. Enhanced levels of vertical illuminance may enhance perceived personal safety and security to create a welcoming environment after dark.

Sufficient illuminance should be provided within bus shelters and waiting rooms to enable those waiting for buses to easily read timetables or magazines and newspapers.

Lighting should be directed only where it is needed, to minimise light pollution and glare. This is particularly important for maintaining clear visibility for drivers, pedestrians, and CCTV cameras.

Image 4.10: Esslingen ZOB, German.
Diffuse LED light panels integrated with canopy design provide ambient light to bus station

Image 4.11: West Croydon Bus Station.
Direct/Indirect pendant downlights suspended below canopy with translucent ceiling panels providing soft uplight to station signage located above canopy

Network Rail document
Public Realm Design Guidance
NR/GN/CIV/200/10

4.4.2 Cycle Hubs, Cycle Storage Racks & Structures

The significant increase in the use of bicycles has led to the provision of dedicated cycle hubs in and around railway stations.

Facilities can range from simple bicycle stands or racks designed for use for short-stay visitors to the station, or indoor bike hubs designed for longer term use by commuters.

One of the lighting design priorities for cycle hubs is to create a safe, functional and visually appealing environment. Good levels of illuminance and uniformity throughout internal bike stores may enhance visibility and make it easy for users to locate and access bicycles.

Well illuminated areas may discourage unauthorised access and provide a sense of security.

Where possible, incorporate natural light through windows or skylights. Natural light creates a welcoming atmosphere during the daytime and should complement the electric lighting provision to create a well-balanced environment.

Local accent lighting or higher levels of illuminance should be provided adjacent to bicycle racks located in the externally to enable cyclists to easily find and lock/ unlock their bikes and to discourage theft.

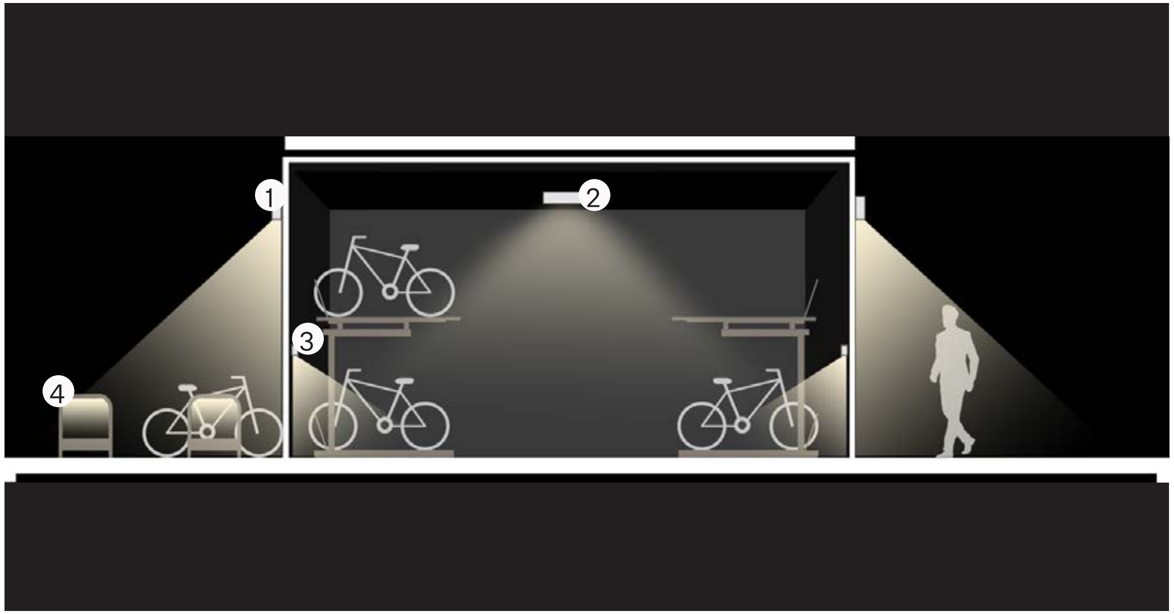


Figure 4.14:
Cycle Storage

Image 4.12:
General - wall lighting outdoors

Image 4.13:
General uniform lighting indoors

Image 4.14:
Local accent lighting for interior bike rack

Image 4.15:
Local accent lighting for exterior bike rack

4.4.3 External Car Parks

A carefully considered lighting strategy is necessary for car-parks to create a safe and pleasant for all users. Enabling good facial recognition for those using the car park can promote a sense of personal safety and security. Lighting designers should analyse the visual tasks and provide appropriate levels of illuminance according to the identified environmental zone. One of the key aspects is the height and placement of luminaires to provide optimum levels of illuminance and uniformity taking into account the local context and scale of the development. Care should be taken to avoid obtrusive light including light spill, glare and sky glow.

Entrances and exits should be provided with enhanced levels of illuminance to assist wayfinding and enhance security. Ticket machines, payment kiosks and should also be highlighted to enable passengers to clearly read instructions and make payments. Help points should be illuminated at consistent lighting level for ease of identification, particularly when the car park is dimmed out of hours. In locations where ticket machines contain money, consistent levels of illuminance should also be maintained.

Code of Practice Guidance

"The Reduction of Obtrusive Light"
Institution of Lighting Professionals - Guidance Note
GN01/21 - 2021

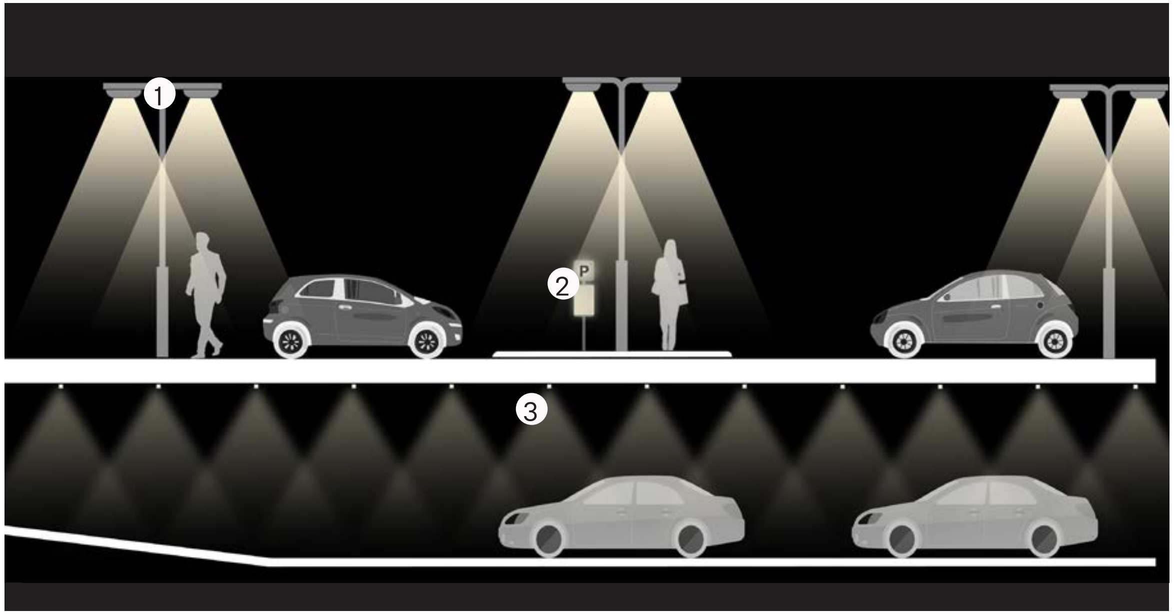


Figure 4.15:
External and Internal car parks

Image 4.16:
General lighting - pole mounted

Image 4.17:
General lighting - pole mounted

Image 4.18:
Task lighting - e.g. signage and ticket machines

Image 4.19:
General uniform lighting - ceiling mounted

4.4.4 Internal Car Parks

Imaginative lighting strategies can be used in covered car parks and parking garages to avoid large covered spaces feeling oppressive and gloomy, both during the day and after dark.

In new build structures the creation of light wells and filtered daylight can make spaces feel pleasant during the daytime.

Lower levels of illuminance can be specified on the driving lanes with higher levels of illuminance utilised on ramps and at entrances and exits. The use of high surface reflectances on walls, floors and ceilings will create greater interreflection and make the car park feel more welcoming for users.

Lighting the perimeter of the parking garage may assist orientation for users of the space. Colour-coded interiors with bold graphics can be used to assist wayfinding and orientation for those arriving and depart in their vehicles and also assist those navigating the space on foot.

Code of Practice Guidance

"Car Park Design"
The Institution of Structural Engineers
ISBN 978-1-906335-63-2 (pdf) - June 2023

Image 4.20: Covered parking garage - Coloured light at the perimeter of the space assists wayfinding whilst white lighting on the driving lane provides good levels of illuminance for all user

Image 4.21: Covered parking garage - Vertical illumination and colourful graphics on the walls create a pleasant environment.

Image 4.22: Covered parking garage with openings at perimeter to bring daylight into the parking environment.

4.5 Concourses

Station concourses are typically large enclosed volumes illuminated with a combination of daylight and electric light. They are busy transition spaces with passengers moving quickly from one point to another.

Within the concourse, there may be directional wayfinding elements, information and help points, departure boards, ticket offices and ticket vending machines. Illuminated advertising displays and video screens may also be competing for the attention of passengers together with active retail frontages within the concourse. It is important that advertising and retail lighting does not conflict with important wayfinding information and a clear visual hierarchy and use of dedicated ‘zones’ for different visual elements should be established. Consistent and uniform levels of illuminance should be provided across the entire concourse area. Extreme variations in light intensity should be avoided.

The lighting design can be used to aid intuitive wayfinding to lead passengers towards their destination, highlighting entrances and exits and the thresholds of staircases, escalators and lifts.

Accent lighting can be used strategically to highlight architectural features, artwork features or directional signage. This can contribute to an aesthetically pleasing environment without creating distracting shadows and contrasts for passengers.

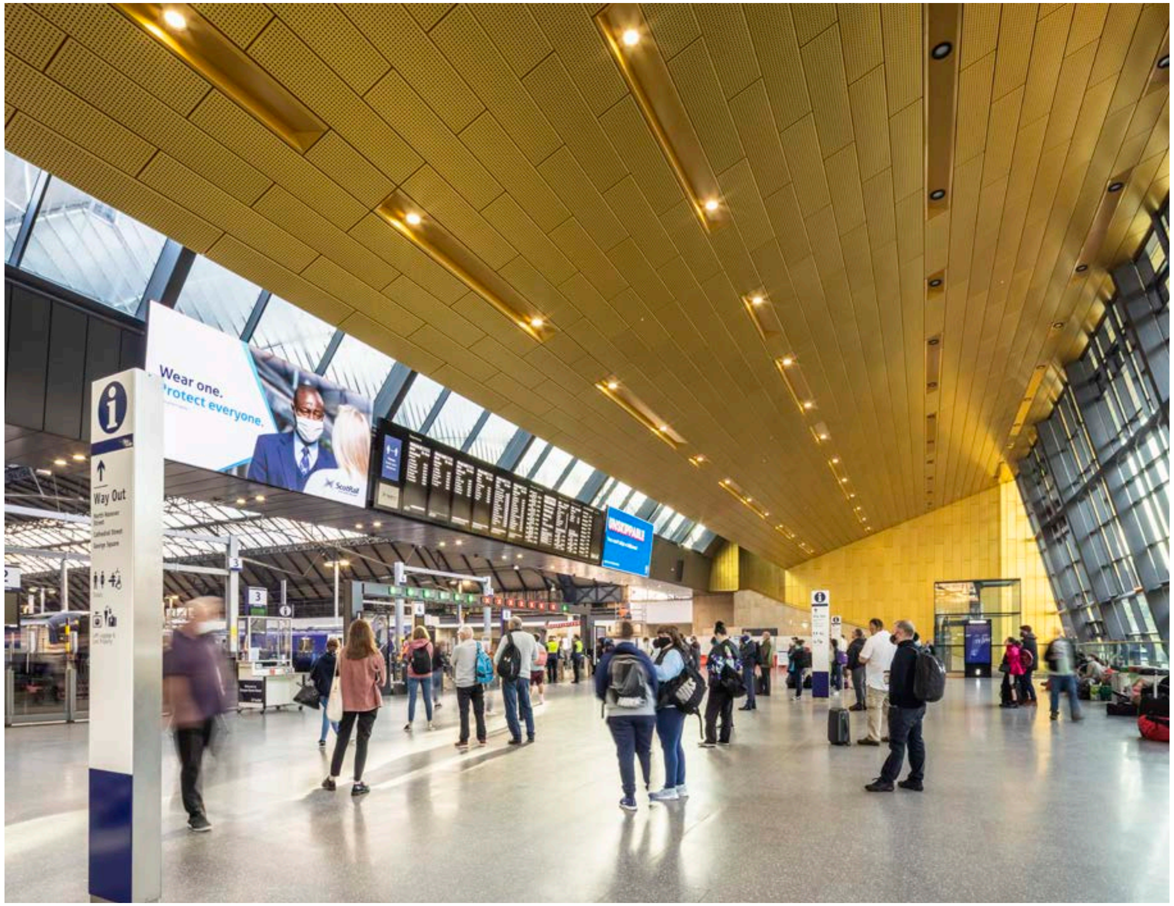


Image 4.23: Glasgow Queen Station.
Lighting integrated into service channels creating uniform, ordered appearance to the ceiling. Daylight-linked lighting controls minimise energy use.

4.5 Concourses

4.5.1 Ticket Vending Machines

Most ticket vending machines in stations have backlit screens either set at an inclined angle at the front of the machine or vertically mounted The direct illuminance onto the face of the backlit screens should be carefully controlled so that the contrast between the illuminated screens and the screen-based text is not compromised. Care should be taken to avoid veiling reflections on screens to which may obscure the passenger information displays. Many modern ticket vending machines, particularly those in the external environment may have integrated local task lighting.

4.5.2 Active Frontage for Retailers

Lighting for retail units within stations should be part of a coordinated retail design strategy for the station. Illuminated retail signage elements and illuminated branding on store-fronts should be visually segregated from station wayfinding elements and directional signage. A unified design approach in the way that multiple individual retailers presents themselves to the station concourse can avoid visual clutter and create an ordered station environment. It is important that clear zones and rules for lighting are established for retail elements that do not clash with station signage or create excessive visual noise.

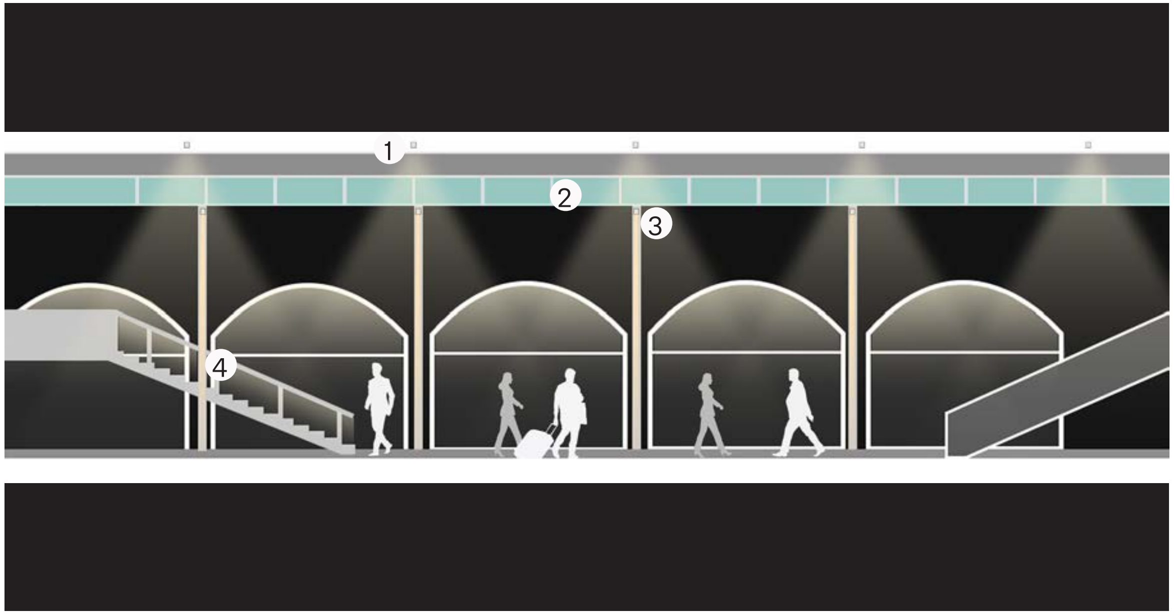


Figure 4.16:
Concourse

Image 4.24:
General uniform lighting

Image 4.25:
Openings-natural light

Image 4.26:
Accent lighting - highlights

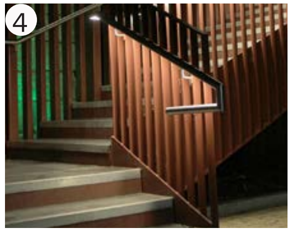


Image 4.27:
Circulation lighting - hand-railing

4.6 Booking Halls and Ticket Offices

There are two types of customer service desks in ticket offices and station travel centres, enclosed and protected ticket offices with a full-height glass screen between passengers and staff and more open desks that might have a partial screen that separates passengers and staff. Good levels of vertical illuminance are required on both sides of the counter top to enable people to clearly see facial expressions. Utilising more diffuse light in these locations is preferred and avoiding the harsh shadowing that might be caused by downlighters. Care should be taken to avoid veiling reflections on both the glass partitions and on monitors and display screens being used by station staff.

The GWR ticket office at Paddington Station is a good example of layers of light working together with the materials and finishes of the room itself to achieve the optimum result.

Aspects of the design which contribute to the success of the lighting design are as follows:

- Indirect lighting of the ceiling coffers provides glare-free ambient illumination of the ticket hall.
- The open ticket counters are well illuminated providing good facial recognition for passengers approaching the desks from the concourse.
- The rear wall behind the desks is illuminated by track-mounted spotlights which clearly define the perimeter of the space.
- The light-coloured retained stone flooring contributes to the overall impression of spaciousness

Image 4.28: Great Western Ticket Office, Paddington Station
Indirect blighting within the ceiling coffers creates the impression of an elevated ceiling elevated ceiling and provides glare-free ambient lighting for the space. The high reflectance values of the retained stone flooring creates a feeling of spaciousness.

4.6 Booking Halls and Ticket Offices

In stations, passengers may be moving from an external space or large concourse into a more enclosed ticket office or travel centre. Booking halls and ticket offices with high ceilings and customer information screens mounted at a low level will feel more spacious than ticket offices with low ceilings and customer information screens mounted at high level which will feel more confined and enclosed.

Achieving legibility through good lighting in ticket halls and offices in train stations involves thoughtful design and implementation. One of the key considerations is to create even and consistent lighting throughout the ticket hall and office areas to eliminate shadows, dark spots and veiling reflections on screens and customer information displays. Avoid extreme contrasts between light and dark areas to enhance overall visibility and prioritise the lighting of vertical surfaces in enclosed spaces

Suitable task lighting should be provided for identified tasks such as ticketing, reading documents, or working at desks.

Figure 4.17:
Ticket office

Image 4.29:
General
uniform lighting

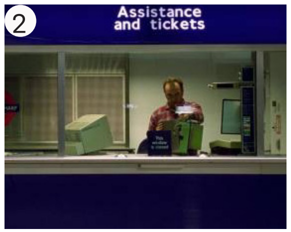


Image 4.30:
General/Task lighting
- Ticket Office

Image 4.31:
Accent lighting -
highlights

Image 4.32:
Vertical Illumination

4.7 Gatelines

A well-lit gateline in train stations is important to assure efficient passenger flow, security, and ease of use at these key decision-making points in the customer journey through the station.

In larger stations there is likely to be suspended, post-mounted or wall mounted digital signage above the located directly above the gateline itself. Internally illuminated LED directional indicators may show the way to open passenger gates or indicate gates that are closed in the passenger's direction of travel. The vertical face of customer information displays should be clearly illuminated without harsh shadows, veiling reflections or reflected glare from the face of the sign that may cause discomfort glare, confusion or hesitation at the passenger gates.

The design of the suspended signage may present opportunities to integrate additional task lighting above the gateline to provide enhanced levels of illuminance in this location.

If this is not possible, lighting designers should consider alternative ways of providing enhanced levels of illuminance at the passenger gates.

When considering appropriate levels of illuminance lighting designers should refer to the recommended step changes in illuminance according to BS EN 12665 to create a visible difference to the background illuminance in the station concourse.

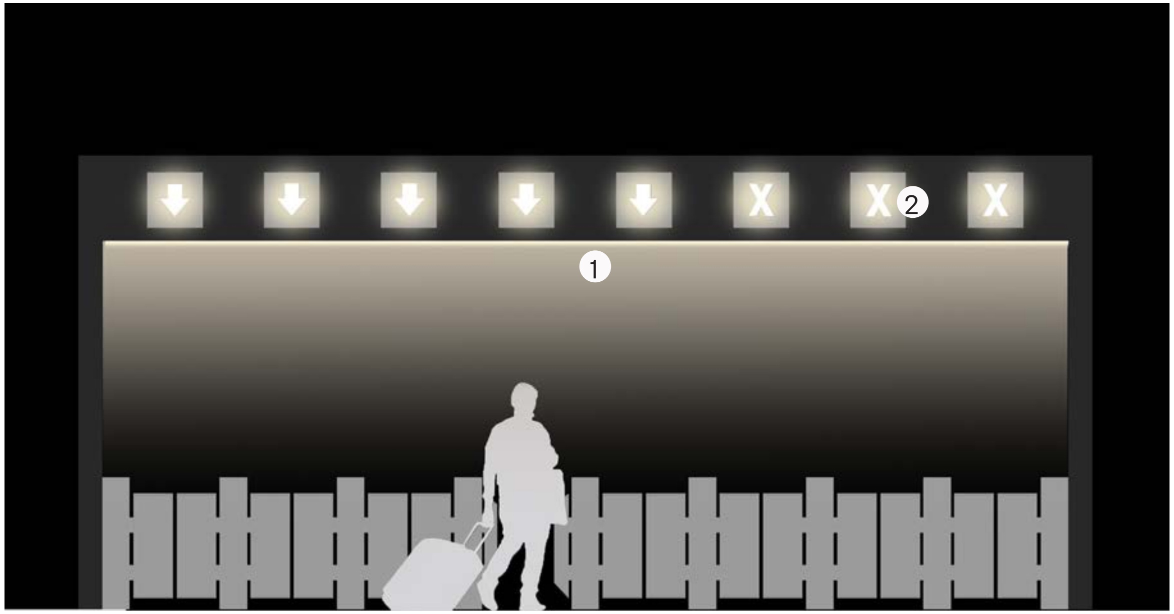


Figure 4.18:
Gateline

Image 4.33:
Accent linear lighting

Image 4.34:
Illuminated LED Direction Indicators on gateline

4.8 Vertical Circulation

4.8.1 Stairs

Staircases should have a consistent level of lighting uniformity to enable passengers to safely navigate the flight of stairs. Levels of illuminance should not change abruptly on the staircase. Harsh shadows that could be mistaken for an additional step or a change in direction should be avoided. Designers should check that there is a clearly visible nosing of contrasting colour and/or texture at the front edge of each step to assist users to clearly identify the changes in level.

4.8.2 Ramps

Ramps and changes in level in stations should generally have a gradual incline to enable them to be easily negotiated by wheelchairs, pushchairs and other passenger groups. Inside the station, levels of illuminance and uniformity should be the same as other spaces with similar uses.

Illuminance and uniformity levels should be provided in accordance with the requirements of BS 12464 whilst noting these are minimum requirements. Where enhanced values are detailed in the Rail Industry Standards such as RIS 7702-INS or the Department for Transport's "Design Standards for Accessible Railway Stations", these should be provided.

Figure 4.19:
Circulation

Image 4.35:
General - wall lighting outdoors

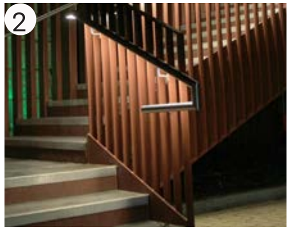


Image 4.36:
Circulation lighting - hand-railing

Image 4.37:
Circulation - general lighting

4.8.3 Escalators & Travelators

New escalators should be specified with integral task lighting such as visually continuous linear LED skirting lighting. Additional lighting should be provided at the boarding and alighting points at the newel-end of the escalator. This may allow users approaching the escalator to easily judge the speed and pitch of the moving steps and to match their pace to the speed of the moving treads. Care should be taken to avoid potential flicker or stroboscopic affects which may cause confusion.

4.8.4 Lifts

Lift cars generally have the interior lighting provided by the lift car manufacturer. Lighting designers should provide additional accent lighting externally within the lift door reveals or at the external threshold so that the lift location is clearly visible to all users.

Network Rail document
Vertical Circulation Design Manual **NR/GN/CIV/200/05**

Image 4.38: Uniform lighting of the lift car. Unibox ,UK

Image 4.39: Lighting detail within the lift's alcove. Unibox ,UK

Image 4.40: Lighting detail within the lift's alcove. Unibox ,UK

Image 4.41: Image of lighting detail on an escalator

Image 4.42: Copenhagen metro - Escalator lighting and general uniform lighting

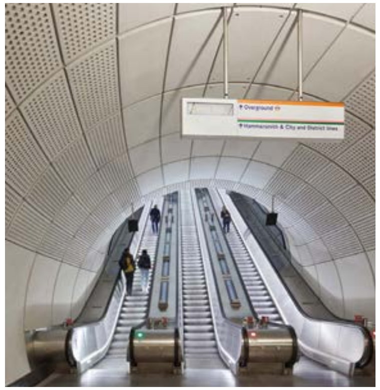


Image 4.43: Grimshaw Crossrail Whitechapel Station - Escalator lighting and general uniform lighting

4.9 Rail Bridges and Footbridges

Existing passenger footbridges at stations can be classified broadly as two types; open footbridges and enclosed footbridges with overhead canopies or fully enclosed box construction.

For open footbridges, the use of fully integrated handrail lighting can provide good levels of illuminance, uniformity. On open footbridges it will not be possible for the handrail alone to provide semi-cylindrical illuminance given that the luminaires are mounted below face level. Therefore supplementary lighting may be required at ends of the footbridge from column-mounted luminaires to provide semi-cylindrical illuminance sufficient for good facial recognition and suitable for station CCTV cameras.

Lighter colour finishes for bridge decks are preferable to dark asphalt surfaces, for example. On staircases a clearly visible nosing of contrasting colour and/ or texture at the front edge of each step may assist users to clearly identify the changes in level.

Fully enclosed footbridges can be treated as typical interior space with lighting recessed or surface mounted on the interior soffit of the bridge. Pedestrian footbridges may often have lift towers attached. Where this is the case, it is important to provide enhanced levels of illuminance at the external threshold of the lift at platform or concourse level.

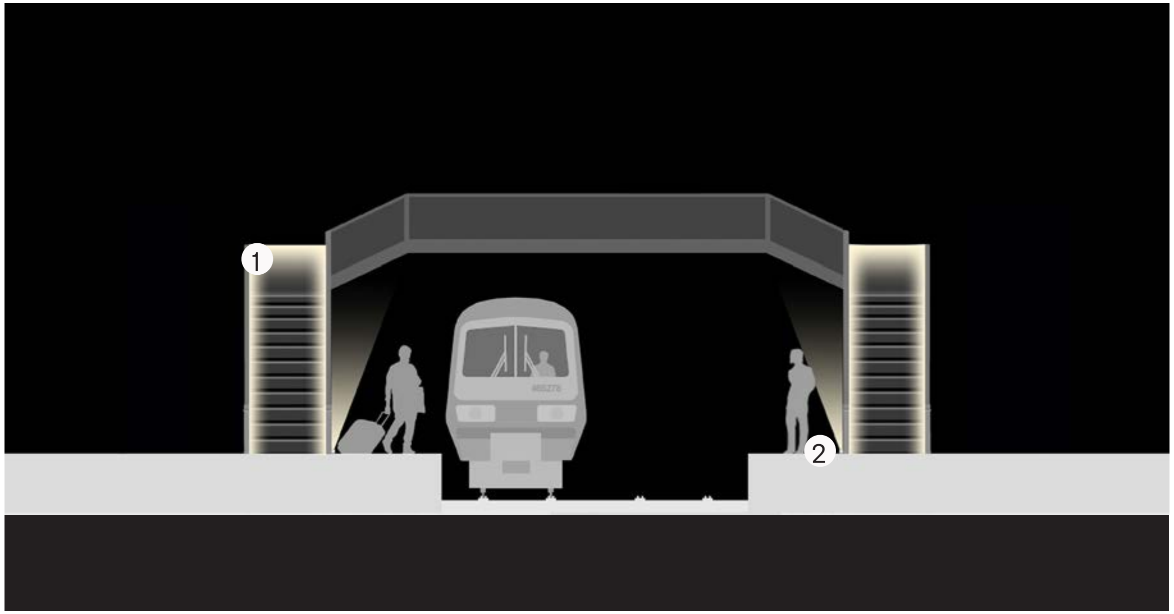


Figure 4.20:
Footbridge

Image 4.44:
Handrail lighting on stairs

Image 4.45:
Indirect lighting illuminates underside of bridge decks

Image 4.46:
Bromborough station footbridge - General illumination of the covered stairs

4.9 Rail Bridges and Footbridges

4.9.1 Rail Bridges

Architectural accent lighting for rail bridges and structures can create visual interest and contribute significantly to the creation of a sense of place.

Red, Green and Blue (RGB) and Red, Green, Blue and White (RGBW) programmable colour-changing lighting elements lighting may also provide opportunities to change the colour of a structure on festive occasions and for special events.

The lighting of railway bridge soffits and structural elements may also assist the drivers of tall vehicles to make a visual assessment of the clearance height of structures passing over roads. This simple measure could help to avoid bridge strikes which frequently cause potential delays and disruption to the railway.

Those responsible for the lighting design in and around the station may consult with the rail operations and the engineers responsible for the maintenance of each structure to ascertain whether the proposed architectural lighting can be fixed to the bridge structure or not.

Care should also be taken to avoid potential glare or visual distraction to train drivers passing over the bridge or other potential adverse impacts to the operation of the railway.

4.9.2 Footbridges

Key considerations for lighting designers are the provision of appropriate levels of illuminance and uniformity for the bridge deck and staircase, specifying good colouring rendering light sources, and specifying robust luminaire types..

There are also opportunities to integrate architectural accent lighting elements both internally and externally to assist passenger orientation after dark and to create visual interest.

It is useful to differentiate the lighting for the footbridge from the immediate surroundings to assist orientation and wayfinding.

In some cases dynamic lighting solutions can be implemented to create a unique site identity for the project.   Intelligent, micro-processor controlled luminaires can be programmed to change colour and intensity in response to external stimuli, the time of day or for special calendar or awareness days and events.

For new construction bridge designs, Network Rail have commissioned several standardised footbridge designs. Possible lighting design opportunities presented by these new footbridge designs are described on the following pages.

Image 4.47: Christchurch Bridge Reading
The use of coloured light to create a distinctive local landmark

Image 4.48: Wandsworth Town Station Rail Bridge
Cast iron panels illuminated with linear RGB lighting

Network Rail document
Footbridges & Subways **NR/GN/CIV/200/07**

4.10 Standardised Footbridge Designs

Figure 4.21: Impression of the Beacon Footbridge after dark

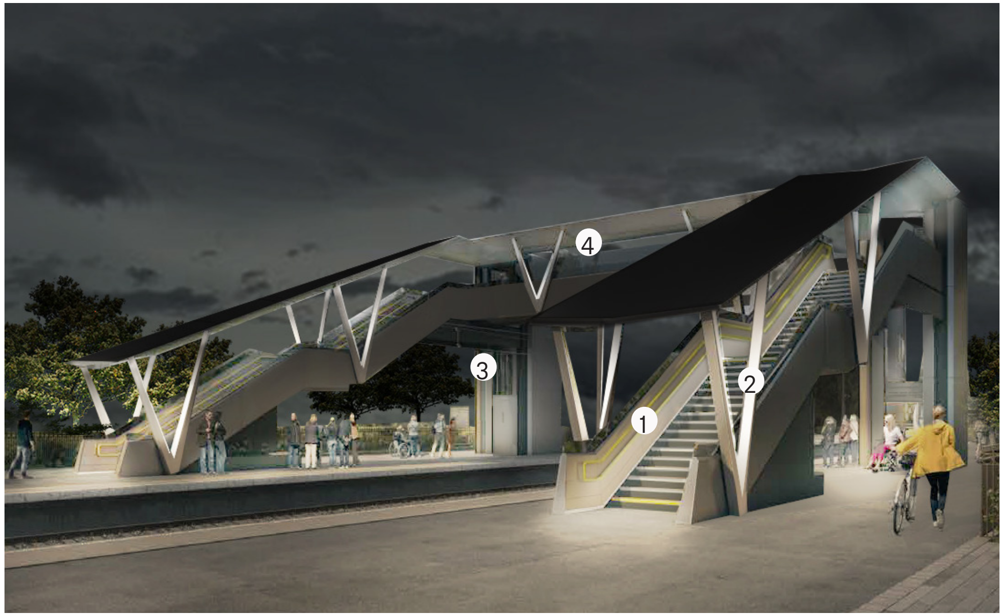


Figure 4.22: Impression of the Ava Footbridge after dark

Beacon Footbridge
The Beacon design emphasizes enclosure and transparency, tailored for smaller local and commuter stations. Lift towers serve as illuminated beacons within the minimal structure, presenting a modern take on traditional railway footbridges.

1. Stair illumination: handrail lighting
2. Pedestrian bridge: handrail lighting
3. Elevator entrances: direct illumination within the alcove
4. Lift Tower (Beacon): Indirect illumination
5. Vertical illumination: Uplighting the tower and under the bridge

Ava Footbridge
Ava has a minimal design. Focused task lighting for the bridge deck and the staircase aids passenger navigation. All lighting is integrated within the bridge cladding at low level to avoid glare. Viewed from the platform, the inclined soffit of the bridge appears brightest.

1. Stairs illumination: handrail lighting
2. Accent lighting on structural details
3. Elevator entrances: illumination within the alcove
4. Pedestrian bridge: handrail lighting and ceiling general illumination

4.10 Standardised Footbridge Designs

Figure 4.23: Impression of the Ribbon Footbridge after dark

Figure 4.24: Impression of the Frame Footbridge after dark

Ribbon Footbridge

The Ribbon design seamlessly integrates with the station environment. Its organic form prioritizes continuity, with local variations limited to cladding choices for lift towers and motor rooms. The canopy lighting expresses the continues ribbon leading from one platform over the bridge to the next.

1. Canopy Lighting (general): linear illumination
2. Stairs illumination handrail lighting
3. Pedestrian bridge: handrail lighting and ceiling, linear illumination
4. Accent lighting on the sitting points

Frame Footbridge

Frame is an elegant, visually striking footbridge with a timeless design, adaptable to heritage and modern settings and different site-specific configurations. Fully integrated lighting elements enhance the design of the footbridge. Good levels of illuminance and uniformity on the staircase and bridge deck assure passenger safety, and comfort, highlighting the distinctive qualities of the design.

1. Staircase illumination - intergrated handrail lighting
2. Pedestrian bridge- intergrated handrail lighting
3. Lift entrances: Canopy and thresholds highlighted
4. Pole top luminaires provide general illumination of adjacent platforms

4.11 Underpasses and Subways

Railway stations frequently have underpasses and subways which allow passengers to move from one space to another. Whether underground, or at surface level, pedestrian underpasses are typically windowless environments with minimal natural light ingress. The lighting may typically be in operation for 24 hours a day.

One of the main priorities for lighting designers should be to create a well illuminated space that promotes sense of safety for all users and which assists orientation and wayfinding.

Priority should be given to the lighting of vertical surfaces and the ceilings of subways and underpasses to avoid spaces feeling gloomy and oppressive for users. Lighting designers should consider that at busy times underpasses may be filled with passengers. Floor surfaces and ramps and changes in level may not be obvious in a crowded space with fast moving passengers.

It is therefore important to check that passengers can clearly see and navigate towards their destination and that passenger information displays and directional signage are visible and well-illuminated at key decision-making locations.

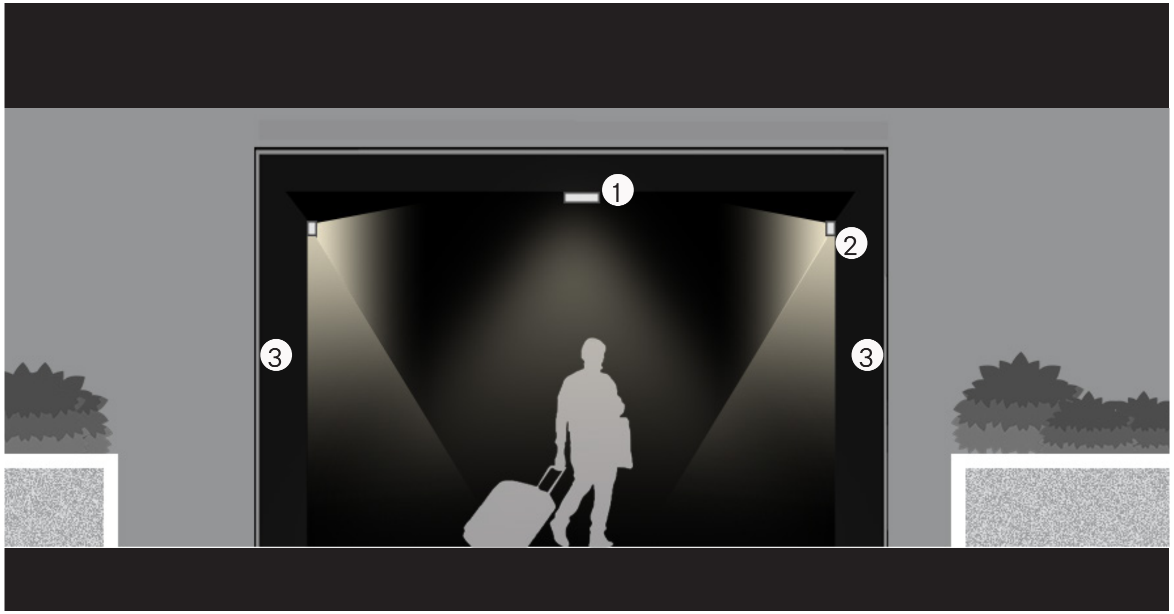


Figure 4.25:
Underpass

Image 4.49:
Ceiling mounted luminaires

Image 4.50:
Perimeter wallwash with colourful cladding panels

Image 4.51:
Vibrant and colourful artwork feature on underpass walls to create a welcoming environment by day and night

4.11 Underpasses and Subways

Light coloured surface finishes on floors, wall cladding and ceilings may create greater inter-reflection of light between floor and ceiling making subways and underpasses feel brighter and more welcoming for those passing through the space.

It is also important for designers to consider the transition between adjacent areas both internally and externally and to provide appropriate levels of illuminance thresholds.

Luminaires specified for subways and underpasses should be especially robust when installed at low mounting heights which may be subject to vandalism.

Lighting can be used strategically to deter potentially anti-social behaviour in areas that are less frequently used.

Underpasses and subways can often provide opportunities for the installation of artwork such as murals, illuminated advertising, media walls or become part of the branding and visual identity of the station itself.

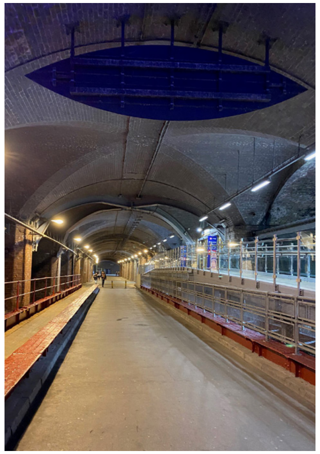


Image 4.52: Leeds Station
High reflectance light coloured floor finishes create a sense of spaciousness.

Image 4.53: Leeds Station
Wall mounted LED uplights illuminate the vaulted ceiling in the subway creating visual interest and assisting passenger orientation..

Image 4.54: Stengården Station - Underpass
Continuously mounted tubular prismatic luminaires highlight ceilings and wall surfaces creating a sense of spaciousness. Bright coloured cladding panels are part of the station branding.

4.12 Platforms

4.12.1 Introduction

General requirements for the design of platform lighting are set out in RIS-7702-INS and RIS-7016-INS, the PRM NTSN and the Department of Transports (DfT's) Accessible Train Station Design for Disabled People: Code of Practice Version 04 - March 2015

Railway Standards make reference to BS 12464 Parts 1 & 2 which detail the requirements for horizontal illuminance and uniformity on platforms.

This guidance provides recommendations for open platforms (BS EN 12464-2), Covered Platforms (BS EN 12464-2) and fully enclosed platforms (BS EN 12464-1).

National Standard

Lighting of Workplaces,
BS EN 12464 - Parts 1 & 2 [1]

[1] *Note: Work on a revision to EN 12464-2 is at an advanced stage. The updated standard is scheduled for publication in late 2024 .*

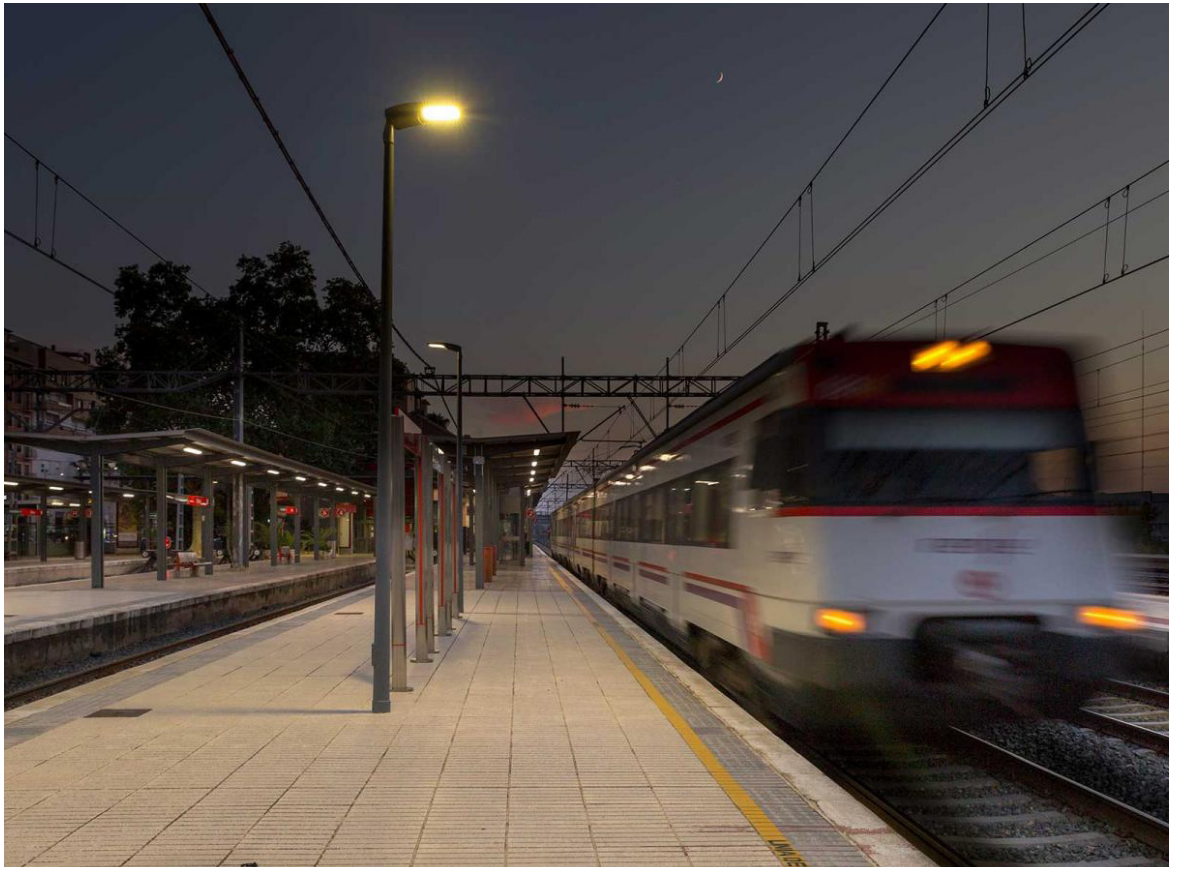


Image 4.55: Xativa Station
Pole top luminaires provide good levels of illuminance.
High reflectance paving stones used on platform surfaces create a more pleasant environment for passengers after dark

4.12 Platforms

4.12.2 Open Platforms

Station platforms are often completely exposed to the elements or partially protected with a small canopy, shelter or waiting room. In smaller stations there may be no interior spaces apart from the platform itself.

Presence detection can be used to dim the platform lighting to a dormant level when the station is not occupied. Opportunities for integrating lighting into free-standing structures or furniture elements should be considered and special attention should be paid to achieving good levels of illuminance at the platform edge.

Providing lighter coloured surfaces and finishes on open platforms should assure that optimum illuminance levels are achieved. Lighter coloured materials can have a greater surface luminance compared to dark surfaces such as asphalt and blacktop, which can negatively impact the perceived brightness and ambiance of a platform. This is particularly important for open areas where the surface of the platform itself predominates.

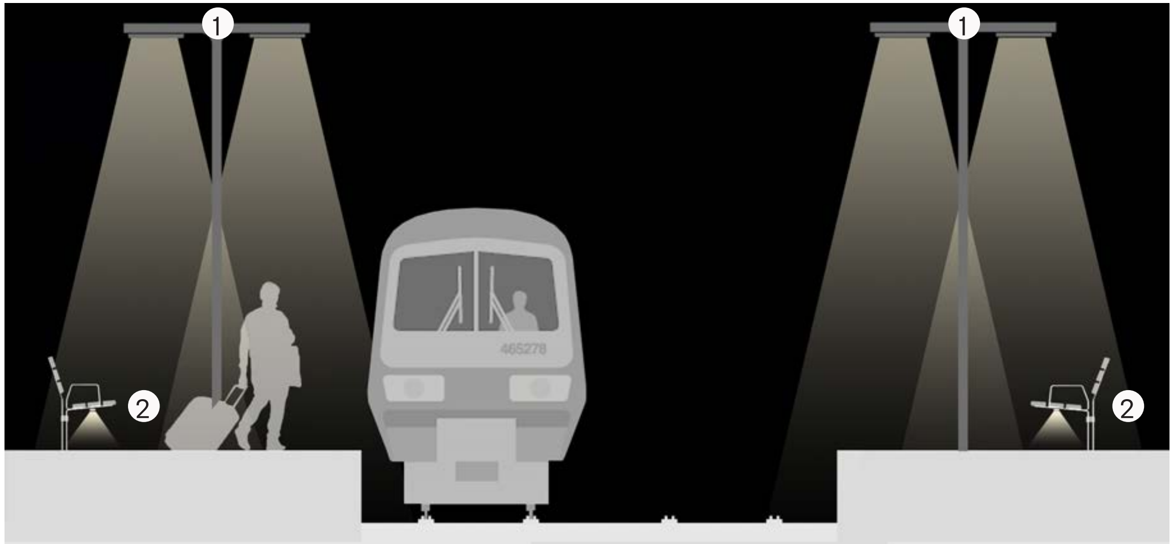


Figure 4.26:
Open Platform

Image 4.56:
Pole mounted luminaires aligned with centreline of island platform create shadow-free illumination up to platform edge

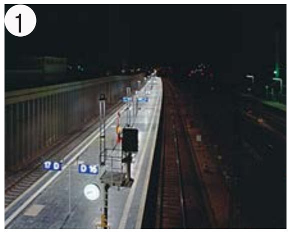


Image 4.57:
Asymmetric lanterns aligned with centreline of island platform create shadow-free illumination up to platform edge

Image 4.58:
Additional accent lighting concealed under benches can provide enhanced levels of illuminance to promote passenger comfort

Image 4.59:
Luminaires mounted onto waiting room exterior to illuminate platform edge

4.12 Platforms

4.12.3 Covered Platforms

Depending on the structure of the canopy and the type of station (whether heritage or modern), lighting equipment can be more easily integrated into the ceiling design or surface mounted.

Functionality should be combined with aesthetics by selecting luminaire designs that complement the architecture of the station and the canopy design.

Additional architectural lighting elements may contribute to the ambience of the station by revealing and enhancing different aspects of the canopy design and the station architecture at night.

In all instances, luminaires should be located at a minimum safe distance of 1.25 metres from the platform edge.

Platform lighting should be designed and installed to avoid the need for possessions and isolations to facilitate the safe maintenance and replacement of luminaires and associated lighting equipment.

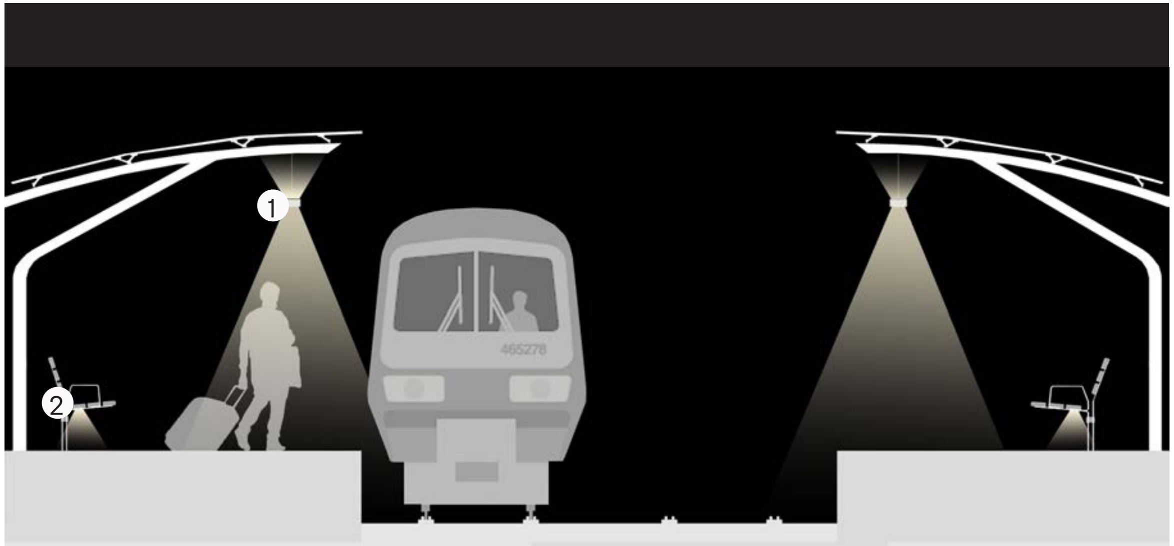


Figure 4.27:
Open Platform With Canopy

Image 4.60:
Direct/indirect lighting - provides enhanced levels of illuminance

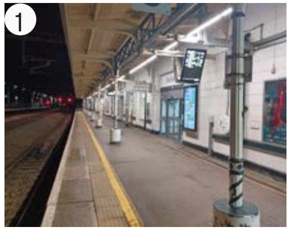


Image 4.61:
Visually continuous luminaires on suspended trunking

Image 4.62:
Ceiling recessed Luminaires with CMS

Image 4.63:
Additional accent lighting concealed under benches can provide enhanced levels of illuminance to promote passenger comfort

4.12 Platforms

Lighting for covered platforms may incorporate a series of layers which provide general lighting, local task lighting and where possible architectural accent lighting.

Lighting for the platform surface should achieve good levels of illuminance and uniformity, paying particular attention to the platform train interface (PTI). An important aspect that affects the illuminance levels and uniformity of the platform is the reflectance values of the materials used. Refer to section 5.1 *"Light Reflecting Properties of Surfaces".*

Indirect lighting to the overhead canopy can provide a more diffuse ambient light on the platform, creating a more legible space and highlighting the station architecture after dark.

Additional task lighting should be provided to elements such as network maps, information displays and help points where appropriate. Enclosed spaces such as booking offices, waiting areas should have a separate lighting strategy.

Considering the legibility of the platform environment after dark, priority should be given to the lighting vertical surfaces to assist passenger orientation and wayfinding after dark. It is also important that passengers can easily read the station name sign and directions off the platform to avoid congestion.

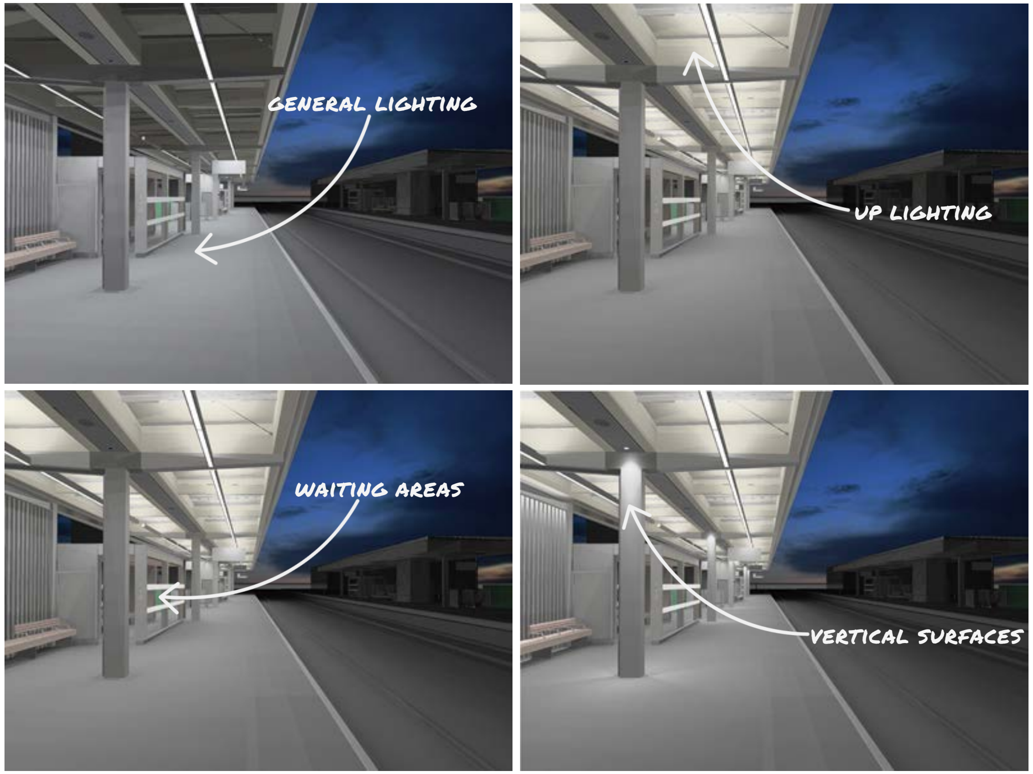


Figure 4.28: Example of layers of lighting applied to the HUB Station canopy design

Network Rail document

Design Manual for Medium to Small Stations

NR/GN/CIV/200/02

4.12.4 Main Termini & Large Train Sheds

In large enclosed volumes, the use of lighting equipment that compliments the overall architectural style of station is important, whether the building is historic or a contemporary structure. The lighting should contribute positively to the appearance of the space, rather than detract from the aesthetic integrity of the building. In large spaces such as this luminaires should be accessible from roof mounted maintenance access walkway to avoid the need for possessions or track closures.

Incorporating recessed lighting that seamlessly blends into the architecture, provides illumination without creating visual clutter. Integrated lighting elements directly into structural elements, such as handrails, columns, or ceilings. This approach can enhance the overall design while providing necessary illumination.

Custom fixtures can be considered to blend into the station architecture. These may be variants of standard manufactured luminaires, with special materials, finishes and colours or custom designed luminaires with a form and function that responds directly to the station architecture. A consistent design language should be maintained throughout, whilst providing a smooth transition between spaces of different scale and volume, such as ticket areas, waiting rooms and platforms.

Image 4.64: Paddington Station - enclosed platform

4.12 Platforms

4.12.5 Fully Enclosed & Sub-Surface Platforms

The lighting design for fully enclosed platforms may require greater attention to the overall balance of luminance within the visual field than daylit station environments.

Greater priority should be given to the lighting of vertical surfaces in these locations. Care also should be taken in the selection of appropriate materials and finishes for locations with little or no connection to natural light. In spaces such as this, indirect lighting can create a sense of spaciousness and convey the impression of an elevated ceiling.

In completely sub-surface platform environments, it is recommended to use Section 12 rated luminaires (as defined by the Fire Precautions (Sub-surface Railway Stations) (England) Regulations 2009 to provide additional protection against dust ingress, consistently higher than average ambient temperatures, rapid fluctuations in air pressure and potential fire hazard within these fully enclosed spaces.

Image 4.65: Birmingham New Street Station
The distribution and placement of the lighting provides excellent levels of overall illluminance and uniformity in this sub-surface environment. The light coloured finishes on both the ceilings and the platform surfaces create greater inter-reflection between floor and ceiling to create a pleasant environment for passengers.

4.12.6 Future Lighting Concept: Catenary Lighting for Open Platforms

Analysis:
Currently, Network Rail uses lighting columns on external platforms to accommodate additional station equipment such as PA loudspeakers, CCTV, station signage and even hanging baskets with annual flower displays. Train operating company (TOC) standards often require separate structures to be provided for Driver Only Operation (DOO), CCTV, Customer Information Systems (CIS) etc. Lighting columns are typically designed and rated for specific head weights and wind loadings based on the use of column-top lanterns only. Columns are spaced to achieve a lighting performance specification based on mandated set of parameters for illuminance and lighting uniformity on the platform surface, while Public Address and Voice Alarm (PAVA) and CCTV systems are set-out according to a different set of mandated parameters, which may not align.

Concept Proposal:
The use of suspended catenary lighting systems on platforms would allow greater flexibility in the setting out of lighting columns. Catenary lighting system typically have wider, more robust columns that typical pole mounted luminaires which may be able to accommodate other station services more easily. This solution also provides an environment fewer lighting columns, integrated station services and more free space on the platform.

Figure 4.29: Typical twin headed lighting columns aligned with centre line of the platform

Figure 4.30: Catenary lighting installation suspended along centre line of the platform

Figure 4.31: Typical open platform lighting solution. Lighting columns are spaced to achieve mandated illuminance and uniformity values for lighting only.

Figure 4.32: Proposed catenary lighting alternative. This solution has fewer lighting columns than a standard solution and offers the possibility of integrating other station services, such as CCTV, PAVA CIS etc. which usally require separate structures to be provided.

4.12.7 Future Lighting Concept: Creating Visibility on Platforms for DOO

Analysis:
Where Driver Only Operation (DOO) is used on the network and where stations are unstaffed, train drivers will be at the forefront of assessing passenger safety when arriving and departing from stations.

After dark, it can be difficult for drivers to clearly see passengers standing on open platforms as the train approaches or departs from a platform.

Concept Proposal:
Placing an illuminated vertical surface or series of illuminated elements on either end of the platform, would serve to silhouette passenger movements as the train approaches and departs from the station enabling the DOO driver to clearly see passengers boarding and alighting.

An array of illuminated vertical louvres are suggested, with the face of the louvres oriented towards the approaching/departing train. Gaps between the louvres would minimize the visual impact of the louvres during the day and allow passengers on the platform to see through the array of objects. These illuminated "pylons" could be activated by sensors as each train approaches the platform, remaining in a dormant mode until needed to support passenger safety when boarding and alighting from trains.

Figure 4.33: Platform end, louvres not lit

Figure 4.34: Platform end, louvres illuminated

Figure 4.35: Possible design of the louvre screen

4.13 Waiting Rooms

Creating the optimum lighting solution for covered waiting rooms requires a considered approach that takes into account both functional and aesthetic requirements.

Waiting rooms should provide welcoming and safe atmosphere that makes passengers feel at ease both during the day and after dark.

A uniformly lit waiting room may contribute to the personal comfort of passengers and discourages anti-social behaviour.

Waiting rooms should be easy to locate and clearly visible from the platform. Lighting designers should aim to provide clear views into and out of the waiting room at all times.

Customer information screens should be clearly visible from within the room and levels of illuminance sufficient for passenger to comfortably read books and newspapers whilst waiting for a train.

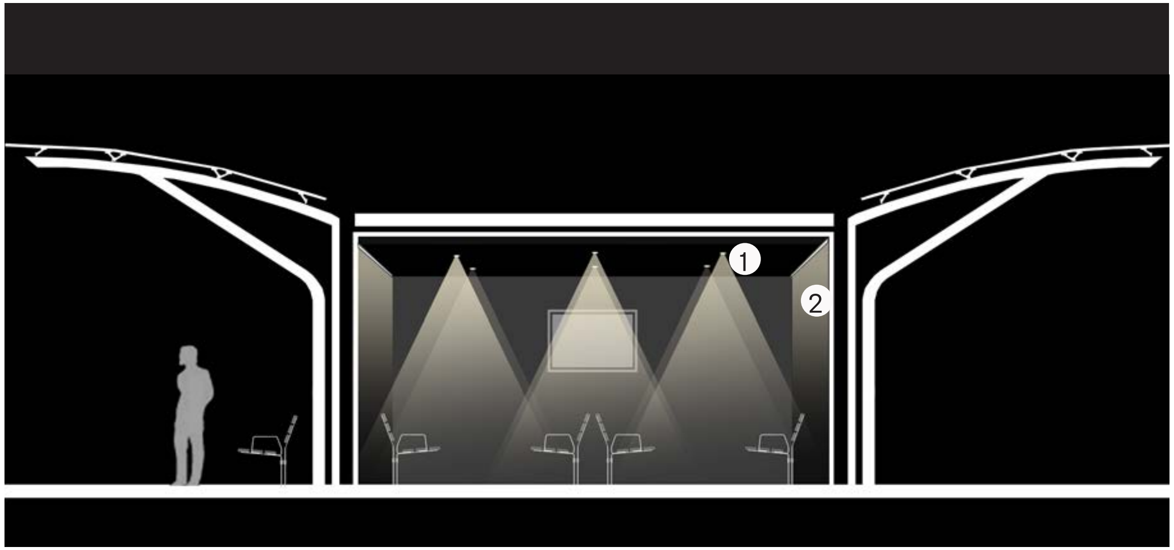


Figure 4. 36
Waiting Room

Image 4.66:
Uniform general lighting

Image 4.67:
Vertical illumination to perimeter walls

4.13 Waiting Rooms

Creating the optimum lighting conditions for enclosed waiting rooms requires a considered approach combining functional and aesthetic requirements.

Consistent levels of illuminance should be provided throughout the waiting room and the lighting of vertical surfaces should be prioritised where these exist.

The opportunity for passengers to see both into and out of the waiting room can make the space feel more welcoming.

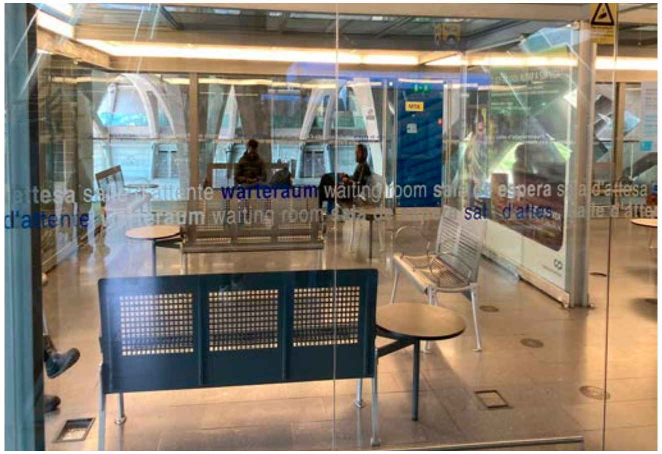


Image 4.68: Oriente Station, Lisbon
Clear structural glass with manifestation creates a sheltered space.

Image 4.69: London Bridge Station
Slatted timber bench with sculptural form in a large concourse.

Image 4.70:
Enclosed waiting room with clear glazing enables passengers to see in and out of the space.

Image 4.71:
Modular shelter with integrated lighting has higher levels of illuminance than the adjacent platform

4.14 Public Toilets

The quality of the lit environment within station toilets can significantly influence the overall satisfaction of users of these facilities.

Frequently there is minimal daylight ingress or no natural light within station WCs. Designers should therefore develop lighting strategies for incorporating indirect or diffuse lighting elements to create a sense of spaciousness and which provide good visual acuity for all user groups.

Care should be taken to avoid harsh shadows and glare from light sources within the space. Priority should be given to seamlessly illuminate the vertical and horizontal surfaces to prevent the toilets from feeling gloomy and oppressive.

The use of programmable time clock controls can enable the illuminance levels in the station toilets to be adjusted in response to ambient daylight levels externally within the station.

Network Rail document

Public Toilets In Managed Stations

NR/GN/CIV/200/04

Image 4.72: Victoria Station WC's
Backlit panels over communal hand-basins

Image 4.73: Victoria Station WC's
Illuminated plants create the illusion of daylight ingress

Image 4.74: Victoria Station WC's
Light colour finishes create a sense of spaciousness

Images 4.75 and 4.76: Victoria Station WC's
Illuminated clerestory panels in cubicles

4.15 Art Installations in Stations

Lighting can be used in conjunction with art installations at railway stations to enhance the passenger experience and create a unique sense of place or memorable focal point in a busy place of public assembly.

Public art can take many forms. It may be figurative art such as sculptures of notable historic figures or interactive installations incorporating new technology.

Abstract designs can be integrated with elements of the station architecture and structures such as bridges, tunnels and viaducts.

Large scale murals may be figurative or abstract, becoming an integral part of the station identity, incorporating elements of local history and distinctiveness.

Simple devices like bold colour schemes in station environments can be enhanced with lighting. Micro-processor controlled intelligent LED systems provide opportunities for artists and designers to create interactive light-art installations which engage directly with passengers within the station environment.

Creative light art installations can also be used in a practical ways in the public realm, integrated into street furniture and other architectural elements in playful and creative ways.

Image 4.77: Platform 5 (2011), Jason Bruges Studio. Interactive light art installation

Image 4.78: St. Pancras Station. Sculpture of celebrity figure

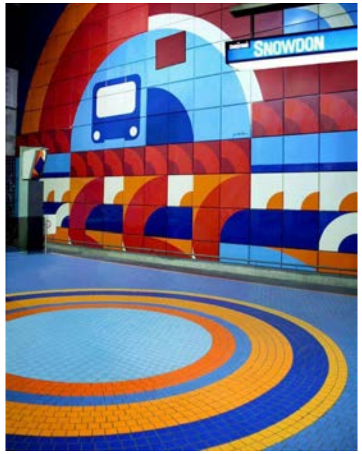


Image 4.79: Colourful tiles at Snowdon station in Montreal, Canada

Image 4.80: Sculptural bench in public realm

Image 4.81: Spotlighting to sculpture

Image 5.1
Queen Street Station Glasgow
Passenger Gateline

5

Lighting Design in Stations

Surface Reflectance & Colour

5.1 Light Reflecting Properties of Surfaces

In all illuminated settings, whether by natural daylight or artificial lighting, there is a component of reflected light that contributes to the overall brightness and colour characteristics of a space. The quantity and quality of light bouncing off surfaces depend on various factors such as the material's reflective properties, including its overall reflectivity, reflectance factor, surface colour, finish, and texture. These attributes, combined with the characteristics of the incoming light, collectively define the visual appearance of a surface, including its brightness, reflectivity, and colour tone.

The perception of an object within a given environment is influenced by the surrounding lighting conditions. Elements such as brightness and colour adaptation, as well as the relative contrast between adjacent surfaces in terms of both brightness and colour, play a significant role in shaping how elements are perceived within a scene. These factors not only contribute to the aesthetic experience of passengers within a station or on a platform but also hold considerable implications for their safety. By understanding and optimizing these aspects of lighting design, it is possible to enhance both the visual appeal and the security of such spaces for all individuals utilizing them.

Image 5.2: Battersea Power Station, platform.
Dark colour palette

Image 5.3: Malmo Station platform in Sweden.
Light colour palette

5.1 Light Reflecting Properties of Surfaces

When light is incident on a surface, some may be absorbed, some transmitted and some reflected. The reflected light may be contained within a very small range of angles - termed specular reflection- or spread over a range of angles - termed diffuse reflection. For a perfectly specular surface, such as a mirror or a polished metal surface, all the incident light is reflected in the same plane as the incident light, and at an equal and opposite angle to the surface normal as the incident light (see Figure 5.1). There is no diffuse reflection and no losses. For a perfect diffuser (white blotting paper and matt emulsion paint are good approximations), the light is reflected so that the surface appears equally bright in all directions and there is no specular reflection (see Figure 5.2).

For most surfaces, the reflection is neither perfectly specular or perfectly diffuse - these surfaces may be termed 'glossy' (with significant specular reflection), 'semi-matt' (with little specular reflection) etc. (see Figure 5.3). The reflectance properties of a material are determined by its structure. Specular reflecting materials have a smooth, homogeneous surface which introduces no distortion into the path of the reflected light. Diffusely reflecting materials have a 'rough', inhomogeneous structure which scatters the reflected light in all directions.

For a coloured surface on the other hand, troughs (corresponding to regions of low reflection) and peaks (regions of high reflection) are seen. A 'red' surface, for example, generally reflects red light but absorbs blue and green. Such an example is shown in the image below. Light reflects off the glossy red ceiling surface, casting a red reflection on the floor. As can be observed, this affects both the perceived brightness of the space and the overall perception of the environment.

In a station environment, the angle of luminaire placement combined with the reflectance of the surfaces can impact the brightness of the space and may also create unwanted reflections, leading to glare. This can result in an unsafe or unwelcoming experience for both passengers and staff. Therefore, when designing lighting for a space, it is crucial to consider the materiality of the surfaces and to properly position the luminaires to take advantage of surface reflectance whilst avoiding unwanted reflections.

Image 5.4: Marienplatz, Ingo Maurer: Circulation space with glossy coloured ceiling. Inter-reflection affects the appearance of other materials and finishes in the station.

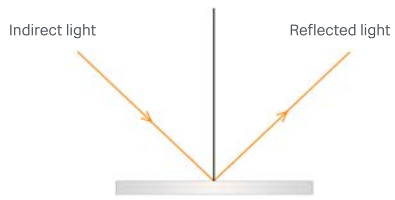


Figure 5.1: Reflection from a perfectly specular surface

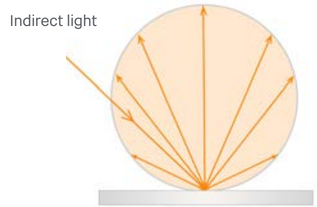


Figure 5.2: Reflection from a perfectly diffuse surface

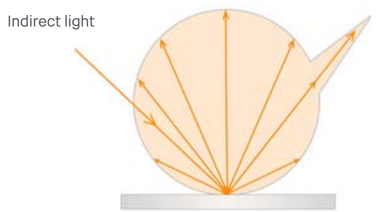


Figure 5.3: Reflection from a glossy surface

5.2 Colour Rendering Properties of Light Sources

In Network Rail projects, the luminaires specified should utilise LED light sources with the highest colour rendering capabilities and consistent colour output over the rated service life. The form factor and the type of LED utilised may vary according to the design of the luminaire or the optical system employed. Typically, high-power point source LEDs are coupled with lenses or reflectors to modify their light output. Mid-power LEDs offer versatility with multiple linear, circular, and "area" modules designed for back-lighting opalescent or micro-prismatic diffusers. Chip On Board (COB) LED modules present a compact array of miniature high-output blue LEDs coated with a yellow cold phosphor layer, which transform the blue light emitted from the LEDs into high-quality white light with excellent colour rendering properties.

The spectral power distribution of the specified LED light sources should be smooth without obvious gaps in the visible spectrum. Ongoing advancements in LED technology and solid-state lighting, together with the introduction of new colour metrics, underscore the importance of considering how the spectral power distribution (SPD) of light sources affects the visual perception of materials and finishes in station environments.

The CIE Colour Rendering Index (CRI) compares the chromaticity coordinates of standard colour samples illuminated by a light source compared to a CIE reference light source of identical colour temperature. CRI is typically derived from measurements across eight or fourteen standard pastel colours (Ra) as shown below. The correlated colour temperature (CCT) of a light source can influence the perceived ambiance of a space. Selecting an appropriate CCT can promote visual comfort and enhance the appearance of materials and finishes in the station. The CRI metric first developed to assess the colour fidelity of fluorescent lamps is now being re-evaluated with several alternative metrics more suited to LED light sources being proposed (See Appendix C Alternative and Emerging Colour Quality Metrics)

CRI	
$R_a = 100$	Near exact colour rendering
$R_a \geq 90$	High colour rendering quality
$R_a \geq 80$	Good colour rendering quality
$R_a \leq 79$	Poor colour rendering quality

Figure 5.4: CIE 13.3 Colour Rendering Index, 1995.

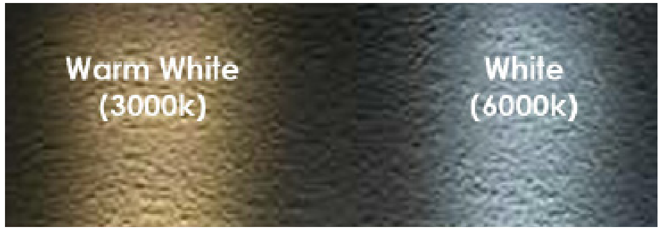


Figure 5.5: The Correlated Colour Temperature (CCT) of the light source impacts the perception of the space and the appearance of the environment

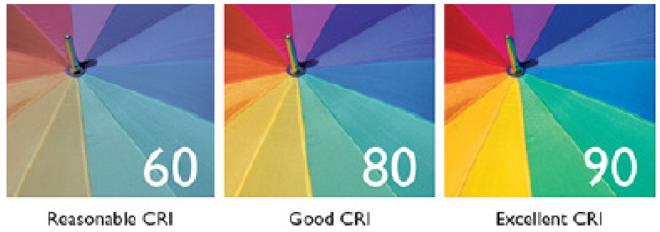


Figure 5.6: Good colour rendering enhances the appearance of saturated colours and the complexion of people's faces.

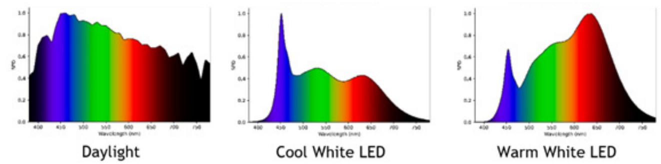


Figure 5.7: Spectral Power Distribution of daylight and LED sources

5.3 Colour Systems

When considering the reflection of light from surfaces for illumination purposes, surface reflectance plays a crucial role, regardless of its colour. However, the colour of the surface does influence the tint of the reflected light. In most cases, this isn't a significant issue. The colour appearance of a surface is influenced by the spectral radiation distribution of the illuminating light source, which can be represented by chromaticity coordinates. These coordinates are typically represented on either a CIE 1931 xy diagram or a CIE 1976 u'v' uniform chromaticity diagram (Figures 5.4 and 5.5). Chromaticity coordinates are applicable to surface colours but only when illuminated by specific light sources, as they combine both the surface's spectral reflectance distribution and the light source's spectral radiation properties. Chromaticity coordinates serve as the basis for evaluating a light source's colour rendering quality.

Paint manufacturers often assign names to describe the colour of their products, which can lead to confusion. To address this issue, various numerical systems have been developed, with the following being the most commonly utilised.

Code of Practice Guidance

Society of Light and Lighting
Lighting Handbook - 2018
Code for Lighting - 2022

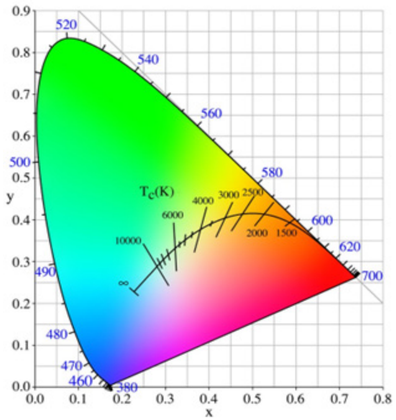


Figure 5.8: CIE (x,y) chromaticity diagram 1931

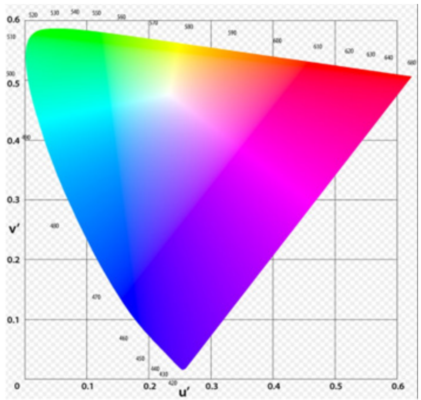


Figure 5.9: CIE uniform (u',v) chromaticity diagram 1976.

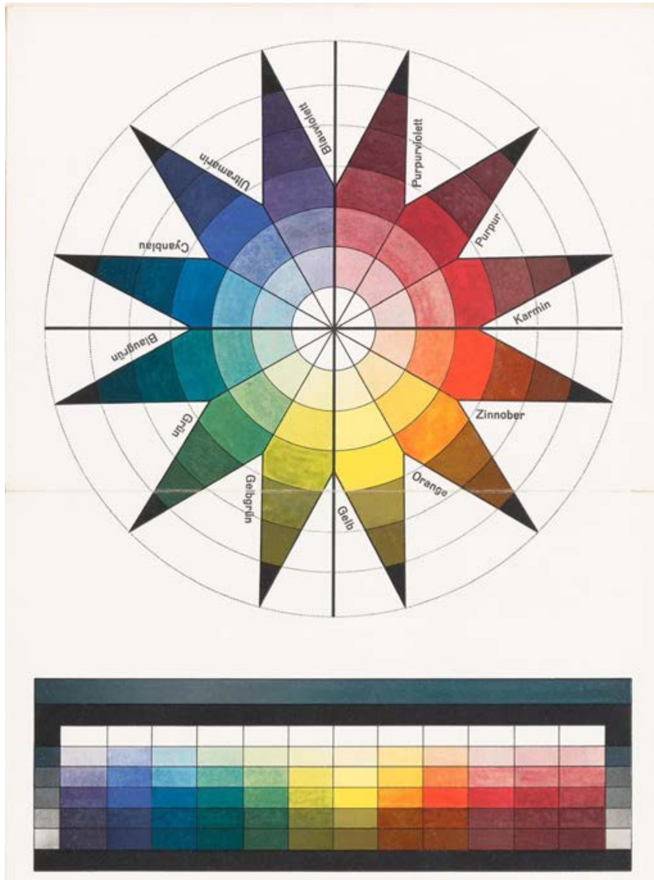


Image 5.10: Colour sphere in 7 light values and 12 tones, Johannes Itten, 1921

5.3.1 The Munsell system

The Munsell system stands as one of the oldest colour classification systems still in use today. Represented by a three-dimensional matrix illustrated this system defines surface colours in terms of three perceptual attributes: hue, value, and chroma.

Hue characterizes the dominant part of the colour spectrum perceived, such as red, yellow, or blue, each positioned around the periphery of a circular plane intersecting the Munsell solid. This circular arrangement includes five principal hues (red, yellow, green, blue, and purple) and five intermediate hues (yellow-red, green-yellow, blue-green, purple-blue, and red-purple).

Chroma denotes the intensity of colour, increasing radially from the central point of neutral grey (zero chroma) to a maximum level determined by the surface's hue and reflectance. Surfaces with zero chroma, lacking discernible hue, are labelled as neutral (N).

Value, represented vertically within the colour solid, measures the lightness of a surface on a scale from 0 (absolute black) to 10 (pure white). While value reflects the surface's reflectance, it differs from reflectance numerically due to the Munsell scale's design, where equal increments of hue, value, or chroma represent roughly equivalent perceived contrast steps (though the value scale's spacing differs from that of hue or chroma).

The relationship between reflectance (R%) and Munsell value (V) can be approximated by the equation:

R= value(value-1) / 100

The Munsell coordinates for a coloured surface consist of hue, value, and chroma, in that sequence. For instance, Munsell notation 2.5GY 618 indicates a hue of 2.5GY, representing a distinct yellowish-green, a value of 6, implying a reflectance of approximately 0.3, and a chroma of 8, indicating moderate saturation without being overly intense.

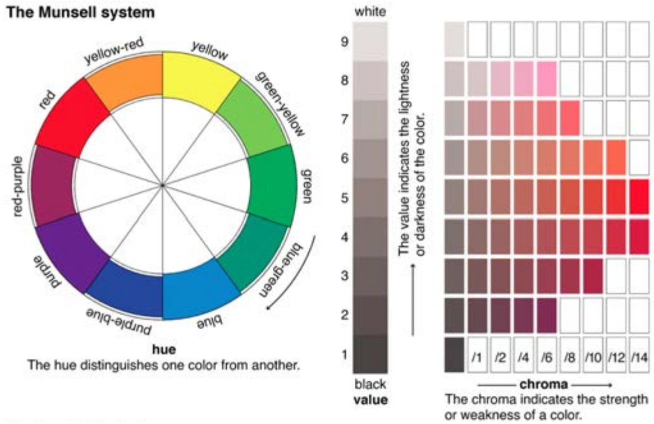


Figure 5.11: The Munsell system

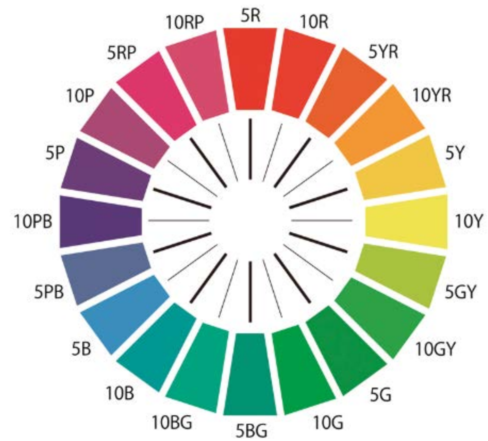


Figure 5.12: The Munsell hue circle

5.3 Colour Systems

5.3.2 The Natural Colour System (NCS)

The Natural Colour System (NCS), originated by Hird and Sivilc in 1981, categorizes colours based on their resemblance to six primary hues: white, black, yellow, red, blue, and green. The system identifies four chromatic colours, each devoid of traces of others, positioned 90° apart on the hue circle, forming the basis for red-green and yellow-blue axes. White and black represent pure colours devoid of other chromatic elements.

Each colour is composed of up to two chromatic hues alongside white and black. For instance, an orange hue might consist of 30% red and 70% yellow, totalling 100% resemblance, denoted as Y30R. Resemblance to black is termed blackness (s), to white is whiteness (w), and to maximum chromatic colour is chromaticness. The NCS triangle illustrates colour resemblance to white, black, and maximum chromatic colour in terms of whiteness, blackness, and chromaticness.

The system utilizes constant-hue triangles in the NCS Atlas, where arrays of constant chromaticness are parallel to the vertical axis, and constant blackness and whiteness are parallel to the triangle's sides. Specification of hue, blackness, and chromaticness fully defines a colour. The NCS Atlas features 1412 colour samples, with ICI (Paints) introducing an atlas reflecting its principles.

5.3.3 Colour and Contrast

Understanding colour systems when designing lighting is important. Different colour temperatures and intensities can alter the atmosphere and functionality of the space. Awareness of colour systems allows designers to create environments that are both visually appealing and practical.

Arthur and Passini's colour contrast theory highlights how colour combinations affect our perception of space. By manipulating colour contrasts, designers can emphasise certain areas, guide passenger flow, and improve wayfinding within the station. For instance, utilizing high-contrast colours for signage and information boards can enhance visibility and readability, especially in busy or dimly lit environments. A common rule of thumb is that the contrast between the foreground colour and background colour should be at least 70%, using the light reflectance value.

Moreover, colour choices influence passengers' emotional responses and overall experience. Warm hues can create a welcoming and comfortable atmosphere, while cooler tones may evoke a sense of efficiency and modernity. By strategically applying colour theories, lighting designers can shape the station's identity and functionality, ultimately enhancing passenger satisfaction and safety.

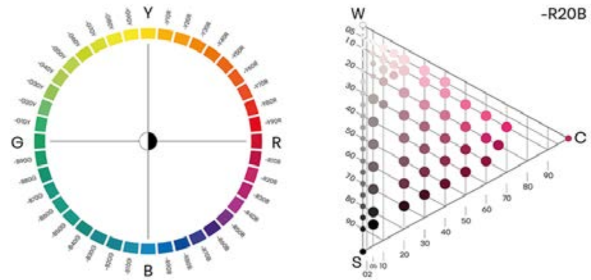


Figure 5.13: The Natural Colour System (NCS)

13		82	13	62	24	28	56	7	38
71	82		79	52	76	75	58	80	89
15	13	79		56	12	17	50	7	47
34	62	52	56		50	47	12	59	76
17	24	76	12	50		6	43	18	53
18	28	75	17	47	6		40	22	56
30	57	58	50	12	43	40		53	73
14	7	80	7	59	18	22	53		43
8	38	89	47	76	53	56	73	43	
19	32	73	21	44	11	5	37	26	58
85	84	16	82	60	80	79	65	84	91
61	78	14	75	44	72	70	51	77	89

Figure 5.14: Arthur and Passini's colour contrast

Image 6.1
Leeds Station Concourse: Generous ETFE skylights and integrated electric lighting

6

Lighting Design in Stations

Technical Guidance

6.1 Developing Technical Specifications

Most new build Network Rail projects and those involving the replacement of existing lighting installations at stations are design and build contracts. Those responsible for commissioning the work may prepare a detailed set of Employer's Requirements as part of the GRIP/PACE process which the Contractor can then use to both finalise the design and detailing of the project and complete the lighting installation. The lighting specification developed from the lighting concepts agreed with Network Rail should not simply be a list of technical requirements and generic luminaire types. To meet Network Rail's expectations, the lighting specification issued as part of the Employer's Requirements should check that the Contractor provides a lighting installation that meets all of the agreed lighting design objectives.

Technical design and sustainability data are a central aspect of this process. The whole life costs and ongoing maintenance costs are also key considerations that should be embedded in the Employer's Requirements and implemented by the Contractors employed by Network Rail. Delivering compliance with regulations and standards should include lighting performance requirements, installation details and advised integration with architectural elements and other building services. The lighting specification should clearly detail: relevant regulations and standards, energy performance targets, sustainability targets, lighting control system performance specifications and other Sponsor or Asset Management requirements.

As a minimum, the lighting specification should include:

- A schedule of luminaires with full details of the products specified, photometric performance, light source efficacy, visual comfort and lighting load.
- Layout drawings showing luminaire locations with important setting-out dimensions and lighting control channels, cross-referenced to the schedule of luminaires
- Detail drawings showing any special mounting details with details of any associated construction work needed.
- Control methodology
- List of IP addresses and commissioning values (i.e. dim to 80%)
- Lighting calculation results demonstrating wall, floor, ceiling horizontal illuminance values, uniformity, diversity, vertical and cylindrical illuminance values as dictated by standards.
- Emergency lighting calculations demonstrating compliance with standards
- Circuit designations

Network Rail recommends that suitably qualified lighting design consultants are employed by the Client / Project Manager to check that an appropriate levels of detail regarding the lighting is incorporated into the Employer's Requirements.

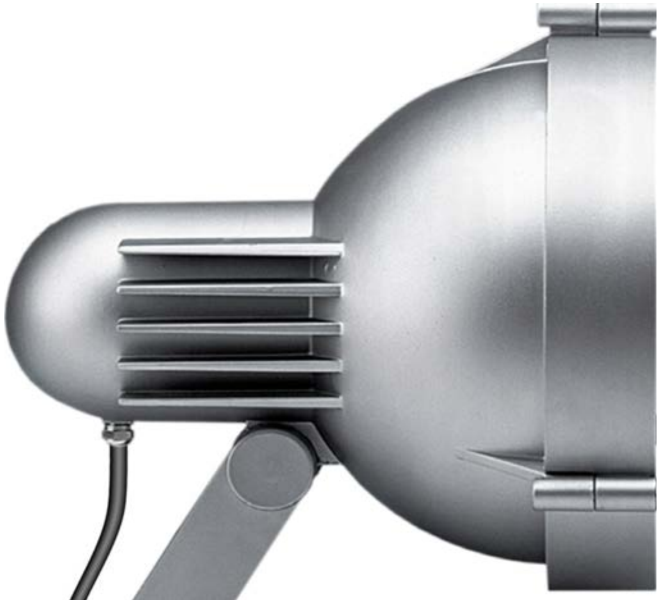


Image 6.2: Cast aluminium luminaire with heatsink. The form of a luminaire enclosure is frequently an outward expression of the technical and performance characteristics.

Network Rail document

Station Design Guidance Design Manual
NR/GN/CIV/100/02

Network Rail
Environmental Sustainability Strategy 2020 – 2050

6.2.1 General Requirements

All luminaires and associated equipment specified should be durable and easy to clean and maintain over their service life, allowing for ease of installation and replacement of control gear, drivers and components. Wherever possible the materials and components utilised in luminaires and lighting equipment specified for railway projects should be locally sourced using minimal, sustainable raw materials travelling minimal distance with minimal waste in terms of operational and embodied carbon.

Specified lighting suppliers and manufacturers should be required to present data on the embodied carbon of the luminaires using an approved methodology such as Chartered Institution of Building Services Engineers (CIBSE) TM66.2. The highest sustainability ratings (based on CIBSE TM65 minimum mid-level calculation) of total embodied carbon considering provenance, manufacture, installation and maintenance are required. The embodied carbon figures should be calculated over the expected service life of the luminaire and the on-site repair and retro-fit capability . Embodied Carbon and Design Life calculations should be considered as part of the same suitability rating of the product over time, for that application. Luminaires should be designed to be repaired, re-manufactured or re-purposed at the end of service life rather than simply being recycled.

6.2.2 Reflectors, diffusers and optical design

Several optical phenomena are typically used in luminaires and lighting systems to control the light emitted from a light source. These fall into the categories:

- Reflectors:

Specially-designed reflectors can shape the light emitted from the light source to achieve the advised photometric performance. The surface finish of reflectors can be completely specular (i.e. mirror-finish) progressing through increasing degrees of diffusion or texture to a completely diffuse matt surface to a achieve a wide range of light distributions.

- Lenses:

High efficacy lenses for point source LEDs or linear arrays can modify the light emitted from the LEDs to achieve a wide range photometric performance characteristics.

High efficacy lenses are also available for linear arrays of LEDs with a similarly wide range of photometric performance characteristics.

- Glare Control Accessories:

Anti-glare louvres, cowls and baffles which absorb most of the incident light on a surface can be used to modify the light output of a luminaire and avoid glare and visual discomfort.

- Diffusers:

Light transmitted through a translucent surface. The light transmission properties can vary from completely clear to completely diffuse. Coloured translucent diffuser materials may transmit certain wavelengths of light and absorb others High efficacy laser-etched polyester films can also be used shape the light emitted by LED arrays to achieve optimum efficiency without causing glare.

Image 6.3:
Ease of installation and future maintenance are key considerations when specifying luminaires and associated lighting equipment for stations.

6.2 Product Specification

	Minimum	Highly desirable	Desirable
Light Source	• Modular, replaceable and upgradeable without extensive skill required • Lamp life 70k+ hours • Balance between light distribution and avoiding glare • High efficacy average of 95 lumens/cW or greater	• Lamp life 100k+ hours • Proven low- glare in all applications • Warranty for 5+ years including colour fidelity • Zhaga compliant	• Module can be disassembled fully into components and reused/recycled by a large number of companies
Optics	• Precise distribution to light the task surfaces • Robust to minimise need of additional protective guards • Replaceable optics, with components available at least for the service life of the luminaire	• Modular optics to change light distribution as needed	• Open source design for optics, so it can be manufactured on as- needed basis by a variety of manufacturers
Controls	• Smooth dimming to 1% with no perceptible flicker • Lighting control system integration for sensors and scheduling • Constant light output	• Smooth dimming to 0.1% with no flicker • Constant light output • Gradual lighting - lighting turning on gradually in sequence as PIR sensors are triggered	• Wireless control • Integrated sensors for gathering data • Linked to incoming and departing train services to save energy and limit impact of station at night
Materials	• Luminaire housing made out of recyclable materials • Balance of robustness/minimal material use • 30 years service life (body, upgradeable gear+light source) • High IP and IK rating to prolong design life • Use very high quality luminaires - minimum 10- year warranty for body parts, 5 years for drivers and light source	• Minimal use of finishes to increase recyclability • Coordination with ceiling systems to reduce material quantity (e.g. IK rating to take into account location within station environment) • Luminaire profile to be used for other services (cabling for cameras, speakers etc) to save on additional containment costs • Manufacturing and transport emissions at net zero • Luminaire housing is made of minimum 30% recycled materials	• Luminaire housing is made from fully post- consumer luminaires • Optics made out of recycled materials • Use of luminaire body to house other service e.g. sensors collecting data or digital infrastructure • No toxic and pollutant materials used in the luminaire
Sustainability	• EU Ecodesign directive compliant • Manufacturer can provide information on all materials' origins for calculations • Luminaire manufacturing is EU- based - 90% + by material weight • All packaging is recyclable (and is recycled) • Modular components (light source, luminaire housing, driver) that can be easily disconnected for maintenance and upgrade • Junction boxes, wiring and control system equipment are easily disconnected for reconfiguration and upgrade (e.g. smart cameras and data retrival)	• Calculate and publish EPD (Environmental Product Declaration). Note: rapidly changing legislation will mean this requirement is to be re-confirmed and reviewed until legislative agreement on EPDs is reached • UK- based manufacturing - 90%? • Extended offering for servicing the luminaire for 20 years (parts) • Minimal use of packaging • No glue or epoxy potting used in the luminaire (with electronics exception)	• Fully UK/EU/EEA-based production of luminaire an all its components • All energy used for manufacturing and transportation is from renewable sources • All packaging is returned to the manufacturer • The luminaire design is open source or IP owned by Network rail and can be manufactured by different companies • CIBSE TM66 CEAM Score of 2.5 or higher

Table 6.1:
Luminaire Selection Table
(Source: Network Rail *"Design Manual for Medium to Small Stations"*)

Network Rail document

Design Manual for
Medium to Small Stations
NR/GN/CIV/200/02

6.2.3 Calculations

When calculating illuminance values and measuring the results it is important to be consistent from the initial setting up of an illuminance calculation through to verifying the values achieved on site at completion. For most projects target illuminance values are defined as an average maintained illuminance combined with a minimum value measured on a task surface. The most common measure of lighting uniformity is the ratio of minimum to average (calculated by dividing the minimum value by the average).

BS EN 12464 - Parts 1 & 2 *"Light and lighting. Lighting of work places, Indoor work places"* recommends that illuminance calculation points should be calculated using a grid of calculation points at which these illuminance values are calculated and verified for the task area, immediate surrounding area and background area.

National Standard

Light and lighting. Lighting of work places. Indoor work places.
BS EN 12464-Part 1

Light and lighting. Lighting of work places. Outdoor work places.
BS EN 12464-Part 2

Design of road lighting - Lighting of roads and public amenity areas. Code of practice
BS5489- Part 1

Designers should check whether the automatic calculation grid spacings in the lighting calculation software being used correspond to the recommended calculation point spacings for the task surface being calculated. The "automatic" default software settings should not be relied upon.

The BS EN 12464 recommends that a band of 0.5m from the walls is excluded from the calculation area except when a task area is within or extends into this border area. On platforms, ramps, stairs and footbridges, calculation surfaces, grid spacings, illuminance and uniformity values may be different. For example illuminance levels should be calculated up to and including the platform edge.

The illuminance on a surface is usually calculated and measured on a regular grid of points with the maximum distance between the points "p" being given by the equation "$p = 0.2 \times 5^{\log d}$" where "d" is the length of the longer dimension of the area being measured. The distance between the calculation/measurement points in "x" and "y" axes (the length and width of each space) should be equal.

For platforms, it is recommended that illuminance measurements should be taken using a 1.0 m x 1.0 m grid across a platform and along its length.

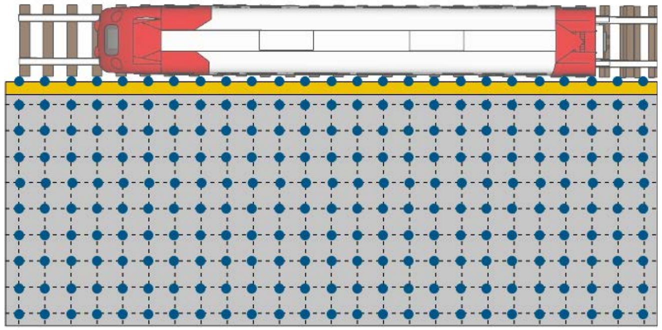


Figure 6.1: Setting-Out of Calculation Grid on Platform Surface

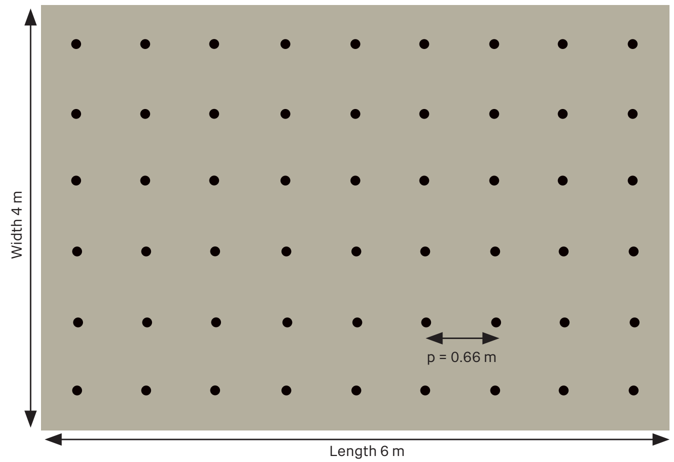


Figure 6.2: Typical illuminance measurement grid.

6.2.4 Maintenance Factors

When calculating average illuminance levels for a lighting installation, it is the illuminance at the end of the maintenance cycle that should be calculated, not the initial illuminance value. Maintained illuminance is therefore the minimum value that may be achieved at the point when the LED light sources are due for replacement.

The SLL Code for Lighting contains a method for calculating maintenance factors which is based on original research published in Commission Internationale de l'Eclairage CIE (2005) CIE Publication 97: 2005 "Guide on the maintenance of indoor electric lighting systems", CIE 154:2003, clause 5 for general outdoor luminaire maintenance factors and the BS5489-1, 2020, clause 5.1.6 for road / footpath lighting maintenance factor calculations.

Those responsible for carrying out design calculations for railway stations should carry out their own assessment of the lighting maintenance factor based on the location, environmental conditions and the uses of each space.

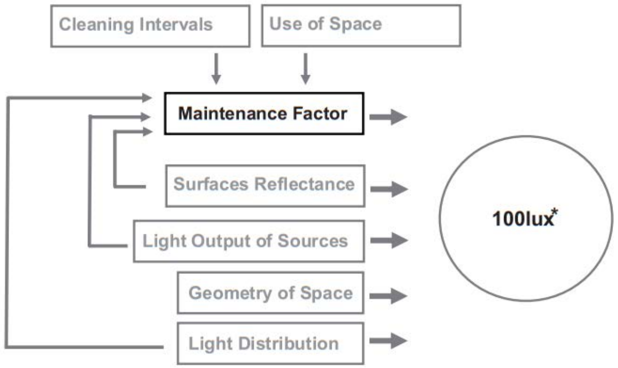


Figure 6.3:
How to determine the lighting maintenance factor

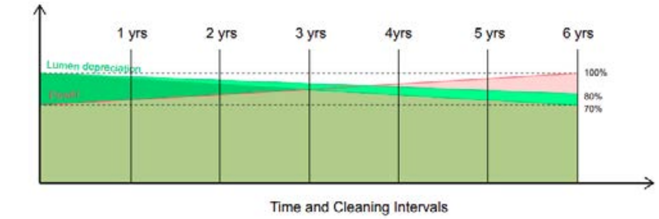


Figure 6.4:
Light output will reduce over time through lumen depreciation. Illuminance levels can be maintained by increasing power/ light

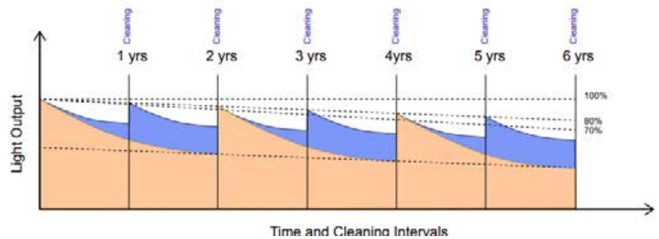


Figure 6.5
Light output can be increased by cleaning the light-emitting components of the luminaires in a station.

European Standard

Guide on the maintenance of indoor electric lighting systems
CIE Publication 97:2005

The maintenance of outdoor lighting systems
CIE 154:2003 clause 5.1.6

National Standard

Design of road lighting - Lighting of roads and public amenity areas. Code of practice

BS5489- Part 1

6.3 Ingress Protection and Impact Resistance

6.3.1 Ingress Protection Ratings (IP)

Luminaire ingress protection (IP) ratings are defined by BS EN 60529. This standard defines the levels of protection against ingress from solids and liquids. Generally, higher levels of ingress protection should be specified in stations.

6.3.2 Impact Resistance Rating (IK)

Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code) are detailed in BS EN 62262:2002+A1:2021. This standard classifies luminaires according to their resistance to impacts from kinetic energy. Higher levels of impact resistance are recommended for the publicly accessible internal and external parts of a station particularly platforms and other harsh environments.

Lighting designers should specify appropriate levels of impact and ingress protection according to the specific area of the station and the operational needs, as detailed in Table 6.2

National Standard

Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
BS EN 62262+A1

Degrees of protection provided by enclosures (IP Code)
BS EN 60529

INGRESS PROTECTION CLASSIFICATION			
FIRST NUMBER		SECOND NUMBER	
IP	Protection Provided	IP	Protection Provided
0	No Protection	0	No Protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	1	Protected against vertically falling drops of water e.g. condensation
2	Protected against solid objects up to 12mm e.g. fingers	2	Protected against direct sprays of water up to 15 degrees from vertical
3	Protected against solid objects over 2.5mm e.g. tools	3	Protected against direct sprays of water up to 60 degrees from vertical
4	Protected against solid objects over 1mm e.g. wires	4	Protected against low pressure jets of water from all directions - limited ingress permitted
5	Protected against dust - limited ingress (no harmful deposit)	5	Protected against low pressure jets of water from all directions - limited ingress permitted
6	Totally protected again dust	6	Protected against strong jets of water e.g. for use on ship decks - limited ingress permitted
		7	Protected against the affects of immersion between 15cm and 1cm
		8	Protected against long periods of immersion under pressure

Table 6.2: Ingress Protection Classification

IK RATING CHART	
IK00	No Protection
IK01	Protected again 0.14 joules of impact (equivalent of a 250g object dropped from a height of 56mm)
IK02	Protected again 0.2 joules of impact (equivalent of a 250g object dropped from a height of 80mm)
IK03	Protected again 0.35 joules of impact (equivalent of a 250g object dropped from a height of 140mm)
IK04	Protected again 0.5 joules of impact (equivalent of a 250g object dropped from a height of 200mm)
IK05	Protected again 0.7 joules of impact (equivalent of a 250g object dropped from a height of 280mm)
IK06	Protected again 1 joule of impact (equivalent of a 250g object dropped from a height of 400mm)
IK07	Protected again 2 joules of impact (equivalent of a 500g object dropped from a height of 400mm)
IK08	Protected again 5 joules of impact (equivalent of a 1.7kg object dropped from a height of 300mm)
IK09	Protected again 10 joules of impact (equivalent of a 5kg object dropped from a height of 200mm)
IK10	Protected again 20 joules of impact (equivalent of a 5kg object dropped from a height of 400mm)
IK11	Protected again 50 joules of impact (equivalent of a 10kg object dropped from a height of 500mm)

Table 6.3: Impact Resistance Rating chart

6.4.1 Fire Risk Assessment

In all instances railway stations may require a Fire Risk Assessment to be carried out. This assessment should be reviewed and updated on a regular basis. Detailed advice for the preparation of Fire Risk Assessments for transport buildings in England, Wales and Northern Ireland is available in the Department for Communities and Local Government publication Fire Safety — Risk Assessment: Transport premises and facilities (DCLG, 2007).

6.4.2 Emergency Lighting

Network Rail and the Train Operating Companies are responsible for the safe movement of passengers to and from their destinations.

UK legislation imposes a duty on persons, including employers and other persons with control of premises, to carry out risk assessments and to take such precautions to check the safety of the occupants. These measures include the provision of safe means of escape, including emergency escape routes and exits, together with, where necessary, signs indicating them. The most recent codes of practice also consider circumstances where occupants of a building may have to stay inside a building during a mains supply failure rather than evacuate the premises.

Legislation also states that suitable and sufficient emergency lighting needs are to be provided, together with emergency lighting of sufficient intensity where people are particularly exposed to danger, in case of the event of failure of the supply to the normal lighting.

Supply failure (either total or local)		
Emergency escape lighting	Emergency safely lighting	Standby lighting
Immediate total evacuates of the premises	Depending on the risk and the system, the occupants might be allowed to stay in the premises in the event of failure of the supply to the normal lighting until: a. There is 1 hour duration left in the emergency lighting system; or b. The system allows occupants to be directed or escorted to a low risk location; or c. The risk is minimal, e.g. if there is	Normal activities can continue but additional precautions are needed to meed escape or safely requirements

Table 6.4: Types of emergency lighting (from BS5266)

Network Rail document
Fire Safety at Stations Design Manual **NR/GN/CIV/300/03**

6.4 Emergency Lighting

The purpose of emergency lighting should be to get all station users to a place of safety. Many station environments are busy, and many users of a station unfamiliar with their surroundings. The responsible person carrying out the risk assessment for a project should consider this operational aspect.

In accordance with BS 5266 1 and RIS-7702 [N6], emergency lighting should be provided in any location in railway premises in which normal lighting is installed. Where normal lighting is installed in open areas, then emergency lighting should also be installed up until those routes reach a place of ultimate safety. Risk assessments should consider the anticipated footfall. Where there are no buildings present, unless identified in the risk assessment, emergency lighting may not be required.

The provision of standby lighting can also be considered, subject to risk assessment and agreement by Sponsor and Asset Management. However, the use of maintained lighting systems is preferred. In railway stations, there are processes which may have to continue during any evacuation and staff may prefer a working level of illuminance in public areas whilst safety procedures are carried out. This may require greater illuminance levels than for emergency escape lighting and for a longer duration. The exact performance requirements of standby lighting systems should be confirmed with the rail operator at the design stage of each project.

The risk assessment conducted by the responsible person at the outset may determine that higher minimum levels of illuminance than those set out in BS 5266- Part 1 (BSI, 2016a) may be needed in many areas of the station. Reference should be made to requirements of RIS-7702-INS, clause G3.6.1.3. If considered a high risk environment then BS5266-1 mandates at least 15 lux or 10% of nominal lighting value (Whichever is the more onerous).

Lighting designers should conduct a thorough evaluation of the emergency lighting requirements in terms of illuminance, uniformity, number and positions of luminaires and duration of the emergency lighting, as this may influence equipment specification. Designers should consider whether central power supplies with slave emergency luminaires may be more economic or whether self- contained battery emergency lighting are more appropriate.

The Use of General Luminaires:
Luminaires which have an Integral Emergency Lighting Facility, where a LED (green) charge light is mounted within the luminaire, normally behind a lens or diffuser should be avoided. When the luminaire lamp is ‘OFF’, the green LED charge light, can, in certain circumstances, wash the entire lens or diffuser with a green coloured ‘glow’. This green glow might be misinterpreted by a train driver, train crew or other employees as a green ‘Go’ signal. Before specifying general luminaires with an integral emergency lighting facility, the designers should be satisfied that the specified luminaires will not cause any confusion when installed at a station.

Wayfinding Signage:
In accordance with BS9992, wayfinding signage may replace more the typical running man emergency exit signage. The illumination of the wayfinding signage may be via external lighting, internal lighting and phosphorescent signs. Section 5 of BS5499-4, places minimum illuminance level requirements on this type of escape signage.

There are also specific requirements for emergency lighting in sub-surface railways, as defined by the Fire Precautions (Sub-surface Railway Stations). (England) Regulations 2009 (TSO, 2009)

Rail Industry Standard for Lighting at Stations
RIS-7702-INS

National Standards

Emergency lighting.
Code of Practice for the Emergency Lighting of Premises
BS 5266

Safety Signs
Code of practice for escape route signing
BS 5499-Part 4

Fire safety in the design, management and use of rail infrastructure. Code of practice
BS 9992

Specifying intelligent lighting control systems for railway stations has several measurable benefits including the reduction in operational energy use. It is also in accordance with the requirement to provide lighting controls as per BRE Digest 498 in accordance with Building Regulation Part L, clause 6.62.

DALI 2 (Digital Addressable Lighting Interface) is Network Rail's preferred control protocol - regarding station categories A and B - for future new build projects and station refurbishment projects.

Where appropriate to the project design, luminaires can be linked in logical control groups according to the uses of each space or luminaires can be individually controlled when needed to enable a high degree of flexibility specific applications.

System interfaces such as astronomical time clocks, daylight sensors and occupancy sensors can allow a dynamic balance between electric lighting and natural daylight ingress to be achieved within the station.

Pre-set lighting scenes can be used to automatically control lighting within the station for the different requirements throughout the day (daytime, transition/dusk, overnight security mode, cleaning and maintenance activities). This may conserve energy while providing optimum levels of illuminance at all times. Switch plates can be provided in secure locations to enable the pre-programmed lighting scenes to be overridden by the Station Manager.

Use of a station-wide DALI 2 control system may also assist maintenance since intelligent LED drivers may be able to report faults in lighting circuits and LED failures to those responsible for the maintenance of the station. This type of automatic monitoring of lighting systems should reduce the frequency of regular manual inspections of all luminaires.

Similarly, the inspection of maintained and non-maintained emergency luminaires can be simplified as battery life and system operation may be remotely monitored without the requirement to run a full 3-hour emergency test.

Once fully commissioned and set-up the lighting control systems in each station should operate automatically from day-to-day with pre-set lighting scenes initiated via an integral astronomical time clock and/or automatic photocell controls.

In locations where it is not possible to install a central DALI-based lighting control system, the use of localised PIR sensors can be considered to dim the station lighting to a "dormant" level when a space it not occupied, for example. Where appropriate to the scope of the project, it may be possible for station design teams to explore and implement ways in which the lighting in the station environment can be programmed to respond in real time to trains arriving and departing from each platform.

Figure 6.6: Typical control system architecture - indicative only

Technical Guidance
6.5 Lighting Control Systems

6.5.1 Flicker and Stroboscopic effects

Flicker refers to rapid changes in brightness which, depending on the frequency, may be visually perceptible or not. Frequencies up to 80 Hz can be recognized by the human eye which is referred to as flicker fusion frequency. Everyone is likely to experience eye-strain in poor lighting conditions, but some groups are particularly sensitive to light conditions such as flicker. One such group is those who suffer from photosensitive epilepsy. Perceived flicker can be experienced as extremely disturbing and, in some cases, it can cause migraines, headaches and more.

Visible and non- visible flickering and stroboscopic effects can arise with LEDs, particularly when they are being dimmed. The lower the dimmed level, the more significant the issue can be. LED failure on a circuit board can result in the voltage operating outside parameters, leading to flicker. Specifying high frequency pulse width modulation (circa 1100-1200 KHz) to minimise flicker and strobe effects for comfortable dimming and interference-free video monitoring or recording by CCTV is recommended.

National Standard

IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers

IEEE 1789-2015

In the event of an over temperature thermal issue, the driver should dim down to attempt to reduce temperature. If the temperature does not reduce sufficiently, it will turn off altogether. Similarly, in cases where over / under voltage situations exists, drivers should shut-down. Before specifying LED luminaires and drives or control systems, lighting designers should communicate with manufacturers to get informed regarding flicker and therefore specify high-quality products to mitigate flicker-related issues.

6.5.2 Open-Protocol control systems and triggers

The lighting control specified should use a universal open protocol and be compliant with new technologies using the DALI-2 protocol (IEC 62386). The control system/s including Bluetooth and wireless control systems should allow for full interoperability and allow the use of luminaires from more than one supplier. System components including luminaires, sensors and push buttons should be easily sourced. Smart cameras and AI based analytic and control should not be excluded due to the control system selected, to allow for future proofing of the system.

Controls and proprietary presence detection sensors should assure maximum energy savings over the life of the installation and provide automated or semi-automated presence based, dimmable lighting performance. The system should also be flicker-free and suitable for the local CCTV.

6.5.3 Daylight-Linked Controls

Lighting control systems within the station can be linked to sensors to enable the electric lighting to be dimmed or switched off when there is sufficient natural light available within a space. Microprocessor-based lighting control systems and electric lighting can automatically adjust levels of illuminance internally to synchronise with levels of daylight externally.

The colour temperature of light sources can also be automatically adjusted to simulate changes in the colour of natural light externally throughout the course of the day

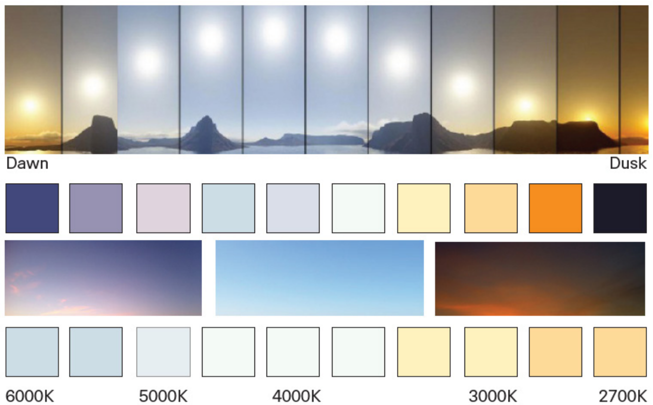


Image 6.4: Colour temperature of daylight changes during the course of the day

6.6 Sustainability

6.6.1 Circular Economy:

There is a real momentum towards achieving a genuine circular economy in the UK lighting industry. Away from the old linear model of *"take, make and waste"* to a sustainable circular model of *"make, use, return'.* At the end of service life luminaires should go back to the manufacturer, either to be refurbished, upgraded or remanufactured as more luminaires. At worst it should be component recovery and re-use.

Embracing circular economy principles can reduce the embodied carbon in all specified materials and installed products on the railway. Appropriate strategies relating to building services installed in future stations, might include the following:

- *Creating Adaptable Stations:*
  Providing a flexible building, where potential uses for the station are clearly defined and the most onerous condition is allowed for by design. For example, providing space in a plant room for additional plant, so station capacity can increase in the future.
- *Adopting Passive Design Principles:*
  Eliminating the requirement for active Mechanical, Electrical and Public Health (MEP) systems in the station. Examples of passive features could include natural ventilation systems, maximising the use of natural daylight, and the use of solar shades to minimise heat gains.
- *Recovery and Regeneration*
  Use of pre-used, re-manufactured, refurbished, or new luminaires and lighting equipment fabricated from recycled materials, as well as assuring that equipment can be re-used and recycled at the end of its service life.
- *Reducing Operational Carbon*
  Reduced consumption of primary resource flows such as energy, water and waste in stations.

6.6.2 Calculating Embodied Carbon:

A large proportion of embodied carbon from lighting and electrical products is associated with the manufacturing stage. This is due to the fact that the majority of luminaire components are made of metals, electronics and plastics, and have a complex supply chain.

The product stage includes the carbon emissions associated with extraction, transport and processing of materials and the energy consumption used to manufacture the product.

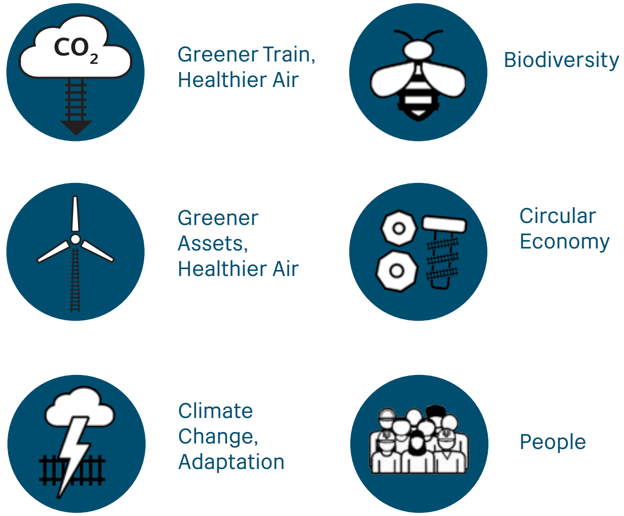


Figure 6.7: Key aspects of the Network Rail Environmental Sustainability Strategy

Network Rail document

Climate Action Design Manual for Buildings and Architecture
NR/GN/CIV/100/04

Network Rail
Environmental Sustainability Strategy 2020 – 2050

6.7 Circular Economy Principles

Network Rail is committed to creating a railway fit for the future, with buildings that respond to environmental challenges.

When designing lighting installations for stations, designers should consider the whole lifetime costs as well as the energy-use and day-to-day operating costs.

The extended operational life of LED light sources and associated electronic components reduces the overall environmental impact compared to older lighting technologies with a shorter operational life which result in greater mineral extraction and a greater number of manufacturing processes over the same period.

The ability to repair luminaires and refurbish them at the end of their initial service life is one of the circular economy principles that all lighting equipment manufacturers should adopt. For example, Belgian Energy Provider Synergrid proposed the following categorisation for street lighting.

These classifications can be adopted for Network Rail projects with only Class 1, 2 and 3 luminaire types being suitable for installation in stations.

Class 1-LED module and auxiliary components can be removed and replaced in site at the luminaire mounting position;

Class 2 – Auxiliary components can be removed and replaced in site at the luminaire mounting height;

Class 3 – luminaire has to demounted before removal and replacement of the LED module or auxiliaries;

Class 4 – The luminaire is sealed and should be discarded in the case of failure of the LED module or any internal components (Not recommended).

Image 6.5:
All parts of the luminaire should be easy to assemble and disassemble at the end of service life.

National Standard

Creating a circular economy in the lighting industry

TM 66: 2021

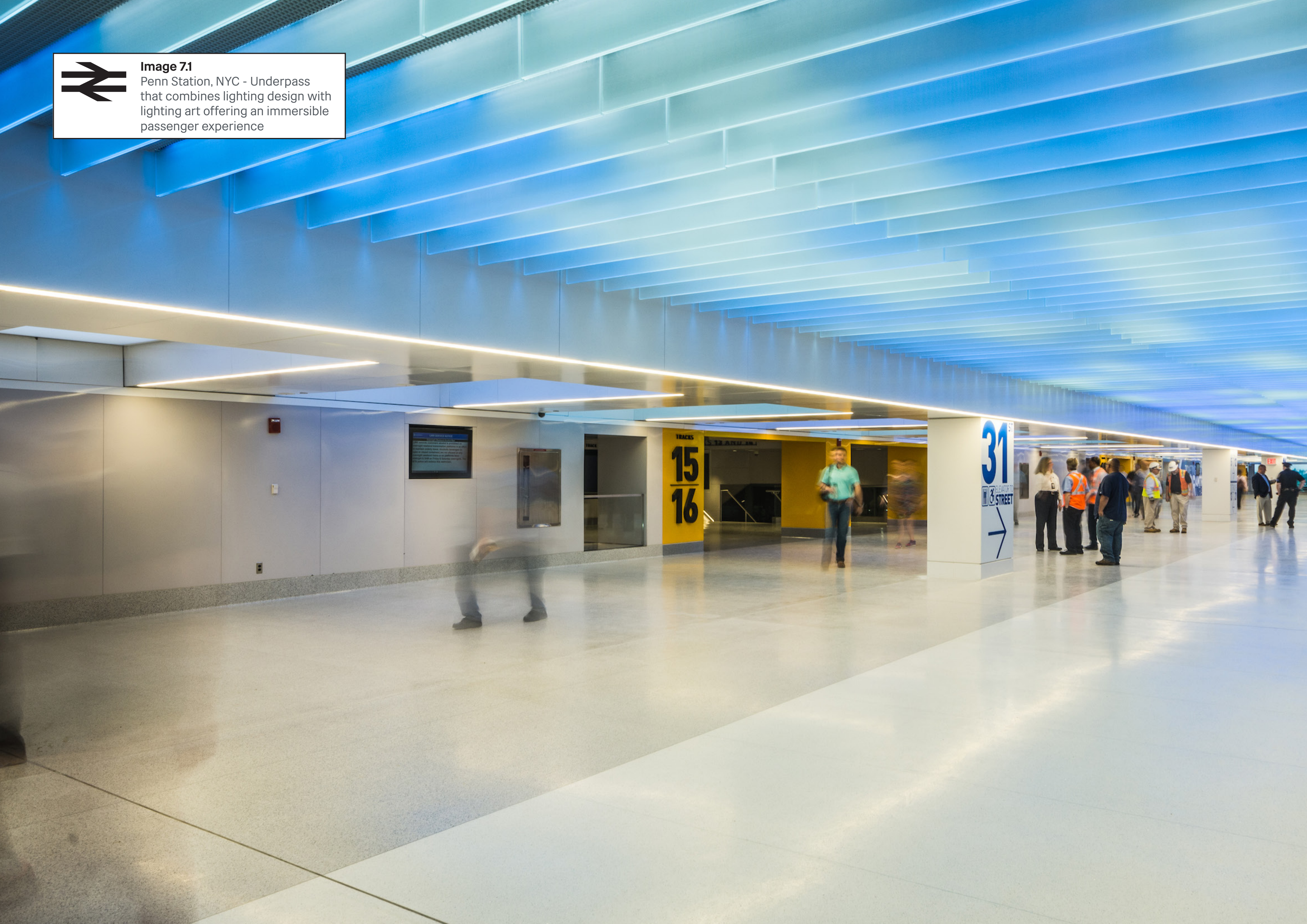


Image 7.1
Penn Station, NYC - Underpass that combines lighting design with lighting art offering an immersible passenger experience

Lighting Design in Stations

7

Installation, Maintenance & Replacement

7.1 Contractors Responsibilities

The person appointed to design the lighting in stations, ideally a specialist lighting consultant should remain involved during the entire construction process since there is a significant risk that the lighting specification could be compromised at every stage of the project from the initial tender through to construction, completion, and handover to Network Rail.

The building form and the associated lighting elements should be considered in harmony from an early stage of each project, since these aspects are frequently developed in isolation from each other. The specification of materials and finishes within the station environment should be determined in parallel with the lighting design to achieve the optimum end results for each project.

The Contractor’s services agreement with Network Rail should make adequate provision for on-site mock-ups for standard luminaire types in order for installation details, wiring and containment to be verified by the Network Rail project manager before proceeding with the final installation on site. For innovative installations and custom luminaire designs, provision should be made for full-scale prototyping with this important aspect factored in to the project programme. The requirement for the Contractor Design Portion of the works should be clearly detailed in the Lighting Specifications, together with the requirement for specific benchmarks and lighting prototypes to be installed for client approval before commencing the final installation on site.

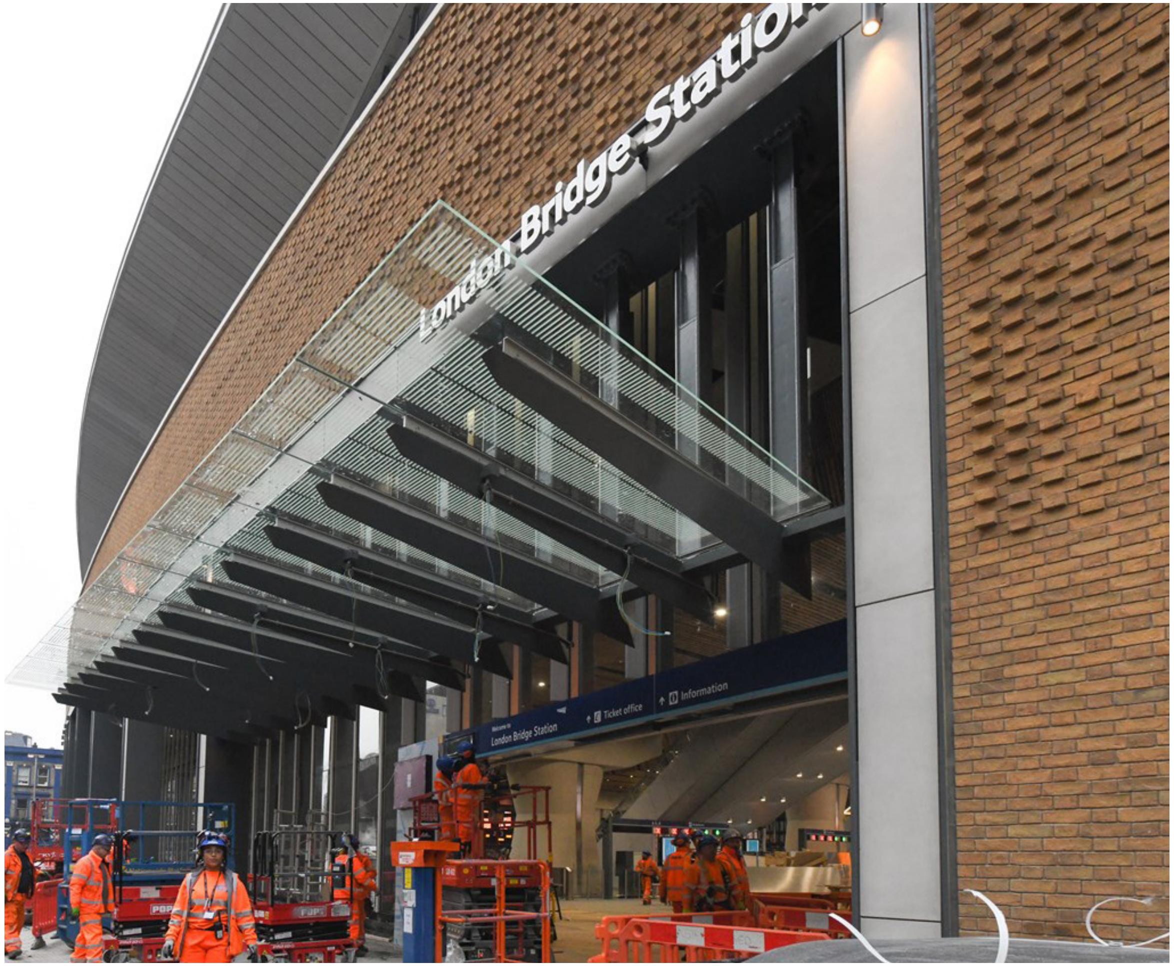


Image 7.2:
London Bridge station under construction

7.2 Cable Management and Integration

Cable management systems for the lighting installation should be considered from an early stage in design development as an integral part of the electrical system design and not an aspect of the project that becomes the responsibility of the installing electrical contractor during the construction stage of the project.

Those responsible for the design of lighting in stations should specify and carefully detail containment which is sympathetic to its surroundings and where possible concealed either by the building structure/fabric or integrated within a cable management system as part of the lighting system. Lighting installations in historic station buildings and heritage structures are likely to require local authority Planning Permission.

Installing contractors should incorporate the following aspects in the system design:

- The design of lighting installation itself should minimise the requirement for overhead work on site.
- Luminaire housings and Cable Management System (CMS) should be robust, weather resistant, resistant to vandalism
- Modular systems should be prefabricated and pre-wired with “plug and play” harness wiring.
- Continuous access along the length of the primary cable management system should be provided.
- Access panels to be provided at regular intervals for cables that require pull-through installation

Image 7.3:
Typical Cable Management System (CMS) railway arch underpass at street level.

7.3 Commissioning and Verification of Design

7.3.1 Verifying on Site

Always use a good quality, calibrated illuminance meter. Never rely on data from a smart-phone "illuminance meter" application.

The illuminance meter used should be calibrated against the V-Lambda curve. Portable hand-held instruments which most closely follow this curve should be able to provide the most accurate readings for all visible wavelengths in a range between 0.01 to 299,000 lx

When measuring illuminance values on site, always follow the calculation grid previously determined at the design stage, so that the most accurate result is recorded.

Consider the inherent calculation and measurement uncertainties when presenting the results.

Image 7.4:
Type F - Hand-held illuminance meter

7.3.2 Hand-Held Illuminance Meters

The performance requirements for illuminance meters are set out in BS 667. The standard defines two types of meter: Type L, which are of high accuracy and generally used in a laboratory, and Type F, in which a certain amount of accuracy has been sacrificed in order to make the instrument portable.

BS667 considers a number of potential sources of error for hand-held illuminance meters puts limitations on them.

A hand-held illuminance meter, which just meets the requirement of this standard, would have a best measurement capability ±6% (Type F) when used on any of its calibrated ranges.

Therefore, for a design that requires an average illuminance of 300 Lux to be achieved, measurements on site could easily range between approximately 280 Lux and 320 Lux and still be considered within acceptable limits.

User error when taking measurements on site may significantly amplify the issues described above.

Source of error	Maximum error over effective range	
	Type L	Type F
Calibration uncertainty*: -10 to 10.000 lux -10.000 to 100.000 lux	1.0% 1.0%	2.5% 3.0%
Non-literary: -10 to 10.000 lux -10.000 to 100.000 lux	0.2% 0.2%	1.0% 2.0%
Spectral correction factor	1.5%	3.5%
Infra-red response	0.2%	0.2%
Ultraviolet response	0.2%	0.5%
Cosine corrections(unless marked as uncor-rected)	1.5%	2.5%
Fatigue	0.1%	0.4%
Temperature change	0.2% per K	0.25% per K

Table 7.1: Performance requirements for luminance meters

National Standard

Illuminance meter. Requirements and test methods.

BS 667

7.3.3 3D Modelling of glare effectively using software

3D modelling of glare is a difficult and time-consuming problem to overcome. The glare calculation given in BS 12464-2 equates to the veiling luminance caused by the lighting installation and is the sum of the veiling luminance produced by each individual luminaire at the observer's eye divided by the equivalent luminance of the environment taking in to account the reflectance of the surfaces.

Using this statement, we can make some suggestions that can assist with in a successful design.

The greater the veiled luminance at the eye compared to the environment increases the glare rating, meaning that we have a few options to reduce this value:

- Increasing the height of the luminaires tends to increase the uniformity at floor level.
- Reducing the spacing of the luminaires may increase the luminance at floor level.
- Designing the luminaires at 0 decline to reduce the distance that each luminaire can affect the eye, therefore reducing the veiled luminance to the eye.

However, even with these suggestions, design software is very precise and the standards that state how to simulate the glare are ambiguous. There is a great deal of accuracy needed in positioning luminaires to check the values achieved are compliant.

The description for the denominator of the glare equation, discussed above, mentions that the reflectance of a surface influences glare. This is not only the floor's reflectance, but also all surfaces that the light can reflect off. BS 12464-2 states that if the value of reflectance is not known, "p" (rho) should be taken as 15%. This is a very low value and has been assumed to be the worst-case scenario for materials used within an outdoor built environment. At a new station or at a standardised station where the material type and colour is known, this value can be found and used. This value heavily affects the glare calculation; the higher the value the easier glare can be to achieve. For example, light grey concrete can be as high as 60-70%. This is not a common platform or station material but illustrates the point that different materials do have significantly higher "p" (rho) values.

It can be noted that certain luminaires and optics are better than others for achieving the required glare rating values in a station environment.

7.3.4 Operational Requirements

Network Rail may have additional operational lighting requirements which the lighting designer should establish with the Project Manager whilst determining the technical framework for each lighting project.

Enhanced lighting provision may be needed for reasons of passenger safety, to illuminate station signage, information boards. CCTV installations may also require special consideration and stations which have train services with Driver Only Operation (DOO) may require increased levels of illuminance to be provided.

National Standard

Light and lighting. Lighting of work places - Outdoor work places

BS 12464-Part 2

7.4 Project Handover

Assuring that the installed lighting systems are commissioned in accordance with the original design intent should assure the optimum outcome for each Network Rail project and the correct removal and decommissioning of old equipment.

Focusing and commissioning of the lighting system should be carried out after the installation has been fully electrically tested and snagging completed.

The recommended commissioning procedure for each lighting project is as follows:

- *One session for pre-commissioning* – attendees to include Contractor, lighting control systems representative, at which the operation of all parts of the lighting installation should be checked to ascertain that all equipment is working correctly, so that focusing and final setting-up can commence.
- *One session for aiming of all lighting, and setting-up of controls* - attendees to include Architect/ MEP (Mechanical, Electrical and Public Health Consultant) /Lighting Consultant, Contractor, lighting control systems representative, – at the end of which all adjustable fittings are aimed and all lighting controls are set.
- *One session for client review* - attendees to include Client and Principal Project Stakeholders, attendees to include Architect/ MEP (Mechanical, Electrical and Public Health)Consultant/Lighting Consultant, Contractor, lighting control systems representative – To check measurement grid points, energy levels, lighting levels etc.

Following project handover, a five-yearly Electrical and Lux Level Test is recommended - Agreement to be included in Mechanical & Electrical files and the Health & Safety file, prepared under the Construction Design and Management Regulations 2015.

Image 7.5:
London Bridge platform under construction

7.5 Maintenance, Refurbishment and Re-use

7.5.1 Manufacturer's Recommendations

Each component of the lighting installation should have carefully considered installation method including an approved access and maintenance strategy. The following information should be provided by the specified luminaire manufacturer.

- Component overview with a summary of specific components.
- Construction details illustrating how each component can be installed on site and replaced when needed.
- Access and maintenance procedures during the service life of key components
- Recommended cleaning intervals and method of cleaning avoiding damage due to inappropriate handling.
- As a minimum, the recommended recycling procedure the end of service life.

7.5.2 Future Maintenance Strategies

Due to the scale and complexity of railway projects, access and maintenance strategies are an important consideration during the design stages. The design team should detail how each element of the proposed lighting system can be safely installed on-site, accessed, maintained and replaced at the end of service life. Regular inspections of installed lighting equipment should be carried out by Asset Management in accordance with published guidance for the maintenance of minor structures.

Image 7.6:
Base-hinged lighting columns provide ease of access at ground level.

Image 7.7:
Use of mobile scaffold tower for maintenance of platform lighting.

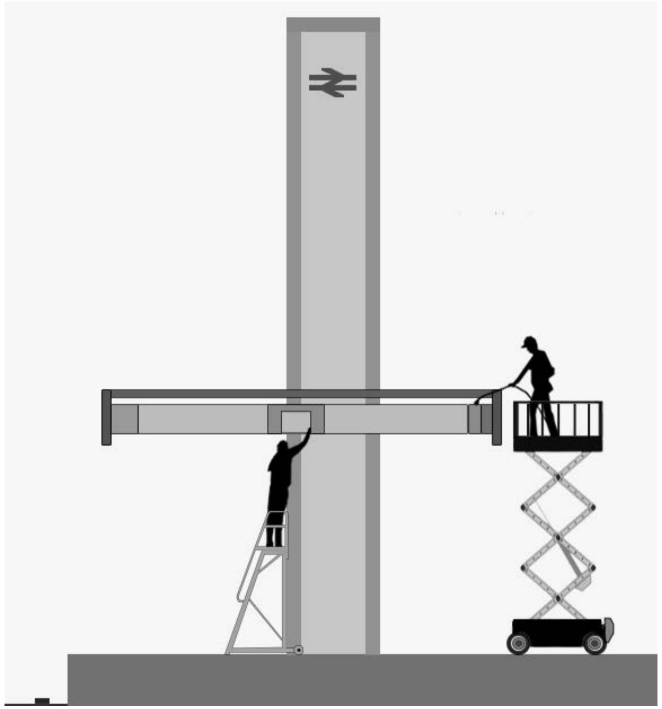


Figure 7.1:
Safe methods of installing and maintaining luminaires and lighting equipment on a station platform

Code of Practice Guidance

"Asset-Management Toolkit: Minor Structures"
Institution of Lighting Professionals Guidance Note
GN22/19: 2019

Image 8.1
Reading Station - Canopies
High reflectance surfaces at night

8

Lighting Design in Stations

Case Studies

8.1 Nørreport Station - Public Realm

Nørreport Station in Copenhagen, Denmark is an example of a project where the lighting design and architecture were developed in an integrated way from the outset.

This competition-winning design by Gottlieb Paludan Architects, COBE, Sweco, and Bartenbach for the renovation of the existing station incorporated lighting elements that remain prominent in the completed installation today: illuminated roofs, luminous columns, and coloured marker lights on the extensive series of bicycle racks surrounding the station entrances.

As Denmark's largest station, Nørreport sees over 250,000 passers by and over 100,000 train users every day, making it a bustling and significant hub within the city.

Given its central location, the station's public realm serves as an important meeting point for local and visitors to Copenhagen. The lighting design was developed to respond to this, acting as a focal point, meeting spot, and enhancing the public realm.

This design aimed to provide a sense of security by eliminating dark areas, iluminating the perimter of each space, reducing glare, and providing consistent levels of illuminance within the public realm.

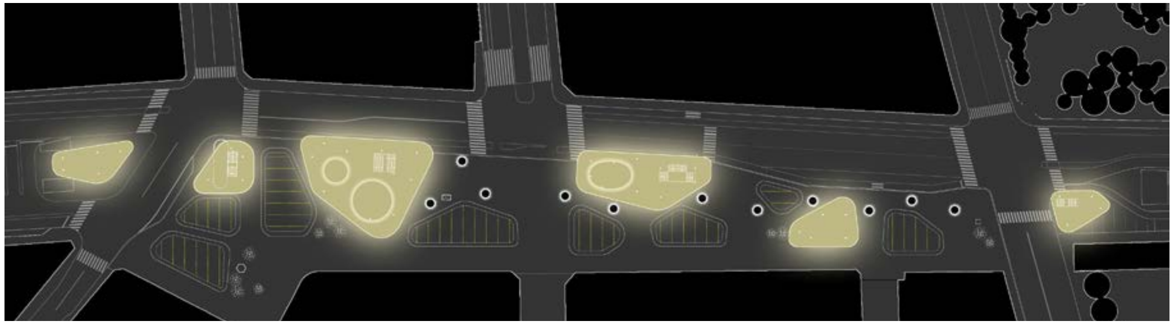


Image 8.2
Lighting plan.

Image 8.3:
Uplighting on the canopy. Nørreport's central area, decorated with the neon sign.

8.1 Nørreport Station - Public Realm

The lighting scheme comprises four main components:

- Ambient lighting from overhead, catenary wire suspended luminaires, reflecting Copenhagen's street lighting aesthetic and seamlessly integrating with the urban landscape.
- Illumination from beneath the white canopies, casting a gentle glow on the ceiling to delineate station entrances and guide passengers.
- Uniform backlighting of the columns serving as beacons visible from a distance.
- Bicycle racks adorned with small luminous marker lights creating a *"carpet of stars"* which attract the eye and create visual interest

The catenary street lighting and the uplighting to the station canopies provide warm white 3000K general illumination to the exterior of the station, whilst the internally illuminated columns have a cooler 4000 K colour temperature, creating a striking contrast and acting as landmarks. Additionally, the bike rack lighting adds a sparkling quality to the public realm outside the station adding further visual interest. In this scheme, the illuminance levels are carefully calibrated with ambient levels of illumination in the surrounding streets to provide safety and easy navigation whilst enhancing the architectural elements of the public realm. Nørreport station's DMX-controlled lighting system, gradually illuminates as daylight fades. Sections of the lighting switch on in response to decreasing natural light levels, starting dimly and increasing gently over time before dimming down later in the evening. This offers optimum energy efficiency for the installation.

The seamless integration of lighting and architecture at Nørreport station, creates a cohesive luminous environment in a busy city centre environment.

Image 8.4:
Lighting of the bicycle racks and catenary lighting.

Image 8.5:
Canopy uplighting in contrast with the tubes illumination.

8.1 Nørreport Station - Platform

In relation to the public realm, the station's platforms also underwent renovation, accompanied by a new lighting design solution. The narrow platform now boasts a bright and safe ambiance, designed by Gottlieb Paludan Architects in collaboration with Sweco Denmark for the lighting design.

The lighting design comprises three key elements:

- A linear luminaire running along the platform.
- Downlights positioned between the columns.
- Wallwashers integrated along the edge of the platform's canopy/structure.

These minimal elements efficiently provide uniform illumination while enhancing visual interest. The linear construction not only illuminates the platform but also enhances the openness and uniformity of the space by uplighting the canopy.

The downlights between the columns offer both visual interest and guidance, while the wallwashers along the canopy edge provide illumination to the station's perimeter walls. By illuminating these walls, the design enhances the perception of a bright and secure station environment.

The platforms lighting seamlessly blends into the architectural components, achieving uniform illumination.

Image 8.6:
The previous scheme at Norreport Station.
Dark surface finishes on the columns and ceiling combined with direct-only lighting scheme created a less inviting space for users.

Image 8.7:
The refurbished platforms at Norreport Station
Direct/Indirect lighting creates a sense of spaciousness, an elevated ceiling and more comfortable environment for passengers

8.2 Kings Cross - Public Realm

Kings Cross is one of the largest stations in London, serving more than 140,000 people a day. The station has a long history dating back to the 1800s and is one of the most important in London. Its renovation in 2012 focused on restoration, modernization, and extension of the station.

Kings Cross exemplifies the integration of lighting technology, functionality, art, and design within its historical context. The lighting of the public realm was carefully designed to provide both visual interest and functionality. Custom-designed 20-metre tall lighting columns elegantly illuminate the square whilst giving it a distinct identity. Strategically placed to align with Cubitt's architecture these columns not only invite people into the space but also aid navigation.

Various illuminated elements within the public realm, such as stone benches with integrated lighting, contribute to visual interest and encourage people to find places to rest. Uplighting along the streets adds to the welcoming atmosphere. Additionally, architectural lighting of the station facade creates visual interest and a unique sense of place. The sensitive orchestration of various layers of light at Kings Cross station elevates its ambience, seamlessly integrating history, functionality, and aesthetics to provide a pleasant experience for all station users.

Image 8.8:
Kings Cross Station Public Realm

8.2 Kings Cross - Concourse

The station's concourse is a fusion of lighting design and artistry. The spacious area is illuminated by direct and indirect lighting, creating a harmonious ambience. Indirect luminaires, strategically placed, illuminating the sculptural concourse roof structure, casting a gentle glow and creating a uniformly lit space that enhances smooth navigation for passengers. Along the side walls, accent lighting adds visual interest while providing vertical illumination, providing an understanding of the surrounding space. Integrated lighting within architectural elements provides a glare-free environment, allowing for clear visibility of information screens and points of interest.

The addition of colourful lighting accents infuses the concourse with vibrant hues, creating a striking visual contrast with the adjacent heritage building. This thoughtful lighting scheme not only enhances the aesthetic appeal of the space but also contributes to a welcoming and accessible atmosphere for travellers passing through the station.

Image 8.9:
Kings Cross Station Concourse

Image 8.10: King's Cross Station Underpass

The Kings Cross Tunnel seamlessly connects Kings Cross and St Pancras stations with KIng's Boulevard leading to Granary Square. its gently curved design, featuring a striking "Art wall" spanning nearly 90 metres, composed of flawlessly joined glass panels. Illumination within the tunnel comprises two key elements: LED screens and downlights. Strategically placed LED downlights provide direct illumination of the floor whilst harmonising with the screens to create a visually cohesive design. Back-lit surfaces employ LED modules emitting a spectrum ranging from full RGB to white light (3000K to 6000K), offering limitless creative possibilities.

The tunnel's design invites various artists to craft unique installations, promising a dynamic experience for the countless daily commuters. Its subtle curvature contributes to an immersive journey, obscuring the tunnel's end and enveloping pedestrians in a captivating play of light. The Kings Cross Tunnel stands as a prime example of design excellence, providing a truly unparalleled and immersive experience for all who traverse its path.

Image 8.10:
Kings Cross Station underpass

Image 8.11:
Kings Cross Station underpass

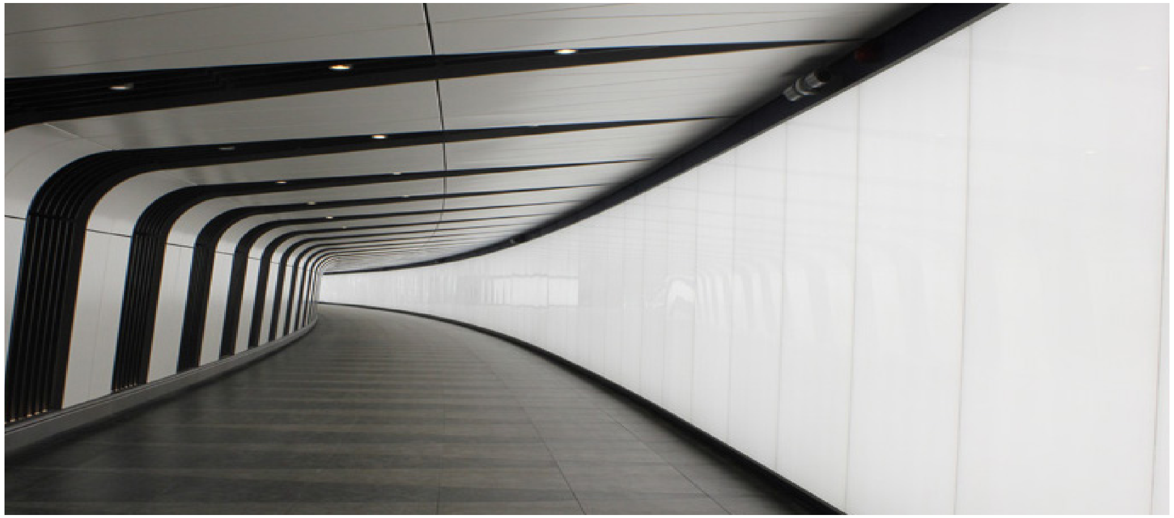


Image 8.12:
King's Cross Station underpass

8.3 Meridian Water - Public Realm

Meridian Water station is the cornerstone of a vast regeneration project. Its new construction boasts a sleek, contemporary design, seamlessly merging aesthetics with functionality. Notably, the station's exterior lighting exemplifies innovative integration within architectural frameworks, offering solutions that facilitate an open-plan ambiance.

Particularly noteworthy is the lighting scheme on the stairs, where careful design seamlessly integrates lights into the railing. This results in a harmonious and consistent illumination, providing both functionality and passenger safety during nocturnal travels, all while enhancing the station's aesthetic appeal.

Furthermore, linear uplights grace the station entrance, enhancing the elegant design of the canopy. Thoughtfully designed, the luminaires not only highlight the architectural feature but also utilise reflected light. Due to the glossy materiality and colour finish of the canopy, indirect-reflected lighting provides a uniform and smooth illumination the entrance area.

The lighting design of this station is an integral part of the station design, where architecture and lighting merge seamlessly creating a safe and aesthetically pleasing passenger experience.

Image 8.13:
Meridian Water Station

Image 8.14:
Meridian Water Station

8.4 Barking Riverside - Public Realm

Barking Riverside station is an essential component of the regeneration of this vibrant London neighbourhood, providing direct connections to Central London. The station boasts generous proportions and a straightforward layout making it easy to navigate. Amidst its overall design by Weston Williamson, one particularly interesting feature is its innovative lighting solution for the public realm.

A catenary lighting system, designed by Studiotech, has been implemented to illuminate the park area surrounding the station. This solution offers effective lighting, creating a pleasant atmosphere for passengers traveling through the station at night. It provides sufficient illumination, a safe environment for navigation while also adding to the station's aesthetic appeal.

The placement of the catenary downlights forms an attractive pattern that beautifully illuminates the area, highlighting pathways for passengers and key features such as planters and bike parking spots. With its warmer colour temperature, this lighting approach offers an unobtrusive solution that feels airy and simple.

The lighting seamlessly blends into the architectural context, enhancing the overall passenger experience. Barking Riverside station not only functions as a transport hub but also contributes to creating a visually appealing urban space for travellers to enjoy.

Image 8.15:
Barking Riverside

Image 8.16:
Barking Riverside

8.5 Leeds Station - Concourse

Leeds Central Railway Station stands as a great example of a concourse area that utilises lighting technology for human-centric illumination and sustainability. The renovation of its previous design created a new concourse, fully utilising natural light through the incorporation of skylights in its newly opened ceiling. Within this space, the lighting design seamlessly integrates into the structural framework, adopting a minimalist and refined approach.

LED linear fixtures, thoughtfully integrated into the concourse's architecture, deliver seamless and sophisticated illumination, remaining unobtrusive and glare-free. Notably, the electric lighting system has a tunable white Human Centric lighting system, regulating the space's colour temperature in harmony with the day's natural progression. This system uses fewer luminaires throughout the day, maximising natural light utilisation while transitioning seamlessly into fully electric light illumination as the night comes. The colour temperature dynamically shifts from warm hues during dawn to cooler tones at midday before reverting to warmer tones at nightfall. This adaptive lighting scheme enhances visual comfort for travellers regardless of the hour, promoting a sense of well-being while optimizing energy efficiency. Through the strategic fusion of natural and electric light sources, alongside sophisticated technological systems, the concourse achieves a holistic and human-centric design, enhancing sustainable and user-centric architecture.

Image 8.17:
Leeds City Station - New

Image 8.18:
Leeds City Station - New

Image 8.19:
Leeds City Station - Old

Image 8.20:
Leeds City Station - Old

8.6 Monk Bridge Viaduct Link, Leeds

The Monk Bridge Viaduct regeneration project at Wellington Place in Leeds has restored access to the historic bridge for the first time in 40 years. The newly developed construction features a staircase design with a fresh look and feel. Lighting on the staircase is primarily provided by handrail lighting, creating a smooth, warm glow that facilitates easy navigation.

The warm colour temperature of the lighting harmonises with the warm wood tones and materials used in the construction, creating an intriguing visual cohesion. Vertical illumination accentuates architectural details, with round luminaires casting light onto the walls surrounding the staircase, adding depth to the scene. Additionally, the incorporation of vertical lighting on the back stone wall enhances the overall atmosphere and provides users with a greater sense of their surroundings.

The staircase design incorporates warm lighting that creates proper illumination for safe navigation, while also enhancing understanding and familiarity with the surroundings through the illumination of vertical elements. The thoughtful design heightens appreciation for the architectural construction, making the journey across the bridge a smooth experience.

Image 8.21:
Viaduct Link, Wellington Place

Image 8.22:
Viaduct Link, Wellington Place

8.7 Brent Cross West - Footbridge

Brent Cross West station boasts a modern, passenger-friendly design with visually appealing architecture. The station's blend of materials and finishes creates an impressive aesthetic.

One of the stand-out features is the station's bridge. Its elegant structure comprises a metallic framework, complemented by translucent surfaces and a sculptural ceiling, creating a captivating visual display. Utilizing a combination of round downlights and linear luminaires the lighting scheme for the bridge is seamlessly integrated into the ceiling architecture. The downlights provide uniform illumination, eliminating dark spots while casting gentle glow spots across the ceiling adding a visually interesting element on the ceiling.

The linear luminaires installed along the sides of the bridge not only serve as directional indicators but also facilitate passenger navigation, intuitively following their movements. It is interesting that the ceiling approach extends beyond lighting, incorporating additional functionalities such as speakers, further enhancing both practicality and visual appeal. Brent Cross West station exemplifies a seamless integration of lighting and more services in a beautiful approach and at the same time provides a safe passenger experience.

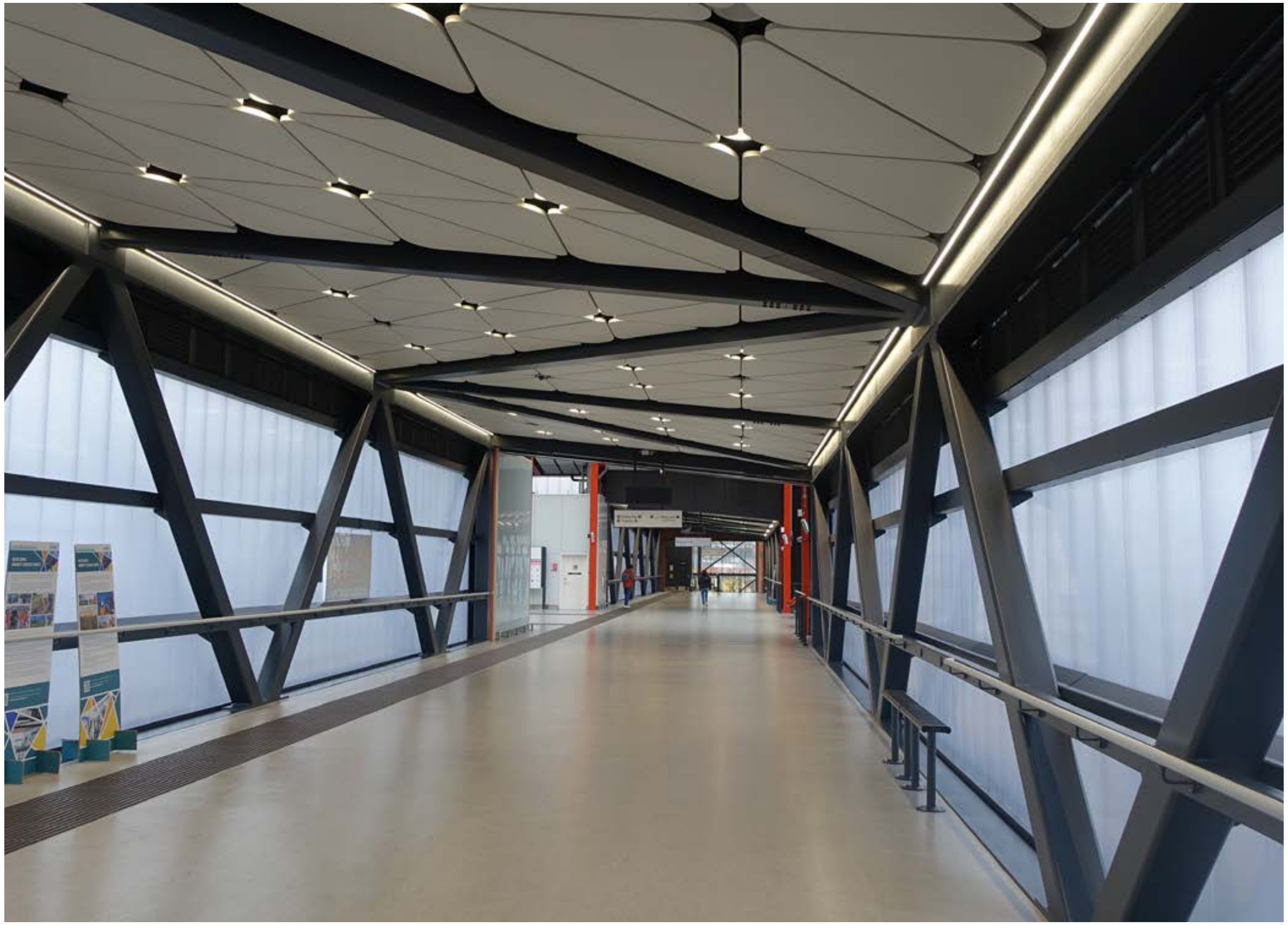


Image 8.23:
Brent Cross Bridge

8.8 Haukeland Station - Underpass

Haukeland Station, part of Bergen Light Rail, is Bergen's first underground station, showcasing innovative underground travel with dual entrances: one through a 40-meter-deep shaft with escalators and lifts, and the other via a staircase leading to a 100-meter-long pedestrian tunnel.

While the lighting approach of the Haukeland Station project is of great interest, the underpass of the project is equally intriguing. The lighting scheme throughout the project has been meticulously crafted to facilitate smooth navigation and to imbue the space with a sense of openness, complementing the architectural elements and materials. Of particular note is the design of the lengthy underpass, which incorporates subtle layers of light to enhance the passenger experience. Uplighting on the golden ceiling creates an illusion of heightened space, transforming the underpass into a serene environment. Additionally, strategically placed downlights provide even illumination and contribute to the overall ambiance while also facilitating safe passage. Linear luminaires accentuate specific vertical surfaces, further elevating the aesthetic by highlighting the accompanying art installations. This comprehensive lighting design not only enriches the architectural and material qualities of the space but also fosters a tranquil atmosphere for travellers.

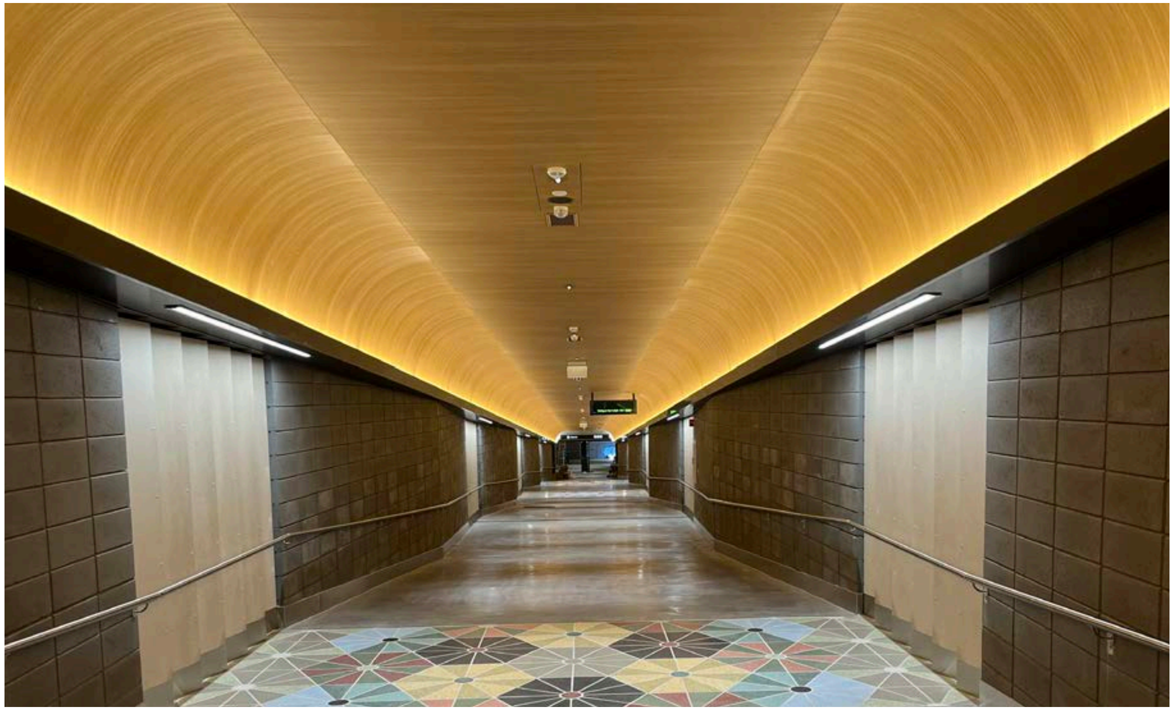


Image 8.24:
Haukeland Station Underpass

8.9 Porteus Road - Underpass

The Porteus Underpass links the Paddington Basin Development with Little Venice. It is a great example of lighting design in an underpass that is simple but combined with a colourful and creative cladding design to provide a safe and welcoming environment for all users. The design of the underpass itself is an art piece. It consists of coloured panels with beautifully designed graphic patterns.

The lighting, following a creative approach, consists of a series of linear luminaires placed at a dynamic angle instead of straight lights. This lighting design distorts the perception of directionality, adding an interesting element to the overall design. At the same time, it provides appropriate lux values for people to navigate and offers uniform lighting that illuminates the entire underpass, enhancing it as a piece of art. The Porteus Underpass exemplifies how innovative graphic design elements and the bold use of colour in public spaces can be supported by simple lighting elements which reinforce the architectural design of the underpass.

Image 8.25:
Porteus Underpass - Orange Tunnel

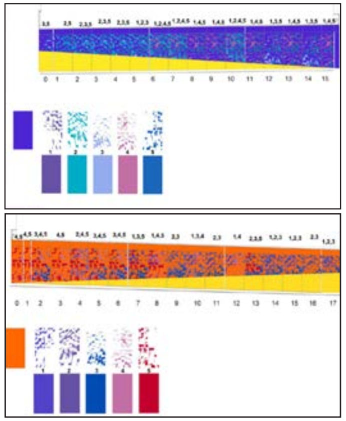


Image 8.26:
Cladding panel design

Image 8.27:
Blue Tunnel Portal

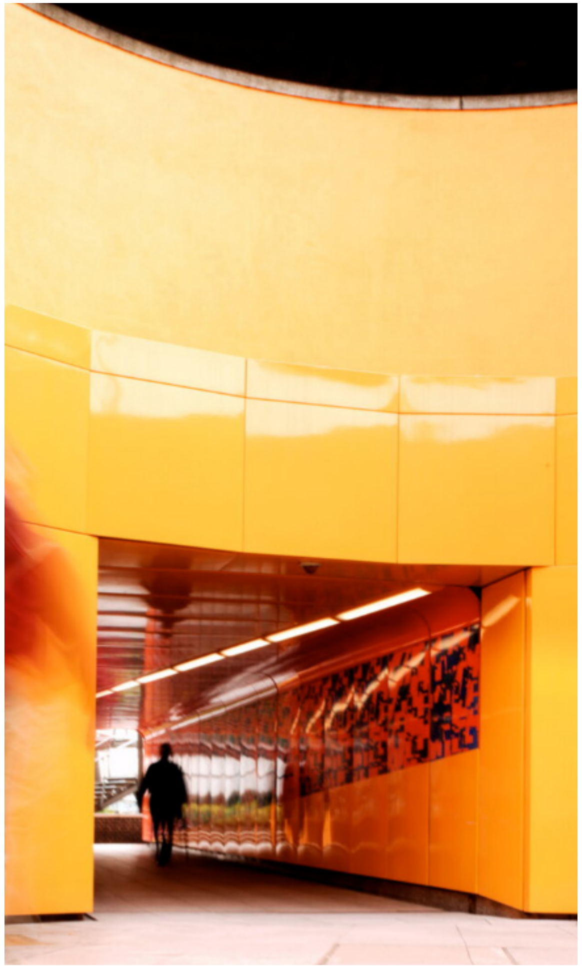


Image 8.28:
Porteus Underpass Yellow Tunnel Portal

8.10 London Bridge - Platforms

London Bridge station stands out as a well-executed contemporary lighting design fully integrated into station canopy design. The arrangement of linear luminaires follows the curves of the platform's ceiling, strategically placed at optimal distances from the platform's edge. This lighting design provides proper illumination for safety and navigation and also adds aesthetic value with its careful placement. In the night scene, the luminaires create an undulating pattern that expresses the form of the canopy following the movement of trains and enhancing the overall ambiance of the station. Furthermore, spotlights positioned at the centre of the platform serve a similar purpose, guiding passengers along their route through the station with more focused illumination.

The lighting design of London Bridge station's platform exemplifies rigorous planning, design and execution. Beyond its practical function of improving passenger safety and ease of movement, it adds a layer of visual intrigue and elegance to this Central London terminus. This integration of functionality and aesthetics underscores the station's commitment to providing passengers with a comfortable and visually pleasing experience.

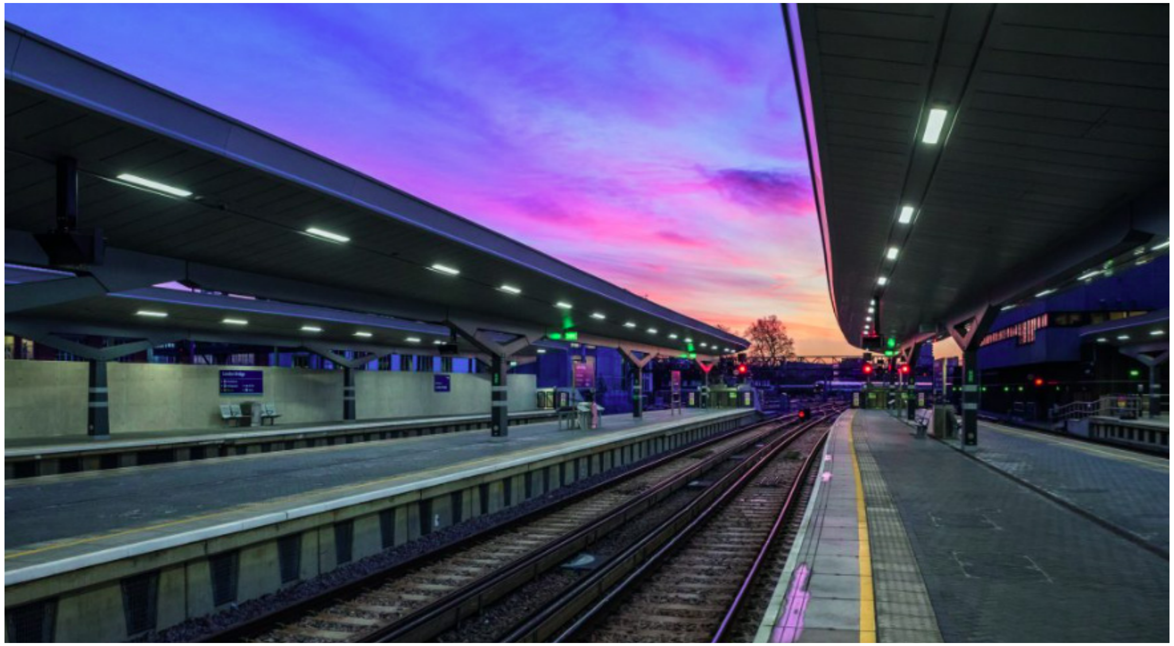


Image 8.29:
London Bridge Station platform

8.11 Birkenhead North - Platforms

Birkenhead North station showcases a wonderful example of canopy lighting on its platform. With its origins tracing back to 1888, the station has a rich history. It's interesting to note how the lighting not only serves its function but also complements the station's architecture.

The placement of the luminaires under the canopy has been carefully considered, providing good levels of illuminance to the area beneath the canopy. This uniform lighting creates a safe environment for passengers, free from harsh shadows. Additionally, the lighting blends well with the canopy design, enhancing both the roof structure and the cast-iron columns now painted in the Merseyrail yellow and grey livery.

Birkenhead North station exemplifies a simple and effective canopy lighting solution that enhances the original architectural features, while also prioritising passenger safety.

Image 8.30: Birkenhead North Station
The colour scheme and the lighting design combine to create an attractive and welcoming platform environment at night.

8.12 Helsingborg Station - Intermodal

Helsingborg Central Station serves as a prime illustration of an aesthetically pleasing lighting solution, which, though not uniformly distributed, still offers adequate illumination for safety and easy navigation. The South Entrance, depicted in the images, emerged after an architectural competition in 2013 hosted by the municipality of Helsingborg. The station's lighting scheme comprises various visual layers, predominantly integrated into its architectural elements.

The primary illumination emanates from the sculptural timber canopy, indirectly lighting the space. The interplay of "organic" lighting patterns on the ceiling adds visual intrigue while enhancing its structural features. The reflective light against the timber ceiling creates a contrasting colour temperature compared to the cooler tones prevalent in the surrounding area.

Remarkably, the station entrance incorporates a bike station beneath, showcasing a design that marries practicality with aesthetics. The reflective ceiling lighting extends to the bike station, supplemented by wall luminaires that enhance visibility and functionality. Furthermore, the lighting scheme accentuates specific elements, such as perimeter structures and seating areas/skylights, seamlessly blending to provide contrast and highlight key features for functional navigation of the station entrance.

Image 8.31:
Helsinborg Central Station South Entrance

Image 8.32:
Helsinborg Central Station South Entrance

8.13 David Oluwale Memorial Bridge, Leeds

The David Oluwale Memorial Bridge in Leeds stands as a remarkable fusion of artistic ingenuity and lighting design, embodying a significant social narrative. Serving in the memory of David Oluwale, its construction imbues it with profound significance. The bridge's structural elegance is enhanced by a creative lighting concept, blending miniature downlights integrated into the handrails with vibrant, edge-lit luminous glass screens decorating its length.

The edge-lit LED panels create a beautiful array of colours, giving the bridge a magical appearance at night. The integrated handrail illumination creates a safe passage for pedestrians, combining functionality with aesthetic appeal. As night descends, the integrated colour changing LED lighting within the glass panels breathes life into the artwork, casting a mesmerizing glow that captivates passersby, transforming a pedestrain river crossing into an immersive sensory experience for all users.

This project seamlessly blends artistry and functional illumination to convey a profound message. It serves as a beacon of remembrance, championing equality and social justice whilst adorning the urban landscape of Leeds with its enchanting beauty.

Image 8.33:
David Oluwale Memorial Bridge

Image 8.34:
David Oluwale Memorial Bridge

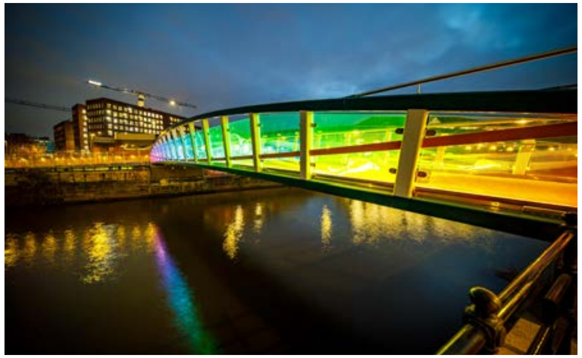


Image 8.35:
David Oluwale Memorial Bridge

8.14 Penn Station - Art Installations

In Penn Station, New York City, the Skyscape project, led by Peter Fajak of SOM, revolutionised underground transit by merging the functional lighting of the concourse with an art installation. Their concept aimed to emulate a digital sky achieved through collaboration with Skanska, Welsbach, and The Light Lab. Spectraglass, an edge-lit glass innovation with embedded RGBW LED lights, formed the backbone of this vision. The result is a calming, ethereal atmosphere, providing relaxation and a safe feeling for commuters amidst the bustling underground.

Studio Miriamandtom's contribution elevated the concourse into an artistic realm. Their animated installation represents drifting clouds and shifting natural light patterns, symbolising tranquillity in a busy underground station environment.

The West End Concourse transcended traditional transit expectations, seamlessly blending technology and artistry to create an immersive, space. Its significance extended beyond aesthetics, offering a tangible link to New York's history while embracing innovative transportation design. It is an innovation project that enriches the commuter experience, combines art with lighting and redefines the essence of underground travel.

Image 8.36:
Skyscape installation in Penn Station concourse, NYC

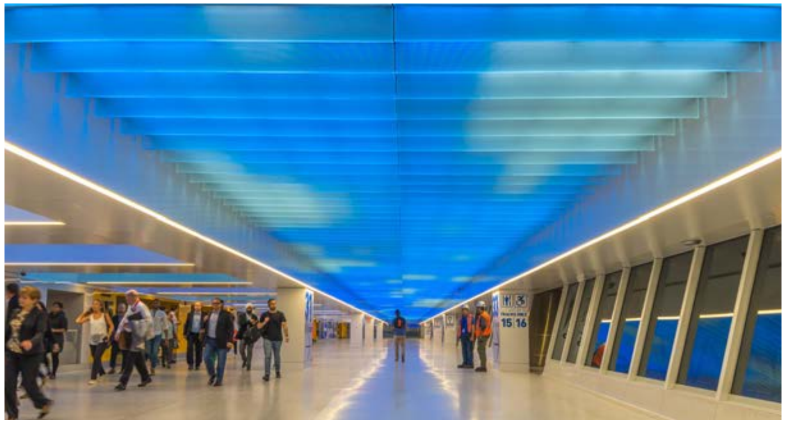


Image 8.37:
Skyscape installation in Penn Station concourse, NYC

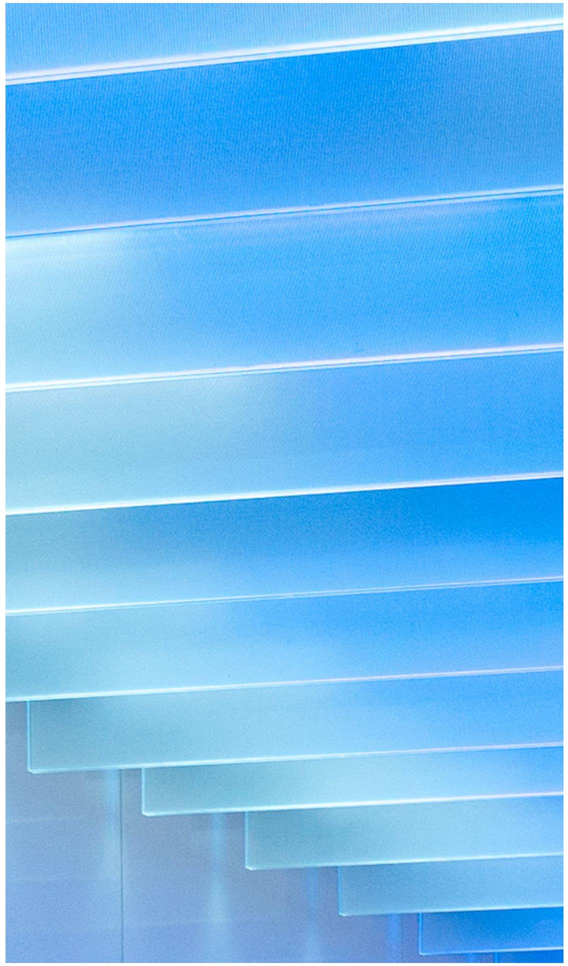


Image 8.38:
Edge-lit glass louvre detail. Penn Station, NYC

Image A.1
Elizabeth Line
Uplighting integrated into the escalator deck creates a sense of elevated space and highlights the GRC cladding panels.

Lighting Design in Stations

Technical Summary and Delivery Guidance

A

In order to deliver a lighting scheme that fulfils all Network Rail technical and aesthetic criteria, you should consider the following aspects whilst preparing a technical design packge for stations :

- → Surface brightness and the homogeneous appearance of luminaire diffusers
- → Glare limitation/Threshold increment (TI) measurement and compliance
- → Control of obtrusive light and light spill into the local environment
- → Consistent vertical illuminance levels
- → Inclusive lighting for visually-impaired users and compliance with the UK Equality Act
- → Defined task areas and calculation grids
- → Electrical performance and lumen per watt efficiency
- → Restricted LED binning (3 Macadam Ellipses)
- → Onsite maintenance and retrofitting capability of specified luminaires
- → Sustainability and embodied carbon report – materials, manufacture, delivery miles and maintenance
- → Complementary direct and indirect sources to achieve compliance (considering architecture, aesthetics and functional requirements)
- → Daylight linked lighting controls
- → Lighting controls, presence/absence detection and automation
- → Cable management and integration

Image A.2:
London Bridge concourse under construction

MPV - Minimum Viable Product

At the outset of each project the definition of Minimum Viable Product should be determined to deliver an appropriate solution for the client and all project stakeholders. As part of the advised whole life cost assessment, sustainability and TM65 manufacturer supplied data for a luminaire includes information that can assist with the correct luminaire selection (see table below). This may also help achieve the correct installation & commissioning in addition to the correct maintenance strategy.

Assuming the luminaire has passed the advised output and efficiency levels validated through lighting design software, the remaining requirements can be summarised as:

- → Detailed TM65 & TM66 data or Product Passport data to validate the embodied and operational carbon of the luminaire
- → Suitable IK and IP rating for the application (see table below)
- → Suitable efficacy and Maintenance Factor for the application
- → Correct commissioning of controls, sensor triggers and daylight harvesting measures
- → Whole Life Cost assessment (over a 30 year design life for the body of the fitting)
- → Sub-Surface - To fully protect against the impact of dust, consistently higher than average ambient temperature, rapid fluctuations in air pressure and fire, it is recommended to use section 12 rated (as detailed in 'The Fire Precautions Sub-surface Railway Stations, England) Regulations 2009')
- → To achieve a 30 year design life, luminaires are preferred to be robust so, Part L lm/W efficacy should be assessed in conjunction with universally open protocol controls, whole life cost and total operational and embodied carbon measurements.

Compliance Assessment Checklist

Station Application Areas / Required for MVP	Full TM65 data available	TM66 Calculation available	IP & IK Recom-mended	Lumen main-tenance @ 25°C ambient ; L70 B10 75,000hrs	Warranty: 10 years -Body 5 years - Electronic gear mini-mum	Modular and repairable/ upgradable on site with supporting case studies	RoHS Compliant	CLO (con-stant lumen output) on board	TI Levels permissible for platforms (see table 3.58 SLL on the following page)	VOC Compatibility test certificate	Salt spray test certificate available from the manufac-turer	CRI (Ra Values) >80	UKCA/CE Certificate available	EMC compliance certification	MVP-PASS/FAIL
Interior concourse/lobby areas			IP65/150J												
Interior circulation areas, cloakrooms, offices			IP65/150J												
Interior lift areas			IP65/150J												
Interior/enclosed platform waiting rooms			IP65/150J												
Interior covered ticket barriers			IP65/150J												
Interior circulation corridors, toilets, offices			IP65/150J												
Exterior covered platforms/rear of platforms			IP65/150J												
Exterior covered stair/ramp			IP65/150J												
Exterior lift areas			IP65/150J												
Exterior covered platforms/waiting areas			IP65/150J												
Ticket barriers (interior covered platforms)			IP65/150J												
Lift areas (interior low level/sub-surface)			IP65/150J												
Stairs/Escalators (low level/subway)			IP65/150J												
Circulation corridors, toilets and offices			IP65/150J												
Platforms and waiting areas			IP65/150J												
(SECTION 12* IK08/IP54)			IP65/150J												

Key:

- No Variations permitted
- Variations permitted subject to approved risk analysis and mitigation
- To be used unless alternative solution are allowed

Luminaire Minimum Viable product Selector

Against each application to be specified into, mark '1' in the box for those documents or certificates that are available for the luminaire to be specified . Under Network Rail guidelines, red categories are compulsory requirements for that application. Check that the manufacturer provides the relevant data in UK approved format. For those documents not available under an amber or green category, apply to the sponsor or DPE for sign off of a non-compliant luminaire.

→ Please see British Standards reference section at the end of this document.

→ 30% degradation over 30 years @ 8hrs day use.

→ For all classified Sub-surface applications, luminaires should comply with the 'The Fire Precautions (Sub-surface Railway Stations) Regulations 1989', commonly referred to as 'Section 12'.

→ Sub-surface/Section-12 applications (subways, lift areas, stairs, escalators, corridors, vent shafts, evacuation routes etc.)

→ *Appropriate minimum IP and IK ratings for each application area to be determined by the project designers and asset management team according to specific project requirements".

Threshold Increment Measurement Table

Ref	Type of task/activity area	Em (lux)		U_o	R_a	R_{UGL}	$E_{m,z}$ (lux)	$E_{m,wall}$ (lux)	$E_{m,ceiling}$ (lux)	Specific Requirements
		Requires	Modified				$U_o \geq 0.10$			
3.58.1	Fully enclosed platforms:									
	-small number of passengers	50	-	0.30	80	-	-	-	-	Special attention to the edge of the platforms, see also note 1 . Avoid glare for vehicle drivers and passengers, see also notes 2 and 3. Illuminance at floor level in reflectance area.
	-medium number of passengers	100	-	0.40	80	-	-	-	-	As above.
	-large number of passengers	200	-	0.50	80	-	-	-	-	As above.
3.58.2	Fully enclosed passenger subways (underpasses)									
	-small number of passengers	50	-	0.30	80	-	-	-	-	Avoid glare for passengers, see also note 3. Illuminance at floor level in reference area. In case of highly reflecting enclosure surfaces the average illuminance level can be reduced by 50%.
	-medium number of passengers	100	-	0.40	80	-	-	-		As above.
	-large number of passengers	200								As above.
3.58.3	Stairs, escalators									
	-small number of passengers	50	-	0.30	80	-	-	-	-	Avoid glare for passengers, see also note 3. Special attention to landings.
	-medium number of passengers	100	-	0.40	80	-	-	-	-	Avoid glare for passengers, see also note 3. Special attention to landings.
	-large number of passengers	200	-	0.50	80	-	-	-	-	Avoid glare for passengers, see also note 3. Special attention to landings.
5.53.4	Ticket hall and concourse	200	300	0.50	80	28	75	75	50	Illuminance at floor level in reference area.
3.58.5	Ticket counters and luggage offices	300	500	0.50	80	19	100	100	75	Illuminance in task areas.
3.58.6	Waiting rooms	200	300	0.40	80	22	75	75	30	

SLL Table: Threshold Increment Measurement Table (Exterior Glare)

Notes

1.

Platform edge: An average illuminance in a strip of 1 m width along the platform edge not less than 50% of average platform illuminance provides appropriate visual conditions along the platform edge.

2.

Limitation of glare for train drivers: For relevant positions and viewing directions a threshold increment not exceeding 15% based on adaptation luminance of 10% of average platform luminance avoids glare for train drivers (for circulation methods BS EN 13201-3:2015)

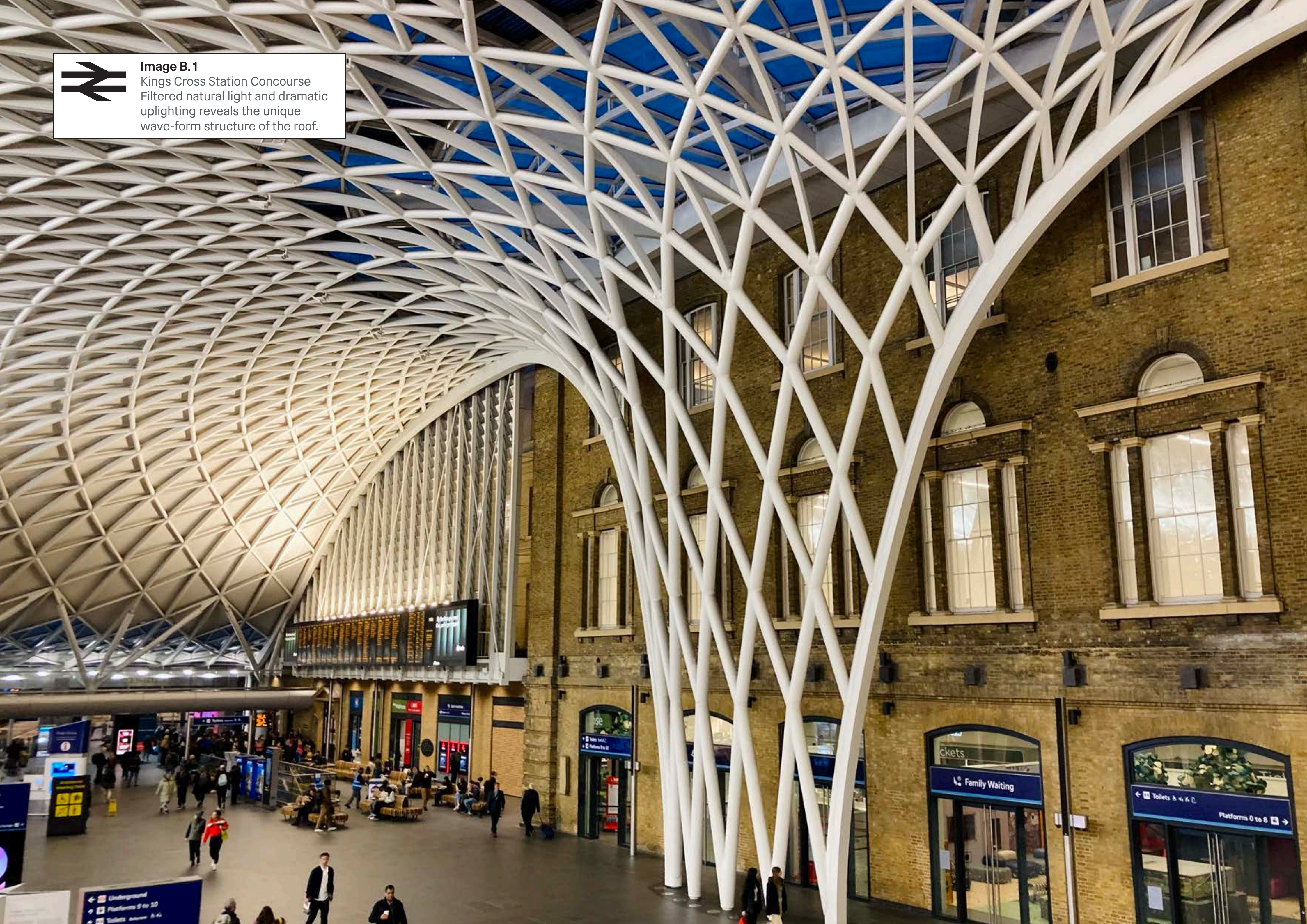


Image B.1
Kings Cross Station Concourse
Filtered natural light and dramatic uplighting reveals the unique wave-form structure of the roof.

B

Lighting Design in Stations

Glossary

Glossary

Accent lighting: focused lighting to emphasize a particular object or to draw attention to an area in the field of vision.

Adaptation: process by which the state of the visual system is modified by previous and present exposure to stimuli that can have various luminance values, spectral distributions and angles.

Brightness: Attribute of a visual sensation according to which an area appears to emit more or less light.

Candela: is the unit of luminous intensity in the International System of Units (SI). It measures luminous power per unit solid angle emitted by a light source in a particular direction.

Chromaticity: Property of a colour stimulus defined by its chromaticity coordinates, or by its dominant or complementary wavelength and purity taken together.

Colour Rendering Index: measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant.

Contrast: (perceived contrast) assessment of the difference in appearance of two or more parts of a field seen simultaneously or successively. EXAMPLE Brightness contrast, lightness contrast, colour contrast, simultaneous contrast, successive contrast

Correlated Colour Temperature (CCT): It defines the colour of the light source, how warm or cool white the light appears. It is expressed in Kelvin (K).

Daylight sensors: is a photocell detecting device that reads available light in a space and sends a signal to the control system.

Dichroic: is a type of optical filter that selectively transmits or reflects light based on its wavelength (color).

Directional lighting: lighting in which the light on the working plane or on an object is incident predominantly from a particular direction.

Disability glare: glare that impairs the vision of objects without necessarily causing discomfort.

Discomfort glare: glare that causes discomfort without necessarily impairing the vision of objects.

Diffuse light: is soft and gentle, lacking directionality and it spreads evenly in all directions from the illuminated surface.

Diffuse reflection: scattering by reflection in which, on the macroscopic scale, there is no regular or specular reflection.

Diffuser: device predominantly using scattering to alter the spatial distribution of radiation from a source.

Dynamic lighting: refers to a lighting system that can change in colour, intensity, or direction over time.

Emergency lighting: lighting provided for use when the power supply to the normal electric lighting fails.

Flicker: perception of visual unsteadiness induced by a light stimulus the luminance or spectral distribution of which fluctuates with time, for a static observer in a static environment

Glossary

Functional illumination: the advised illumination needed for activities in a space. It prioritizes practicality and functionality over aesthetic consideration.

General lighting: overall illumination to a space

Glare: condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution or range of luminance, or by extreme luminance contrasts

Glare control accessories: tools or attachments used to minimize or eliminate glare from lighting fixtures. They help improve visual comfort by reducing the harshness or discomfort caused by excessive brightness or direct light.

Halogen lamp: is an incandescent lamp consisting of a tungsten filament sealed in a compact transparent envelope that is filled with a mixture of an inert gas and a small amount of a halogen, such as iodine or bromine.

Horizontal illuminance: illuminance on a horizontal plane.

Illuminance: the amount of light that falls onto a surface per unit area, measured in lux (lx). It indicates the brightness or light intensity experienced at a specific point, typically on a horizontal surface, and is influenced by factors such as the distance from the light source and the angle of incidence.

Impact Resistance Rating (IK) measures the level of protection provided by an enclosure against mechanical impact, such as from objects or physical shocks.

Incident light: light that strikes a surface.

Indirect lighting: when light is directed upwards towards the ceiling or walls, creating a softer, more diffused illumination that reflects into the space.

Ingress Protection (IP) ratings classify the level of protection against solid objects and moisture for electronic devices and enclosures.

Integrated lighting: fixtures or systems that are designed to be seamlessly incorporated into architectural elements or furniture.

LED: a light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it.

Lenses: optical components used in lighting fixtures to control the distribution and direction of light. They come in various shapes and materials and can modify the beam angle, focus, or diffusion of light to achieve desired lighting effects and minimize glare.

Light pollution: Sum total of all adverse effects of artificial light. refers to the existence of undesired, unsuitable, or excessive artificial illumination. It includes the effects of poorly designed lighting, whether it’s day or night.

Light spill: Unintentional or excessive spreading of light beyond its intended target area

Glossary

Lighting controls: Tools that enable users to manage lighting fixtures, offering adjustments in brightness, colour, timing, and energy consumption. They range from basic switches and dimmers to advanced technologies like sensors and smart home systems.

Light distribution: Refers to how light spreads from a luminaire, affecting its coverage and intensity in an area. It determines the pattern and uniformity of illumination.

Lighting focusing involves directing light from a fixture to a specific area or object, adjusting its intensity and angle to highlight or accentuate particular features within a space.

Lighting installations: (when not referring to lighting art) involve arranging and setting up luminaires within a space to achieve desired illumination effects.

Luminance: It describes the amount of light that passes through, is emitted from, or is reflected from a particular area, and falls within a given solid angle.

Luminous Intensity: the measure of the amount of visible light emitted from a source in a particular direction, typically measured in candelas (cd). It quantifies how bright a light source appears from a specific viewing angle.

Lux: (symbol: lx) is the unit of illuminance, or luminous flux per unit area, in the International System of Units (SI). It is equal to one lumen per square metre. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface.

Lumens: is the unit of luminous flux, a measure of the perceived power of visible light emitted by a source, in the International System of Units (SI)

PIR (Passive Infra-Red) detection: is a technology used in motion sensors to detect movement within a specified area. It operates based on the detection of infrared radiation emitted by objects within its field of view.

Photocell: also known as a photoresistor or light-dependent resistor (LDR), is a sensor that detects the presence or absence of light. It works by changing its electrical resistance based on the intensity of light falling on it.

Rated life: is an estimate of how long the bulb is expected to last under normal operating conditions. It's usually provided by the manufacturer and is typically expressed in hours.

Reflectance: the ability of a surface to reflect light according to its materiality, indicating the proportion of light that is bounced back from the surface when it is illuminated.

Reflectance factor: is a measure of the ratio of reflected light to incident light falling on a surface. It quantifies the efficiency with which a surface reflects light across the visible spectrum.

Reflectors: are tools used to redirect and enhance the distribution of light, commonly made of materials like metal, plastic, or fabric.

Glossary

Recessed lighting: luminaires installed into openings in ceilings or walls, with the light source set back into the surface to create a seamless and unobtrusive appearance.

Smart lighting systems: automated lighting setups that can be controlled remotely or programmed to adjust brightness, colour, timing and more according to preferences or conditions.

Specular reflection: glossy or polished reflection of light off a smooth surface, where the angle of incidence equals the angle of reflection commonly seen on polished surfaces like mirrors or glass.

Task lighting: focused illumination to provide optimal visibility for specific activities or tasks.

Uplighting: lighting technique where fixtures are positioned to shine light upwards, typically towards ceilings, walls, or architectural features.

Uniformity or uniform illumination: even distribution of light across a given area, providing consistent brightness levels without significant variations or hotspots.

Veiling reflections: reflections of light on surfaces, often causing a reduction in contrast and visual clarity.

Visual comfort: is the feeling of ease and lack of strain when seeing things in a space under certain lighting conditions. It involves factors like reducing glare and using the right amount of light.

Visual tasks: activities that require visual perception and interpretation, such as reading, writing, or any other task that relies on seeing and understanding visual information.

Wall-washing: lighting technique where light is evenly spread or directed across a wall or a vertical surface.

Watt (symbol: W): is the unit of power or radiant flux in the International System of Units (SI). It is used to quantify the rate of energy transfer.

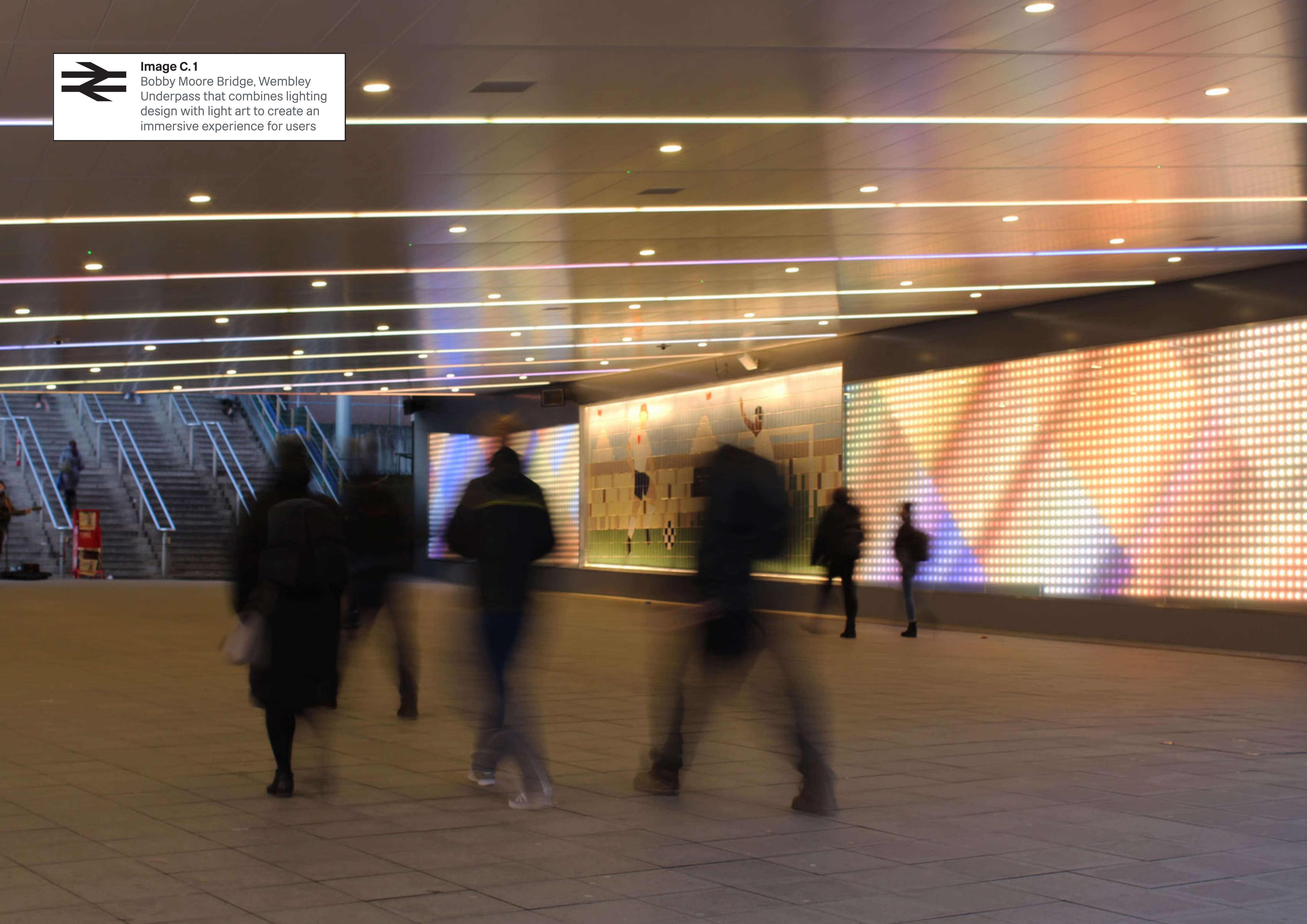


Image C.1
Bobby Moore Bridge, Wembley
Underpass that combines lighting design with light art to create an immersive experience for users

C

Lighting Design in Stations

Reference Documents

Reference Documents

A wide range of Network Rail and industry-wide documents and guidance notes were used in compiling the Lighting Design In Stations manual.

These documents are drawn from a range of sources which have been used whilst developing this design guidance.

Rail Standards and Guidance documents:

- DfT Design Standards for Accessible Railway Stations - Code of Practice (2013)
- DfT National Technical Specification Notice: Persons with Reduced Mobility (NTSN - PRM) (2021)
- RIS – 7702-INS Issue 1 Lighting (2013)
- RIS-7700-INS Issue 2 Rail Industry Standard for Station Infrastructure (Withdrawn 02/06/2018)
- Railway Group Standard GI/RT7016 “Interface between Station Platforms, Track and Trains” Issue 2 - December 2007

Relevant Network Rail Design Guidance:

- Station Design NR/GN/CIV/100/02
- Public Realm Design at Stations NR/GN/CIV/200/10
- Station Design Guidance - Design Manual NR/GN/CIV/100/02
- Heritage: Care and Development - Design Manual NR/GN/CIV/100/05
- Masterplanning at Stations - Design Manual NR/GN/CIV/100/07
- Design Manual for Medium to Small Stations - Design Manual NR/GN/CIV/200/02
- Vertical Circulation - Design Manual NR/GN/CIV/200/05
- Public Realm Design Guidance for Stations - Design Guidelines NR/GN/CIV/200/10
- Wayfinding Design Manual - NR/GN/CIV/300/01
- Inclusive Design NR/GN/CIV/300/04

British, European and International Standards

- BS EN 12464 - Part 1: Light and lighting. Lighting of work places — Indoor work places
- BS EN 12464 - Part 2: Light and lighting. Lighting of work places — Outdoor work places
- BS 5489 - Part 1: Design of road lighting — Lighting of roads and public amenity areas
- BS 5266 - Part 1: Emergency lighting - Code of practice for the emergency lighting of premises
- BS 8300 - Part 2: “Design of an accessible and inclusive built environment - Buildings. Code of practice” Part 1: External Environment / Part 2: Internal Environment
- BS EN 12665: Light and lighting. Basic terms and criteria for specifying lighting requirements
- BS EN 17037 + Amendment A1: Daylight in buildings
- BS EN 62722-2-1: Luminaire performance — Particular requirements for LED luminaires
- BS EN 60529 + Addendum A2: Degrees of protection provided by enclosures (IP Code)
- BS EN 62262 + Addendum A1: Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
- BS 667: Illuminance meters. Requirements and test methods

Reference Documents

Good Practice Lighting Design Guidance

Society of Light & Lighting

- → "Code for Lighting" (2022)
- → "The Lighting Handbook" (2018)
- → Lighting Guide 10: "Daylighting — a guide for designers "(2014)
- → Lighting Guide 12: "Emergency lighting" (2022)
- → Lighting Guide 15: "Transport buildings" (2017)

Institution of Lighting Professionals (ILP)

- → GN08-23: Bats and Artificial Lighting (2023)
- → GN01-21: Guidance Note 1 for the reduction of obtrusive light (2021)
- → PLG03: Lighting for subsidiary roads (2012)
- → PLG08: Guidance on the application of adaptive lighting within the public realm (2016)

Designplan Lighting Ltd.

- → Rail Lighting "Provincial, Suburban, Feeder and Minor Stations (Cat B,C,D,E,F)

Alternative and Emerging Colour Quality Metrics

- → ANSI/IES TM-30-20+E1
  Method for Evaluating Light Source Color Rendition (2020)
- → CIE 224:2017: Colour Fidelity Index for Accurate Scientific Use (2017).
- → Color Quality Scale (CQS)
  (US) National Institute for Standards and Technology (in progress)

Further Reading

- → Daylighting: Architecture and Lighting Design Paperback - Peter Tregenza, Michael Wilson
- → The Design of Lighting - Peter Tregenza
- → Learning to See: A Matter of Light Hardcover - Howard M. Brandston
- → Lighting as an Integral Part of Architecture - Richard Kelly
- → Eye and Brain: The Psychology of Seeing - Richard Gregory

D

Lighting Design in Stations

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Image D.1
Seville Santa Justa Station: Filtered natural light from vaulted canopy structure. The amount of light ingress varies, reinforcing the sense of sequential spaces.

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