Design Manual
NR/GN/CIV/200/01

NetworkRail

Materials & Components

Document verification

Verification

Anthony Dewar
Professional Head, Buildings & Architecture Technical Authority

Frank Anatole
Principal Architect, Buildings & Architecture Technical Authority

Standard Change Lead

Boaz Yariv
Senior Architect, Buildings & Architecture Technical Authority

Revision Information

Version: 1.0
Date issued: September 2024

Description of changes

First Version

Disclaimer

How to use the guidance suite

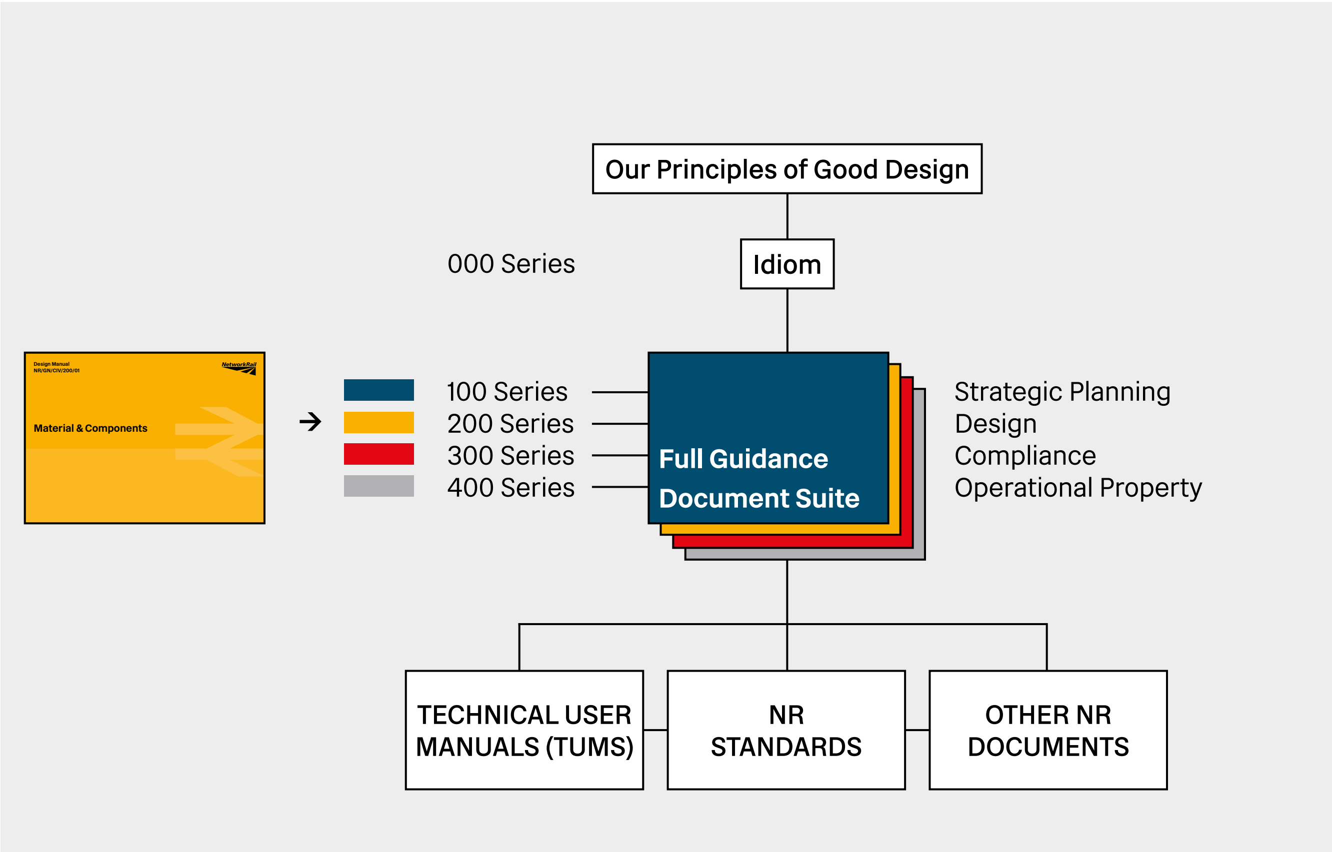


Figure 0.1 Network Rail Document Suite Summary

References to other documents

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

Example

Standards Reference

Network Rail Environmental
Sustainability Strategy
NR/L2/ENV/015

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

About this document

The Network Rail Design Guidance for Materials and Components presents general advice and recommendations on the selection and specification of materials, finishes and component elements for the built environment across Network Rail Stations and operational property estate.

The intended audience for this manual are designers, project teams, project sponsors, station facility managers and others involved in design and delivery of built environment assets for Network Rail.

The manual is divided into five sections:

1

Section 1
Guiding Principles

Outlines the purpose and scope of the document and key themes and topics to consider when specifying materials for transport environments.

2

Section 2
Materials & Finishes

Provides reference examples of typical materials, along with uses, finishes, and sizes, as well as product references.

3

Section 3
Components & Fixtures

Provides reference examples of typical components, along with uses, finishes, and sizes.

4

Section 4
Maintenance

Sets out key principles for the maintenance, renewal, and replacement of material and component installations.

5

Section 5
Sustainability

Provides an overview of sustainable material measures and outlines core sustainable design priorities.

A

Appendices
Appendix A-D

Supporting information and tools including a material selection toolkit, case studies, and reference documents.

Contents

Section 1: Guiding Principles Page

1.1	Purpose and Scope of the Document	10
1.2	History of Materials	11
1.3	The Psychology of Materials	12
1.4	Material Sample Boards	13
1.5	Guiding Principles of Material Selection	14
1.6	Sustainability	16
1.7	Hazardous Materials	18
1.8	Floors	20
1.9	Walls	30
1.10	Ceilings, Soffits and Roofs	39

Section 2: Materials & Finishes Page

2.1	How to read this section - Materials	46
2.2	Timber	47
2.3	Brick	65
2.4	Stone	70
2.5	Ceramics	82
2.6	Concrete & Render	87
2.7	Metals	99
2.8	Glass	111
2.9	Composites	120
2.10	Flat Roofing Materials	125
2.11	Applied Finishes	131

Section 3: Components & Fixtures Page

3.1	How to read this section - Components	134
3.2	Platform	135
3.3	Shelters & Canopies	136
3.4	Seating	137
3.5	Doors, Shutters & Gates	139
3.6	Barriers	141
3.7	Handrails	143
3.8	Fencing	144
3.9	Cycle facilities	146
3.10	Help and Information points	147
3.11	Water Fountains	148
3.12	Bins	149
3.13	Services & Containment	150

Section 4: Maintenance Page

4.1	Surveys, Preparation and Setting Out	153
4.2	Workmanship	154
4.3	Renewal and Replacement	155
4.4	Design Life	156

Section 5: Sustainability 160

5.1	Sustainability Strategy	161
5.2	Circularity	162
5.3	Carbon	164
5.4	Assessment and Measures	167

Appendix A: Standards and References Page

Design Guidance Notes for Composites	170
Glossary	172
Reference Documents	173

Appendix B: Material selection toolkit Page

Material Toolkit Definitions	178
Materials Selection Toolkit - Walls	179
Materials Selection Toolkit - Floors	185
Materials Selection Toolkit - Ceilings	188
Materials Selection Toolkit - Roofs	192

Appendix C: Case studies Page

Case Studies Introduction	196
Waterloo	197
Paddington	198
Hackney Wick	199

Appendix D: Acknowledgements Page

Acknowledgements	201

Hint and tips
To quickly navigate this document click on any of the sections or titles on this page.

To return to the contents page you can click on the Double Arrow symbol.

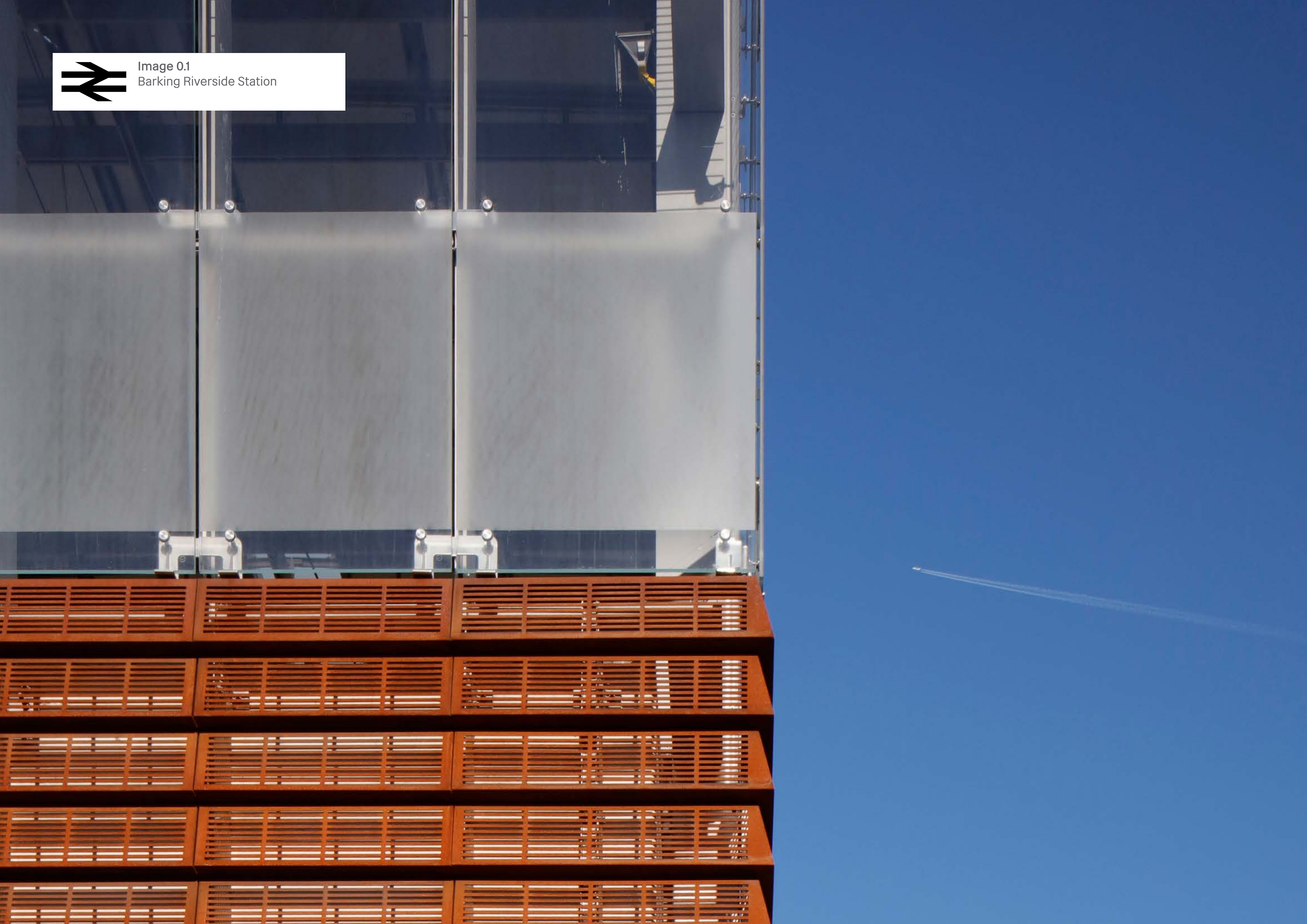


Image 0.1
Barking Riverside Station

Materials & Components

Section 1: Guiding Principles

1

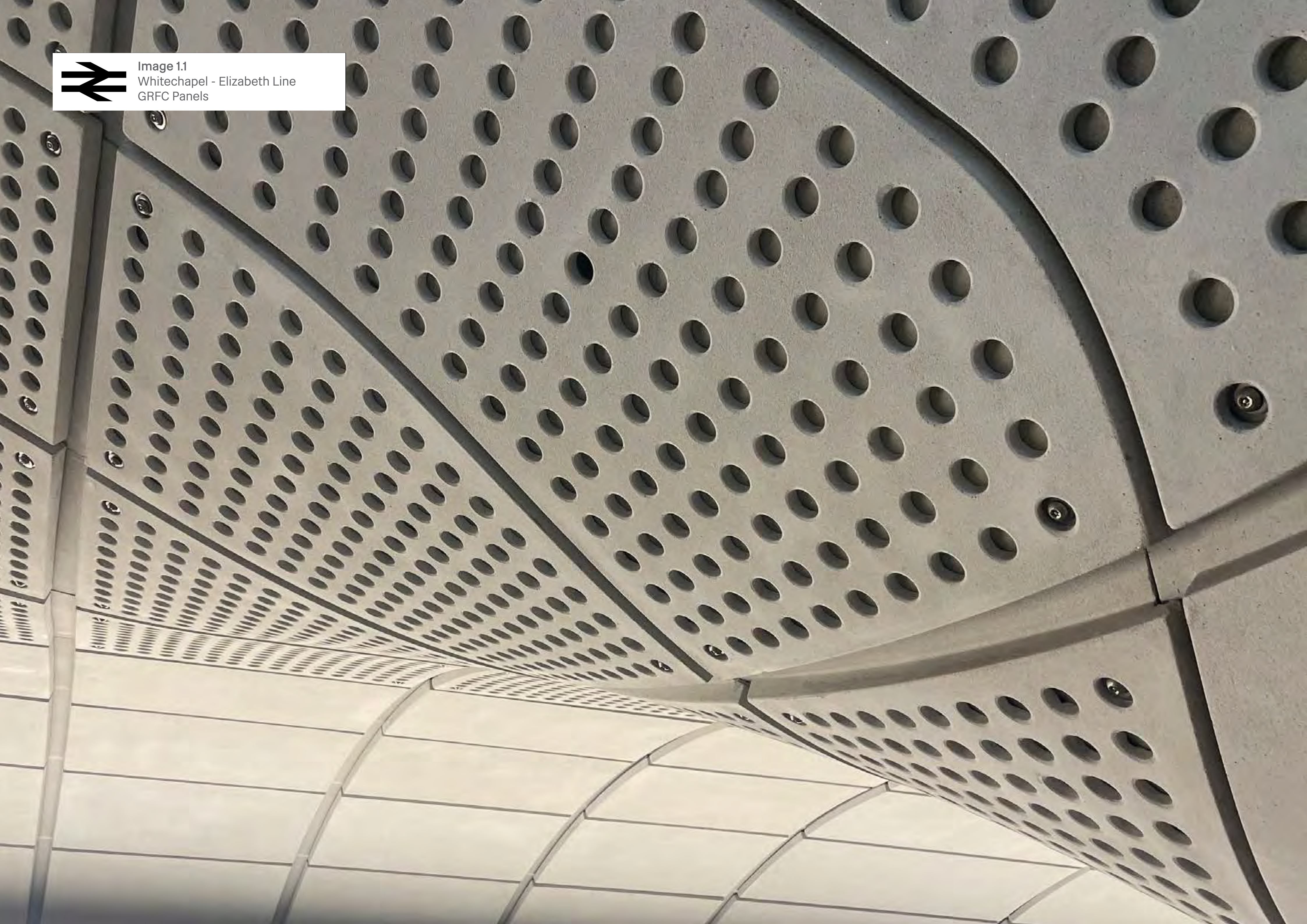


Image 1.1
Whitechapel - Elizabeth Line
GRFC Panels

1.1 Purpose and Scope of the Document

1.1.1 Purpose

The Network Rail Design Guidance for Materials and Components presents general advice and recommendations on the selection and specification of materials, finishes, and component elements of the built environment across Network Rail stations and operational property estate.

There is greater potential for innovation in material and component selection than almost any other element of building design. The purpose of this guidance is to aid those involved in designing or delivering stations in their early material considerations.

1.1.2 Scope

This manual serves as a reference for the use of materials at any stage of the passenger journey. It is intended for designers, project teams, project sponsors, station facility managers, and others involved in the design and delivery of built environment assets for Network Rail.

The guidance offers a high-level overview of construction materials and their typical applications, such as in floors, walls, ceilings, soffits, and roofs. It provides a general reference on the qualities of various materials and their common uses. The guidance does not include the detailed specifications or instructions typically provided by the relevant standards or product manufacturers, as these can vary significantly and should be consulted separately.

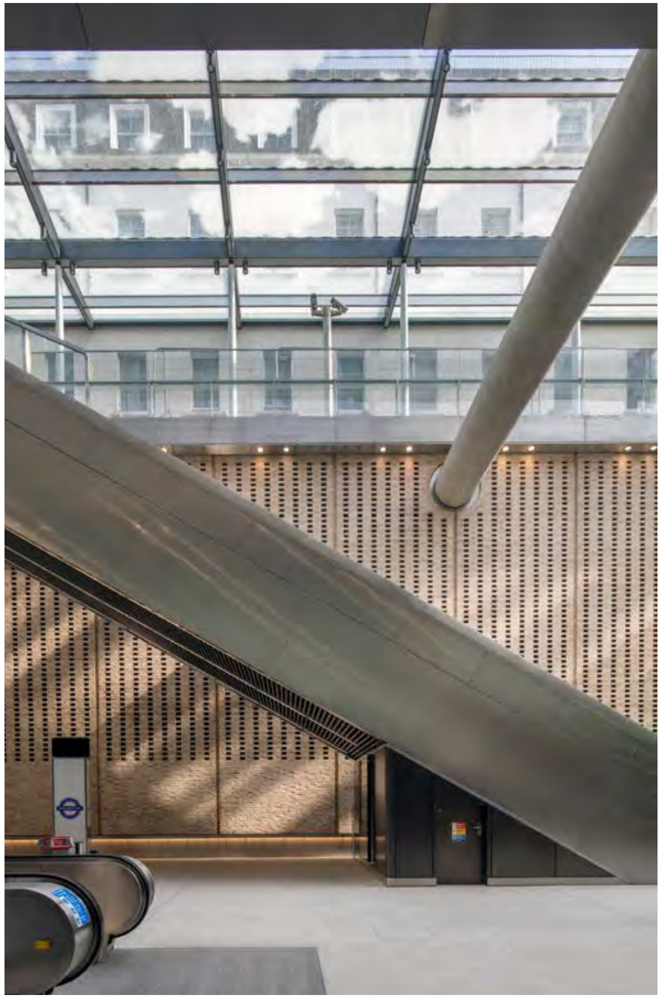


Image 1.2 Paddington Elizabeth Line station concourse

1.2 History of Materials

From the steam-powered beginnings of the Industrial Revolution to the sleek and modern designs of today, each station carries with it a unique connection to the local context, engineering prowess, and links to the past.

Material choices were historically not merely utilitarian decisions, but a reflection of the prevailing architectural styles, societal values, and technological advancements of each era. From the opulent Victorian stations, adorned with ornate ironwork and lavish stonework, to the Art Deco gems of the early 20th century, characterised by streamlined façades and geometric motifs, the evolution of stations mirrors the ever-changing landscape of architectural trends.

Having been built across many different time periods and locations, stations strive for a balance between local solutions and common elements shared across stations.

With the aim to enhance user experience across the Network Rail assets, incremental improvements to materials are always sought. Understanding both the practicality and aesthetic values of materials and balancing them with environmental concerns is important for all public facing projects, and is encouraged throughout this document.

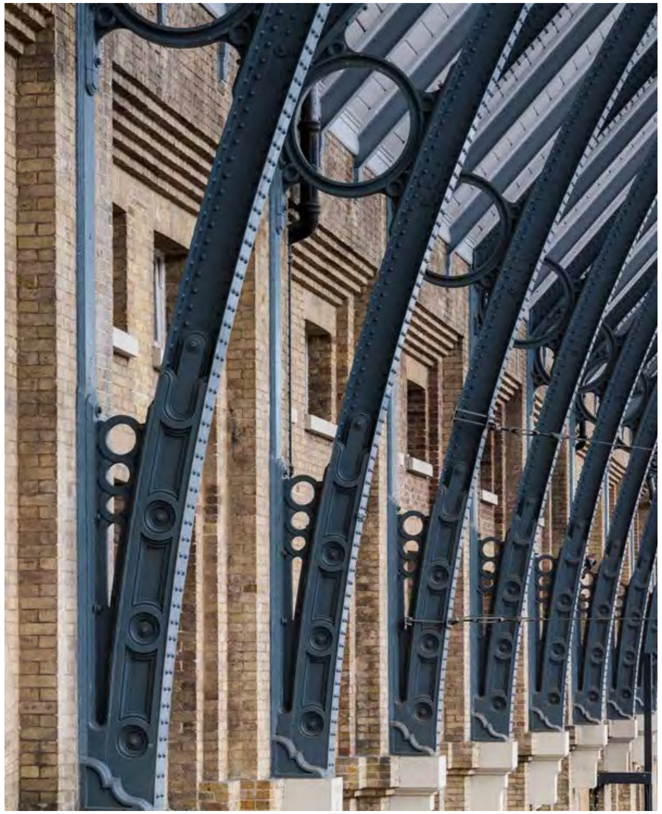


Image 1.3 Kings Cross Station - Historic Train Shed Structure

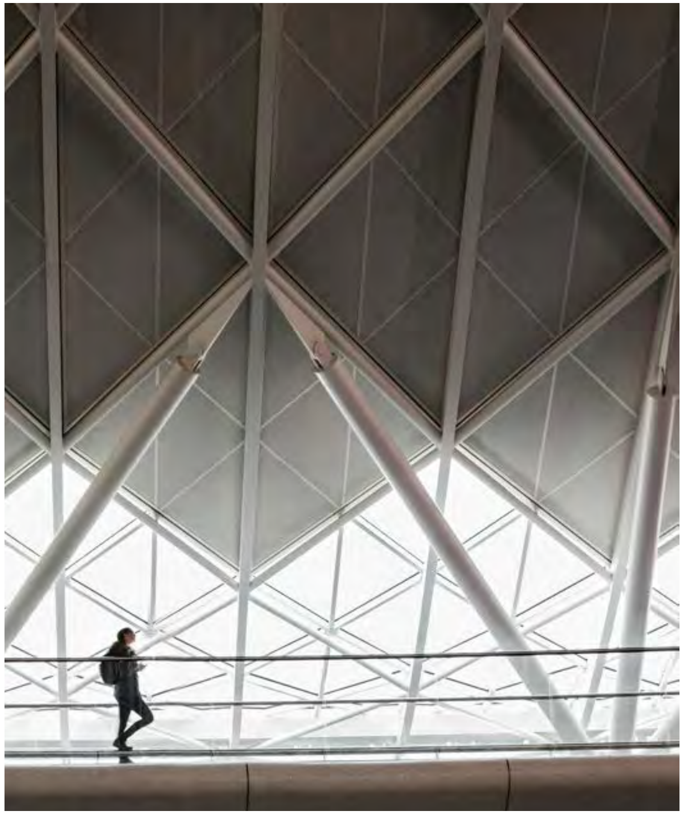


Image 1.4 Kings Cross Station- 2012 Extended Concourse

1.3 The Psychology of Materials

1.3.1 How materials affects users

Many studies have shown how materials, colours, textures and finishes have the ability to shape our moods, carrying simple meanings. As elements of our environment that we see, touch and sometimes smell and hear, they evoke memories, stimulate senses, and generate conceptions about place, quality, value and security.

We are siginificantly influenced by our senses, brands and companies leverage this by employing the highest quality materials and finishes for a reason - they are making an implicit statement about their trustworthiness, values, and commitment to providing the best quality for staff and clients.

To be reassuring, details that anchor walls and columns to the ground are often constructed of heavy masonry or stone. To provide cover without being oppressive, finely worked steel members span the building's height, with transparent glass providing glimpses of the sky as well as the joy of light.

To provide comfort, wood, one of the most biophillic materials, provides warmth and familiarity - a recognisable and reassuring tactile surface that comes closest to the objects that the passenger touches (walls, doors, handrails, floors, seating) as they negotiate an unfamiliar space.

1.3.2 Enhancing the user experience

Great care should be taken in both the selection and placement of materials and finishes in any station environment. Factors such as the performance and durability of the material should be foremost in the designer's mind, together with consideration of maintenance and sustainability. It is not enough to calculate the capital cost. A material's carbon footprint over its anticipated design life should also be a key factor in its specification.

Beyond questions of durability and cost, materials have the ability to enhance the user experience and station environment. Materials can be brought to life by light, which is refracted or absorbed depending on finish. Selection can also be a qualitative decision based on the requirement to create an attractive, warm, and colourful backdrop, or the requirement to pay due respect to the architectural and engineering heritage.

NR Guidance Suite Reference

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

Standards Reference

Network Rail Environmental Sustainability Strategy
NR/L2/ENV/015

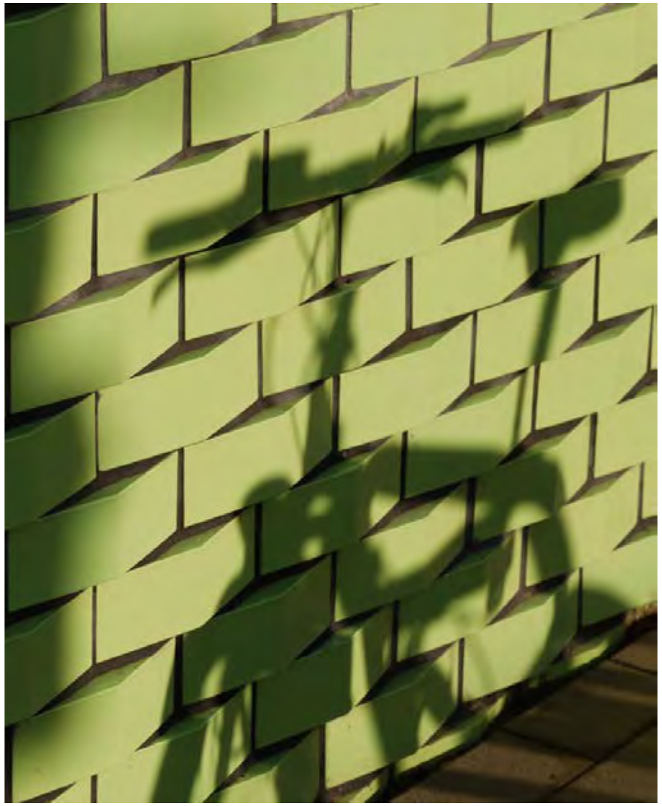


Image 1.5 West Hampstead Thameslink Station - Feature Wall

National Standard

Design for the mind. Neurodiversity and the built environment. Guide
PAS 6463

1.4 Material Sample Boards

Material sample boards play an important role in construction as they serve as tangible representations of the materials which are proposed. These boards offer a preview of textures, colours, and finishes, allowing stakeholders to make informed decisions before the actual construction begins.

They can serve as a common reference point during discussions, so that everyone has a clear vision of the chosen materials. This proactive approach minimises the risk of errors or changes during the construction phase, ultimately saving time and resources.

One significant advantage of material sample boards is that they provide a hands-on experience, allowing architects, designers, and clients to physically interact with the materials. This tactile engagement enhances the understanding of how different elements may come together in the final scheme. It helps in avoiding misunderstandings and assists stakeholders to be on the same page regarding the aesthetic and functional aspects of the project.

External and internal material sample boards should be included in design information and presentations to help in demonstrating the design intent of any proposals. They should also be included in Form A and D packages for early sign-off.

Image 1.6 Example Material Samples Board

Image 1.7 Woolwich Elizabeth Line Facade Material

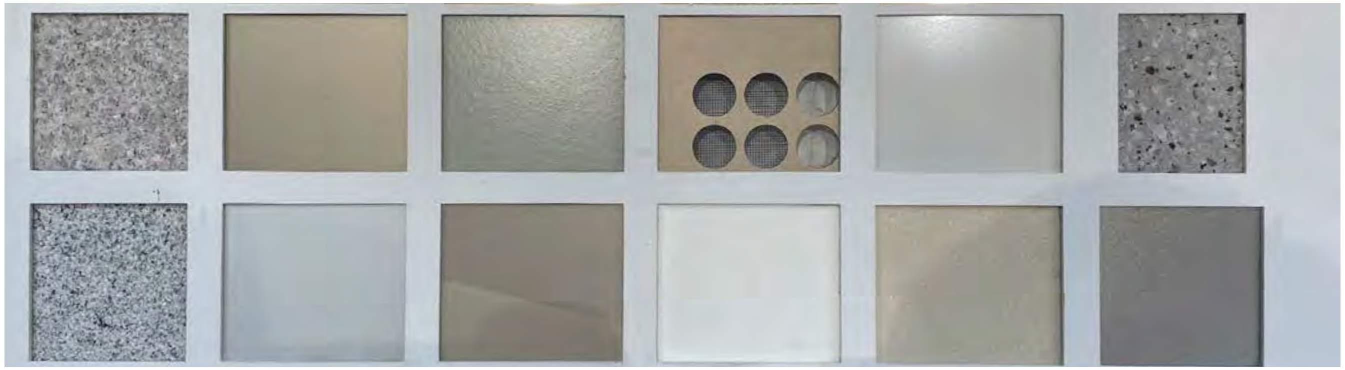


Image 1.8 Paddington Elizabeth Line - Samples Board

1.5 Guiding Principles of Material Selection

Golden Threads			
Decarbonisation and Environmental Sustainability	**Inclusion and Accessibility**	**Security and Safety**	**Maintenance and durability of materials**
• **Carbon Efficiency:** Prioritise materials with low lifecycle carbon footprints, assessing emissions from extraction to disposal for comprehensive decarbonisation. • **Recycled and Renewable Focus:** Opt for materials with high recycled and renewable content, adhering to circular economy principles. • **Efficiency and Durability:** Choose materials with long-term durability to minimise maintenance, aligning with sustainable asset management principles. • **Innovation in Sustainability**: Stay informed on sustainable materials and technologies. • **Climate-Resilient Selection:** Consider climate change impacts on material performance, selecting resilient materials for infrastructure robustness, in line with sustainability and climate resilience goals.	• **Universal Design Principles:** Choose materials that allow accessibility for all passengers including those with diverse abilities and requirements • **Tactile and Visual Contrast:** Where required, select materials with clear tactile and visual contrast to assist passengers with visual impairments, enhancing wayfinding and safety. • **Ease of Navigation:** Opt for materials that facilitate easy navigation for passengers with mobility needs, allowing seamless movement throughout railway stations. • **User-Centric Engagement:** Engage diverse user groups in the material selection process, gathering feedback to enhance inclusivity and address specific needs. • **Compliance with Accessibility Standards:** Check selected materials comply with accessibility standards, fostering a universally accessible railway environment that accommodates everyone.	• **Fire Resistance:** Select materials with appropriate fire resistance properties in line with applicable regulations and standards. • **Anti-Slip Properties:** Opt for floor materials with appropriate anti-slip properties to minimise the risk of slips and falls, especially in high-traffic or high risk areas. • **Resilience to Vandalism:** Choose materials resistant to vandalism and tampering, enhancing the security of railway assets and minimising disruptions to operations. • **Environmental Resilience:** Consider materials resilient to environmental factors such as extreme weather, contributing to prolonged durability and minimising safety risks associated with material degradation. • **Structural Integrity and SIDOS (Security in the Design of Stations):** Select materials with in line with applicable SIDOS recommendations and project specific TVRA (Threat and Vulnerability Risk Assessment) requirements.	• **Proven Long-Term Durability:** Prioritise materials for reduced maintenance frequency and costs, contributing to sustained reliability of railway infrastructure. • **Low Maintenance Needs:** Select materials with low maintenance requirements, minimising disruptions, optimising maintenance efficiency, and supporting reliable railway operations. • **Predictive Maintenance Compatibility:** Choose materials which allow easy identification of issues, allowing timely interventions to prevent major disruptions. • **Wear and Tear Resistance:** Opt for resilient materials in high-traffic areas, extending infrastructure lifespan and maintaining operational efficiency. • **Lifecycle Cost Assessment:** Conduct comprehensive assessments, prioritising materials balancing upfront costs with long-term maintenance.

Image 1.9 Golden Threads of material selection - Key guidelines driving the selection of materials for anyone involved in the design and construction of stations

1.5 Guiding Principles of Material Selection

Key Factors of Material Selection

Identity	Aesthetics	Sustainability
Each station on the network has a unique identity, and materials and finishes can play a significant role in visually expressing this.	Beautiful, tactile material choices can enhance the passenger experience, create a positive environment and contribute to creating an excellent transport network with a strong identity.	Network Rail is committed to reducing carbon emissions and minimising the consumption of natural resource. Sustainable material solutions should be considered as an intrinsic part of the design process.
Safety	**Context**	**Inclusivity**
Safety in material specification is paramount and careful consideration should be given to the safe and non-harmful performance of materials including fire and security certification.	Location is an important factor in material selection, with factors like climate, foot traffic, and aesthetic integration important to durability and functionality. Materials should be suitably tested for their location. Chosen materials should respect a building's history and architectural heritage. In the case of listed buildings the consideration of appropriate materials should be given the utmost priority at the start of any works.	Network Rail should be seen as an exemplar organisation in terms of appropriate materials and finishes that consider all user groups in their safe use and perception of stations and buildings
Innovation	**Buildability**	**Cost & Maintenance**
Innovative material solutions should be explored wherever they have the potential to offer improvement on performance , safety and sustainability.	Materials should be assessed by their ability to meet constructibility and programme requirements, as well as the desired quality of the final built product. Consideration should be given to transporting materials to site and the process of assembly and installation.	Station material choices should consider the whole cost of a product including it's durability, cost and maintenance. Consideration should also be given to the ease and ability to maintain specified materials as well as their eventual disassembly or recycling.

Image 1.10 Guidance on the factors to consider during the selection of materials

1.6 Sustainability

Prioritising Low-Carbon Materials
Materials with lower carbon footprints throughout their life cycles should be prioritised. This process involves a comprehensive examination of emissions from extraction to disposal.

Several tools now exist to help with the assessment of a materials embodied carbon such as the 'Material Pyramid' which can be tailored to individual projects to visualise the climate impacts of construction materials in a user-friendly format with the highest embodied carbon materials at the top and the lowest at the bottom. Unlike traditional Life Cycle Analyses (LCAs) that require specialized knowledge and often focus on complex data.

Promoting Renewable and Recycled Content
In order to reduce the environmental impact of projects, it is recommended to promote materials with significant renewable and recycled content. This strategy aims to reduce reliance on new resources while embracing circular economy principles, thereby curtailing resource consumption and waste generation.

Enhancing Energy Efficiency and Durability
In the pursuit of energy efficiency and durability, careful selection of materials is important. Opting for materials with prolonged durability can minimise the frequency of maintenance, repairs, and replacements. This approach contributes to sustainable asset management principles, reducing both carbon emissions and life cycle costs.

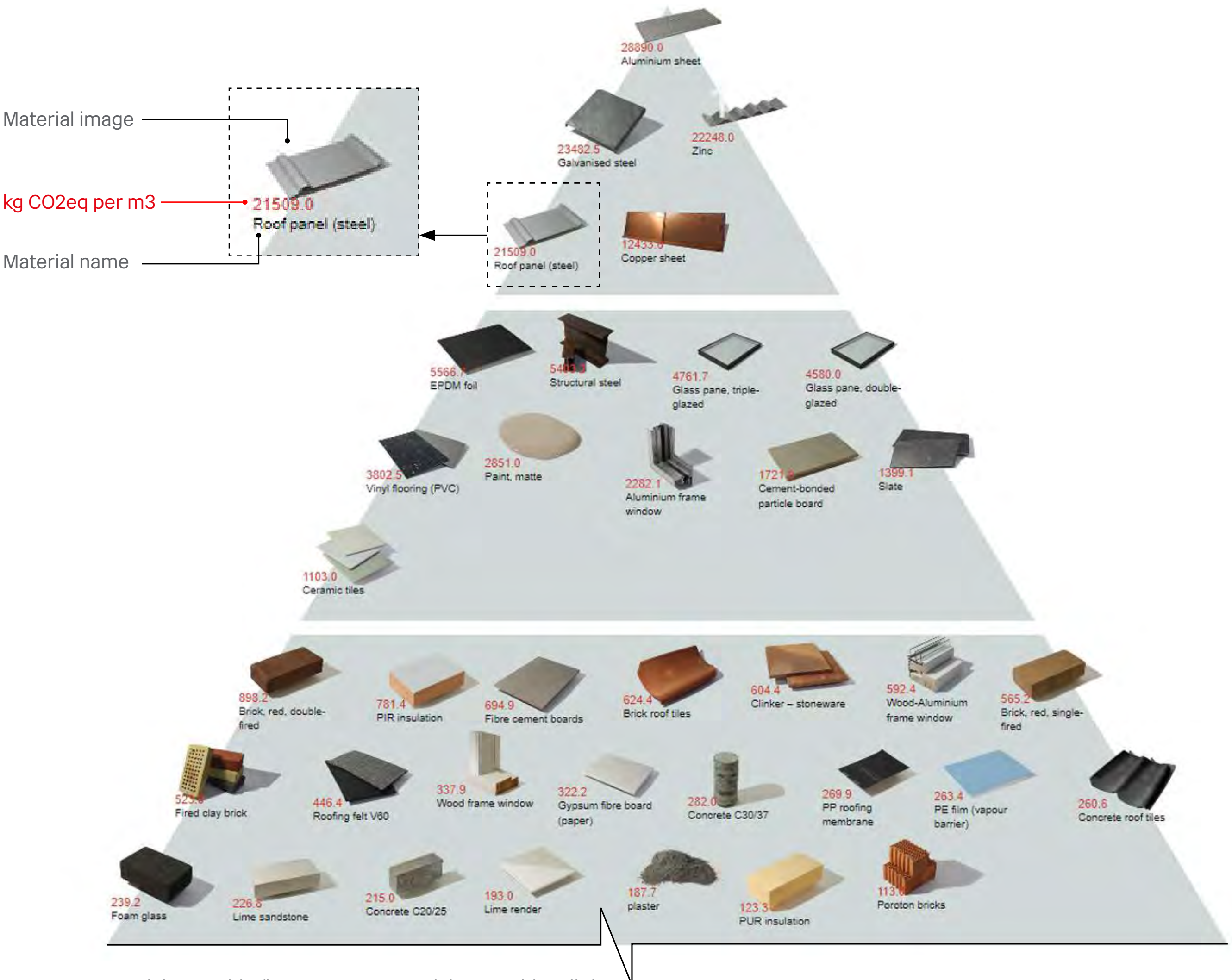


Image 1.11 Material Pyramid - (https://www.materialepyramiden.dk/)

1.6 Sustainability

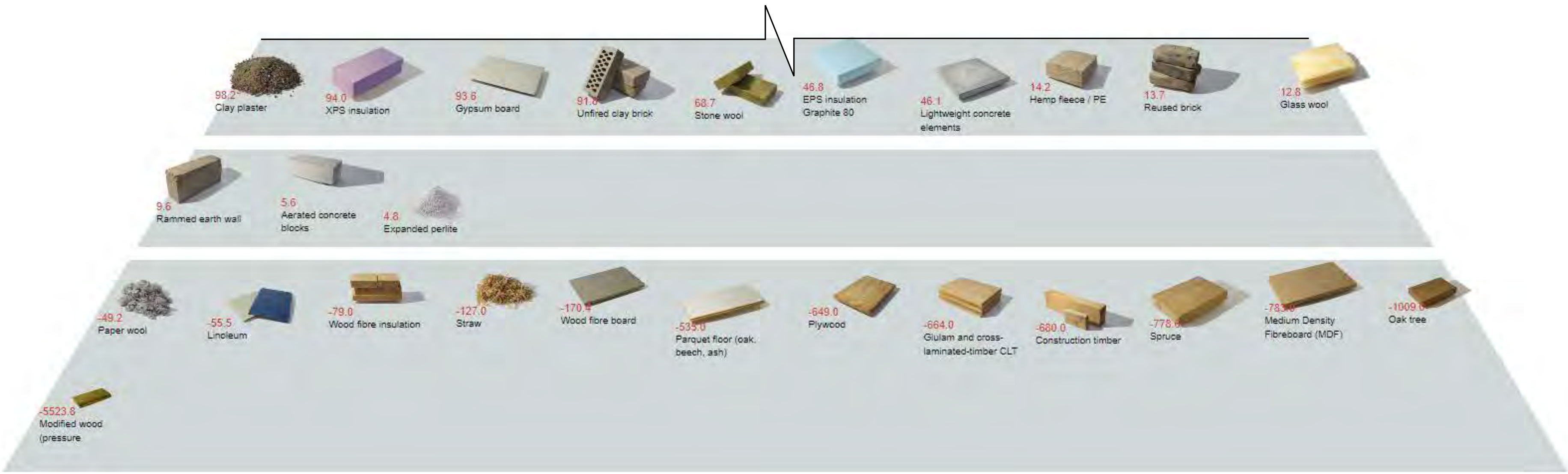


Image 1.12 Material Pyramid (continued) - (https://www.materialepyramiden.dk/)

Staying Updated with Sustainable Innovations

Sustainable materials and technology are constantly improving. Specifiers should remaining attuned to developments in sustainable technologies and materials wherever they have the potential to offer improvement on performance, safety and sustainability.

NR Guidance Suite Reference
Climate Action Design Manual for Buildings and Architecture **NR/GN/CIV/100/04**

Prioritising Climate Resilience

Given the escalating challenges posed by climate change, prioritising materials resilient to extreme weather conditions is imperative. Materials should enhance the robustness of infrastructure, reinforcing commitments to sustainable and climate-resilient railway systems.

Standards Reference
Network Rail Environmental Sustainability Strategy **NR/L2/ENV/015**

Embracing Circular Economy Principles

A circular economy is a sustainable alternative to the traditional linear economy of make, use and dispose. The aim of a circular economy is to extract fewer virgin resources from the planet and to keep existing resources in use for as long as possible. Embracing circular economy principles in materials specification is recommended to minimise resource utilisation and waste generation throughout the material life cycle.

1.7 Hazardous Materials

When specifying construction materials, it is important to avoid hazardous materials that pose health and environmental risks. Guidance on hazardous materials can be obtained from the Health and Safety Executive (HSE). Key hazardous materials to avoid include:

Asbestos:
Previously used for insulation and fireproofing, asbestos fibres can cause severe respiratory diseases, including lung cancer and mesothelioma.

Lead:
Found in old paints, pipes, and roofing materials, lead exposure can lead to neurological damage, especially in children, and various other health issues in adults.

Polychlorinated Biphenyls (PCBs):
Used in electrical equipment, sealants, and paints, PCBs are highly toxic and can cause cancer and adverse effects on the immune, reproductive, and nervous systems.

Chromated Copper Arsenate (CCA):
Used to treat wood, CCA contains arsenic, which is a carcinogen and can leach into surrounding soil and water, posing environmental and health risks.

Formaldehyde:
Commonly found in adhesives, insulation, and pressed wood products, formaldehyde is a known carcinogen and can cause respiratory issues and skin irritation.

Volatile Organic Compounds (VOCs):
Present in many paints, solvents, and adhesives, VOCs can contribute to indoor air pollution and cause headaches, dizziness, and long-term health effects.

Silica Dust:
Generated from cutting, grinding, or drilling concrete and stone, silica dust can cause silicosis, a serious lung disease, as well as other respiratory problems.

Creosote:
Used for wood preservation, especially in railroad ties and utility poles, creosote is a carcinogen and poses skin and respiratory hazards.

RAAC (Reinforced Autoclaved Aerated Concrete)
RAAC is prone to deterioration over time, particularly in harsh environmental conditions. This degradation can result in structural problems, compromising the safety and longevity of buildings constructed with RAAC.

Standards Reference

Health and Safety Executive
Control of Substances Hazardous to Health (COSHH) Regulations 2002. Approved Code of Practice and Guidance

Control of Lead at Work (CLAW) Regulations 2002

Control of Asbestos Regulations 2012. Approved Code of Practice and Guidance

Image 1.13 RAAC - Reinforced Autoclaved Aerated Concrete

Image 1.14 Asbestos

Image 1.15
Woolwich Elizabeth Line Station

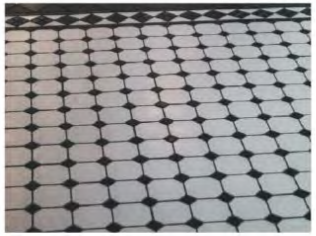
1.8 Floors

1.8.1 Guiding Principles to Consider

- → Identity
- → Aesthetics
- → Sustainability
- → Safety
- → Context
- → Inclusivity
- → Innovation
- → Buildability
- → Cost and Maintenance

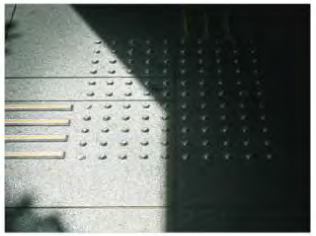

Natural Stone


Terrazzo


Ceramic Tiles


Brick Paving


Paving Slabs


Tactile


Asphalt


Macadam Bitumen


Resin Bound Aggregate


Timber


Entrance Matt


Metal

Image 1.16 Example flooring materials in a station environment

1.8.2 Identity

Floors can present an opportunity to incorporate the identity of a regional area by using local materials or through subtle iconography, for example Transport for London's London Underground roundel embossed steps. Selecting flooring materials for railway stations demands thoughtful consideration of the intended identity. Whether conveying reliability with durable options like terrazzo or embracing regional character through local materials, the chosen materials play an important role in articulating the station or route's unique identity.

For example the terrazzo at St Pancras International Station has a unique stone mix which references the colours of the wider stations materiality including the blue beams, red brickwork, and stonework.

National Standard

Building Regulations
Access to and Use of Buildings: Approved Document Part M

1.8.3 Aesthetic

Although often seen as purely a utilitarian choice, the aesthetics of flooring materials are key to creating welcoming and visually pleasing railway environments. Specifiers should opt for materials which complement the overall station architecture and material context. In additional to the material itself consideration should be given to the sizes of tiles to make sure the scale and pattern is appropriate for the overall area.

The floor material finish is important, not only in terms of aesthetics and working with other materials, but also how it works functionally in defining spaces. Consideration should be given to material, texture, and surface of the floor of both interiors and exteriors so there is a smooth transition between spaces. If the material internally is significantly different to the material used externally, members of the public are less likely to feel able to enter into the station to use it as a route through from one street to the other.

Image 1.17 Unique terrazzo and parquet jatoba flooring at St Pancras International

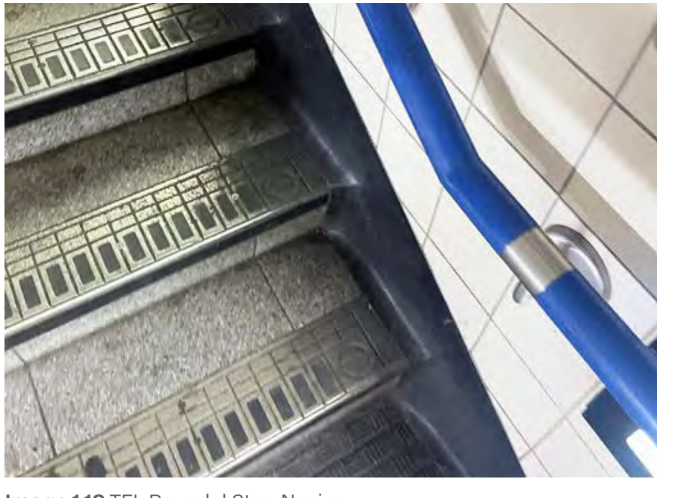


Image 1.18 TFL Roundel Step Nosing

1.8.4 Sustainability

Floors of stations represent some of the largest materials by area and so choosing sustainable floor materials can make a large impact. Prioritising materials with low embodied carbon reduces initial environmental impact, while circularity emphasises recyclability and reuse. Opting for flooring with a favourable whole life cost, factoring in installation, maintenance, and longevity can also help with the reduction of operational carbon.

Materials like recycled granite and composite floor tiles embrace circular principles, contributing to reduced waste.

NR Guidance Suite Reference

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

Standards Reference

Network Rail Environmental Sustainability Strategy
NR/L2/ENV/015

Image 1.19 Internal station floor treatment at Woolwich Elizabeth Line Station

1.8.5 Safety

Slip Resistance

Slip resistance is based on the frictional force (coefficient of friction pulling force/ weight of object) necessary to keep a shoe heel or crutch tip from slipping on a walking surface. While the dynamic coefficient of friction during walking varies in a complex and non-uniform way, the static coefficient of friction, which can be measured in several ways, provides a close approximation of the slip resistance of a surface. This is commonly referred to as the Slip Resistance Value, or SRV.

Contrary to popular belief, some slippage is necessary for walking, especially for persons with restricted gaits; a truly "non-slip" surface could not be walked over.

Dry, clean floors do not normally present a slip hazard. It is only when they become wet, greasy, or loose materials fall onto them that a slip hazard develops. By preventing contamination of the floors it is possible to reduce or even eliminate the slip risk in the workplace.

Contamination is anything that ends up on floors and can be a by-product of cleaning or as a result of adverse weather conditions. With all contamination, the first option should be to try and eliminate the problem.

Statistically the highest incidents of slips trips and falls involve people running for trains particularly those with wheeled luggage.

It is understood that people's behaviours change when typically pulling luggage and often the weight of what is being pulled is difficult to judge and additional force is used which can induce a fall when moving from surfaces with varying SRV.

The diagram to the right illustrates the factors that can contribute to slip accidents and the action to take to prevent them. It is called the slip potential model. One or more of these factors may play a part in any slip accident.

The cleaning and care regime is critical in respect of maintaining the slip resistance values of the surface. It has been proven that the slip resistance of floors will vary seasonally and according to patterns of wear such as desire lines of pedestrian movement.

Should surfaces degrade over time a number of remedial treatments can be considered, which range from applied coatings, inlaid carborundum strips and surface etching. Whilst acknowledging the performance enhancement that may be possible with such treatments, the effect on cleanability and appearance following treatment should be analysed carefully, particularly if there is an impact on the lifespan of the material

Image 1.20 Manchester Piccadilly Station Concourse Floor

Image 1.21 HSE Slip Potential Model

1.8.5 Safety (Continued)

Slip Testing

The prevention of slip accidents is an important driver to the selection of floor materials. The choice of a material should take into account not only its properties when new but also its probable behaviour when worn or contaminated. Even the most slip resistant surface can become slippery if not correctly maintained.

Testing floors in-situ can identify many factors that affect the slip performance of the flooring material such as cleaning regimes, maintenance, wear or weathering and traffic patterns all of which can affect the performance of the flooring material. Tests should be carried out to ascertain the slip resistance and roughness of new floors before hand over but also periodically during the life of the asset.

It is also important to assess how slippery floors are in stations as there is a duty of care to check that floors are not slippery and put people's safety at risk. A number of suppliers provide a comprehensive on–site consultancy service regarding slip issues on any surface, and carry out slip resistance tests using equipment tested and approved by the Health and Safety Executive (HSE).

The 'Pendulum' floor friction test as developed by the British Ceramic Research Limited (CERAM), is accepted by the HSE and the UK Slip Resistance Group (UKSRG) as the most appropriate testing method for the type of floor surfaces to be found in stations. BS 7976–1; BS 7976–2, and BS 7976–3 refer to the calibration, operation and testing of the pendulum apparatus.

The Health & Safety Executive paper 'Assessing the slip resistance of flooring' (2007) has a categorisation of slip potential based on Pendulum Test Vales (PTV). There is no minimum nationally agreed standard but Network Rail has adopted acceptable good practice and requires that all floor surface materials achieve a target of more than 40 SRV (Slip Resistant Value) on the 'Pendulum' test when the material is both wet and dry and when fitted with a '4s' rubber shoe in non-platform areas. It is important to note that platform surfaces require higher slip resistance values as stated in NR/L3/CIV/030

Slip Potential	PTV
High Slip Potential	0-24
Moderate Slip Potential	24-35
Low Slip Potential	36+

Image 1.22 HSE slip potential classification, based on pendulum test values (PTV)

Image 1.23 Pendulum Test

National Standard

Determination of slip resistance of pedestrian surfaces. Methods of evaluation
BS EN 16165

Standards Reference

Platform Components & Prefabricated Construction Systems
NR/L3/CIV/030

1.8.6 Context

Station Context

The station flooring has to consider 3 key areas (listed adjacent) in the process of arriving, waiting and boarding at a station. Beginning with arrival and typically the transition from exterior to interior space through the gateway between the station and its surrounding environment which may be beyond the physical boundary of the station and under the management of a third party.

1. **External areas of stations:** including platforms where there is complete exposure to the elements and usually no cleaning regime other than removal of litter. The transition between platform zone and station facility zone is often separated by the physical barrier ticket gates which naturally adjust the gait of pedestrian movement as people pass through them.

2. **Internal controlled areas:** increasingly concourse spaces include retail spaces which often sell food and beverages which contribute to the contamination of the floor surface. These internal controlled areas require a full and constant cleaning regime. Passengers often rely on a visual connection between the station facility zone and the platform so they can gauge the time taken to travel between the two points without resorting to running which increases the likelihood of a slip or trip.

3. **Internal uncontrolled areas:** traditional station concourses and platforms under glazed or partially glazed roof where there is no climate control and therefore a risk of wind, condensation, rain or snow ingress as well as walked-in dirt have to be managed. These risks can therefore affect the choice of finish

Image 1.24 Barking Riverside Station Exterior

Image 1.25 Leeds City Station concourse with retail

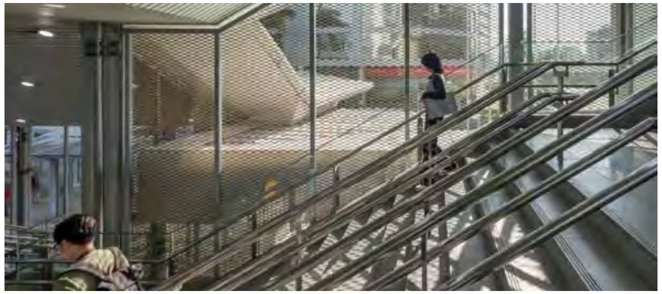


Image 1.26 Internal uncontrolled staircase

1.8.7 Historic Context

In historic station environments, flooring materials should be chosen with a keen awareness of the heritage context and any listed status. The selection should honour the station's legacy, opting for materials that reference the historical context while maintaining robustness. The thoughtful integration of flooring materials should not only complement the historic quality of the station but also contribute to a cohesive environment, enhancing the overall cultural and architectural significance of cherished railway landmarks.

Most ground level floors in stations have been either rebuilt or re-covered during their lifetimes. However, original flooring materials, such as encaustic tiles and wood blocks, do exist in some buildings. Where these remain and could continue in service as a suitable and safe contemporary floor, they should be authentically repaired where possible. Thought should be given to both durability and slip resistance and testing is required where a slip-resistant treatment is to be applied to an existing floor.

Skirtings and mouldings are often an important element in the character of a floor and should be retained if original. Victorian skirtings are generally of more generous proportions than readily available replacements and may require specialist manufacture.

Image 1.27 Chessington South Station - Mosaic Tiling

Network Rail's town planning teams and the Railway Heritage Trust should be consulted when alterations are proposed to Listed Buildings or buildings in conservation areas.

Image 1.28 Southern Railway Toilet - Mosaic Tiling

NR Guidance Suite Reference

Heritage: Care and Development
NR/GN/CIV/100/05

1.8 Floors

1.8.8 Inclusivity

Floor finishes should comply with the Building Regulation Part M requirements, as well as the Department for Transport 'Design Standards for Accessible Railway Stations: A Code of Practice'. This document sets out criteria which provides a guide for providing a safe and user friendly environment for all.

Considerations should include at minimum the Light Reflectance Value of the chosen floor, providing an appropriate contrast to wall finishes. The inclusion of tactiles where required, for example, to demarcate the bottom of stairs, or the edge of platforms for the blind and partially sighted. Further detail on tactile paving is available in the Network Rail Tactile Wayfinding Guidance document - NR/GN/CIV/300/06.

Particular accessibility considerations should be given to the abutment of materials thresholds, where slip resistances cannot differ greatly, neither can bold changes in colour occur. The Building Regulations (Part M) require that floor surfaces contrast with adjacent wall finishes. The floor colour should differ in light reflectance value (LRV) by at least 30 points unless the surfaces are lit by over 200 lux, in which case a minimum difference of 20 points is acceptable.

National Standard

Building Regulations
Access to and Use of Buildings: Approved Document Part M

1.8.9 Innovation

New materials which have the ability to offer improvement on performance, safety and sustainability should be considered when specifying floor materials. Innovation should also be considered where it may offer improvement to passenger experience, aesthetic appeal or the identity of a station.

Where possible specifiers should search for sustainable alternatives or ways that specification might support environmental goals. Many new flooring products are now available which feature high recycled proportions and are suitable for mass transit use.

Specifiers should keep updated with the latest industry developments. However, it is important that any new materials undergo rigorous testing and certification for their specific application to assure safety and efficacy

Standards Reference

Department for Transport
Design Standards for Accessible Railway Stations: A Code of Practice

Image 1.29 Floor patterning that could be mistaken for steps

Image 1.30 Platform edge tactile paving

NR Guidance Suite Reference

Tactile Wayfinding
NR/GN/CIV/300/06

1.8.10 Buildability

Compatibility between existing and proposed substrates is important when specifying flooring. Accurate assessment and preparation of the substrate help achieve a level finish, reducing the risk of uneven surfaces and providing a high-quality installation.

Incorporating access points for services and utilities within the flooring design is important and this should be coordinated to maintain aesthetic quality. Strategic placement and planning for these access points facilitate future maintenance and upgrades, allowing for utilities to remain easily reachable without significant disruption to the flooring.

Seamless connections between new and existing flooring are important for uniformity and stability. Careful alignment and integration prevents gaps or misalignments, establishing a cohesive appearance and maintaining structural continuity across different sections.

Incorporating movement joints into the flooring design accommodates thermal expansion and contraction, preventing cracks and damage. These joints are necessary in larger areas to maintain the floor's integrity and prolong its lifespan by allowing natural movement without compromising the structure.

1.8.11 Cost and Maintenance

There are two primary costs for flooring materials: initial installation and lifespan cost. These costs are not mutually exclusive. A material may be cheaper to install but have higher maintenance costs over its life cycle. Conversely, a more expensive material initially might have lower long-term maintenance costs. Therefore, both installation and life cycle costs should be assessed together.

Network Rail has a stringent cleaning regime for its floors, with heavy footfall in certain areas. The maintenance strategy should inform material selection, as maintenance and replacement costs might exceed initial capital costs.

Consideration of future replacement materials are fundamental. If a floor area requires replacement in 25 years, seek assurance that the same material can be procured.

Street scarring from utility work or repairs reduces the visual quality of public spaces. Adopting a like-for-like replacement strategy during maintenance provides a uniform look and maintains the flooring's integrity, preserving the visual appeal and structural consistency of streets and public spaces.

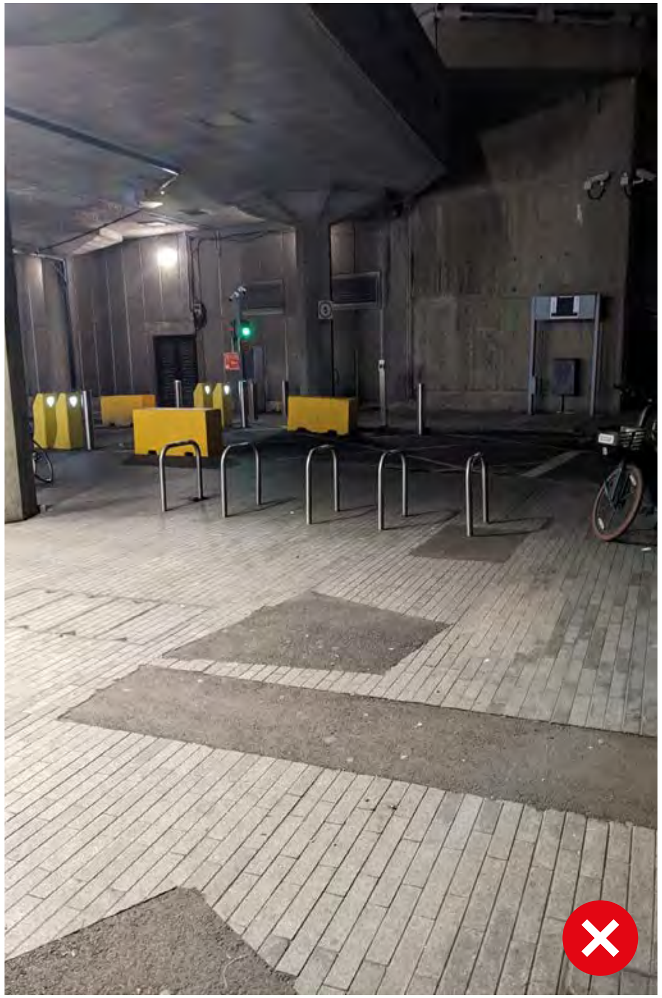


Image 1.31 Example of 'street scarring'

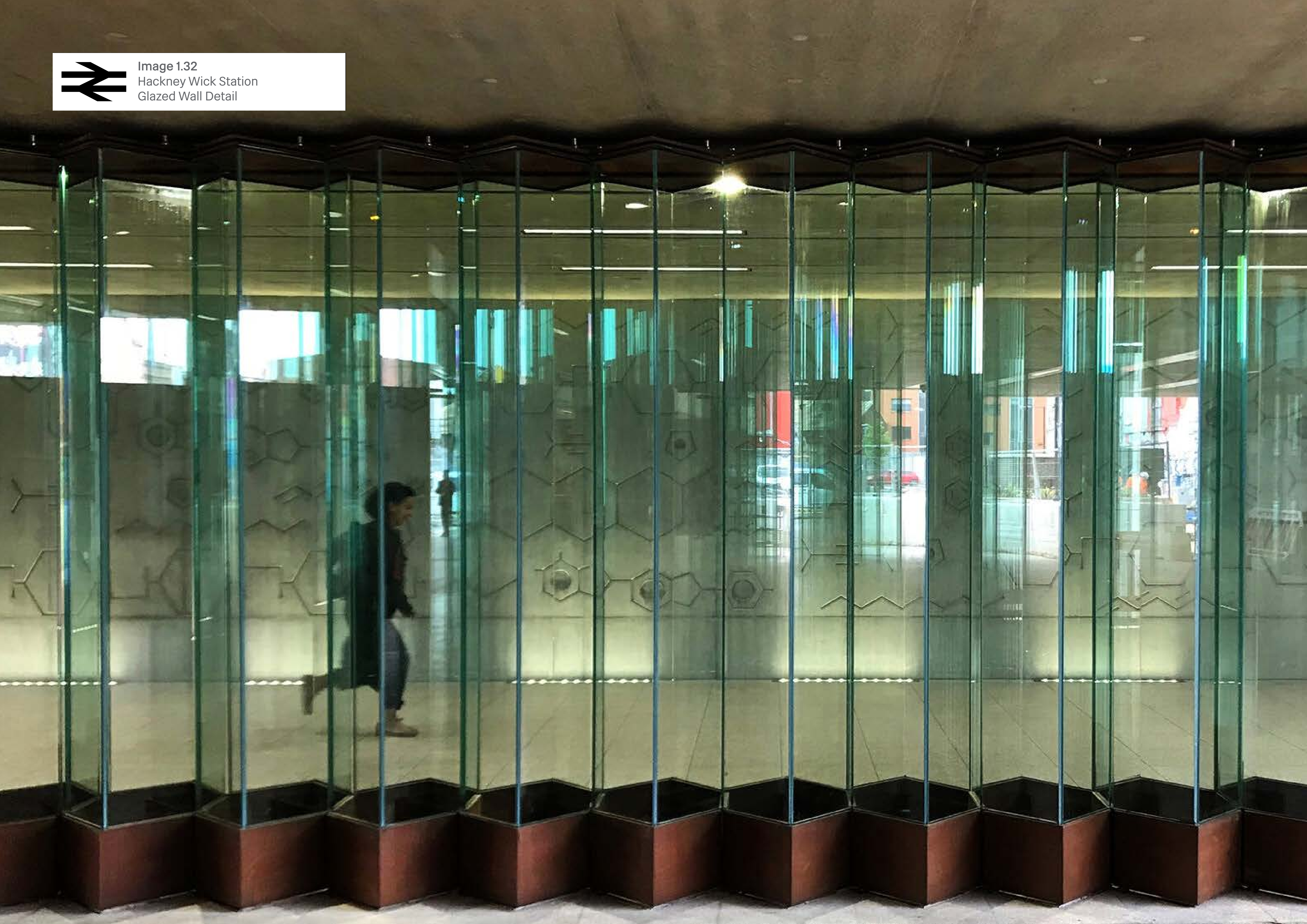


Image 1.32
Hackney Wick Station
Glazed Wall Detail

1.9 Walls

1.9.1 Guiding principles

- → Identity
- → Aesthetics
- → Sustainability
- → Safety
- → Context
- → Inclusivity
- → Innovation
- → Buildability
- → Cost and Maintenance

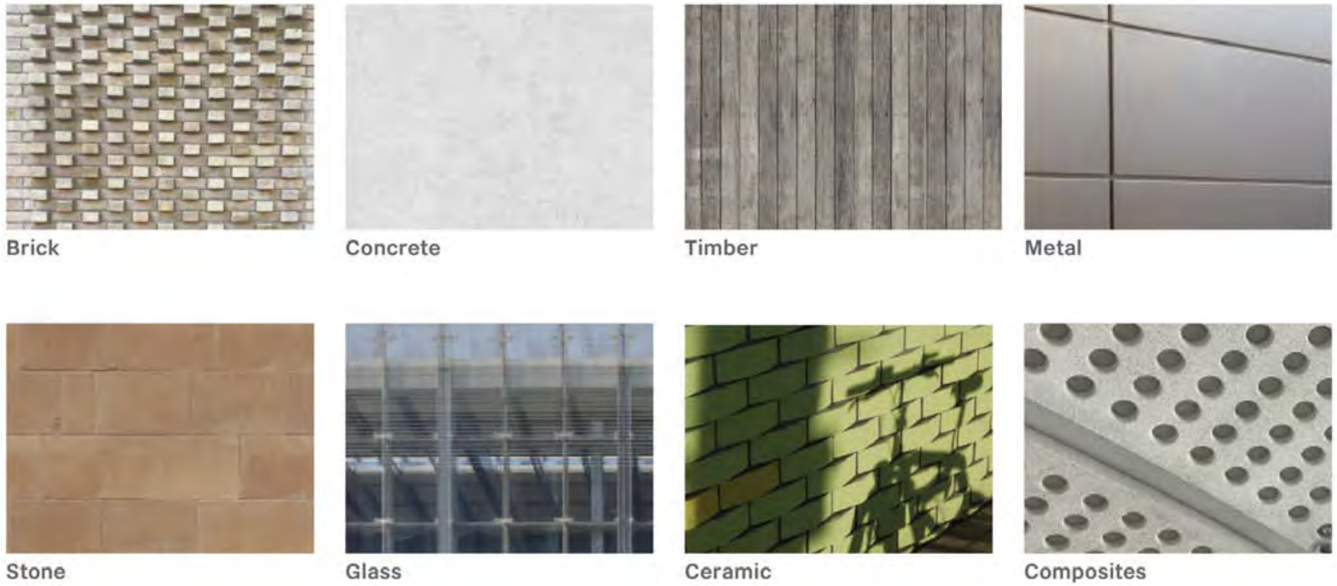


Image 1.33 Example wall materials in a station environment

1.9.2 Identity

Crafting a railway identity starts with choosing the right wall materials. Each texture, pattern, and finish should reflect the station's unique character and cultural context. By aligning designs with the station's visual language, a consistent and recognisable image can be created, resonating with the local community and heritage. Integrating thematic elements into the walls fosters a sense of place and connection for passengers. Materials should not only complement the station's architecture but also enhance the passenger experience. Consistency in applying these principles provides a cohesive and memorable journey.

In addition to visual appeal, wall materials can foster a deeper connection with passengers. Integrating thematic elements into the wall design creates an environment that people can identify with and take pride in. This might mean using motifs that reflect local landmarks or historical themes, transforming the station into a meaningful gateway to the community it serves.

The materials chosen should not only complement the station's architecture but also enhance the overall passenger experience. Imagine walls that echo the station's architectural style while also being durable and easy to maintain. Thoughtful integration provides a station that remains a pleasant and functional space over time.

Consistency in applying these identity principles across all wall materials is crucial. When passengers see a cohesive design language throughout the station, it reinforces their sense of place and connection to the railway. This attention to detail helps create a memorable and enjoyable experience, making the station not just a transit point but a part of the journey itself.

1.9.3 Aesthetic

Wall finishes present an opportunity to elevate the visual appeal of railway spaces. Designer's should consider colour palettes, textures, and materials that enhance wayfinding and establish distinct zones within stations.

Wall materials should harmonise with surrounding elements, such as lighting, signage and any historical features to contribute to a cohesive and welcoming environment.

Wall materials should not be a purely utilitarian choice, and should strike a balance between aesthetics and practicality. Materials should be durable, easy to maintain, and compliant with safety standards but also enhance the passenger journey through beautiful materials and finishes.

Specifiers should also seek stakeholder input so that aesthetic choices resonate with project specific passenger expectations and historical contexts.

Image 1.34 St Pancras Brick Arches

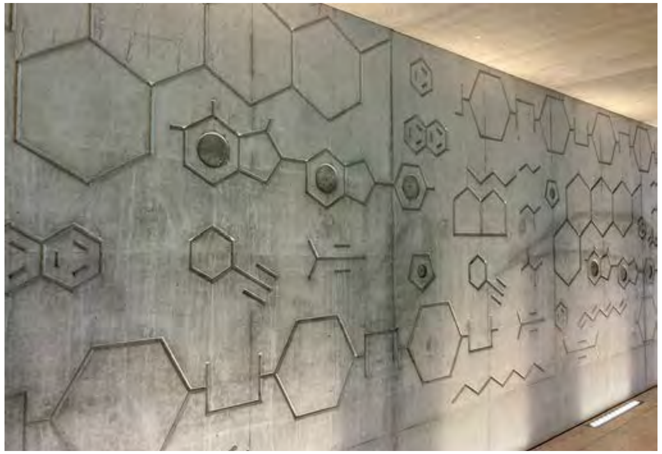


Image 1.35 Hackney Wick station interior wall

1.9.4 Sustainability

To prioritise materials with a lower lifecycle carbon footprint, specifiers should evaluate factors such as extraction, production, transportation, and end-of-life disposal. Thorough assessments are necessary to quantify emissions at each stage of a material's life cycle, promoting a comprehensive approach to decarbonisation.

Emphasising materials with a high proportion of renewable and recycled content is crucial to reduce dependency on virgin resources and promote circular economy principles. Procurement decisions should consider the availability and sustainability of raw materials.

Materials selected should exhibit long-term durability, minimising the requirement for maintenance, repair, or replacement. This strategy not only reduces carbon emissions but also lowers life cycle costs, aligning with sustainable asset management principles.

Considering the long-term impacts of climate change on material performance and resilience is necessary. Materials should be chosen to withstand extreme weather conditions and environmental challenges, allowing infrastructure investments to remain robust and resilient.

Opting for environmentally friendly wall materials that require minimal maintenance over their lifespan, such as recycled metal panels, reclaimed wood, or low-maintenance composites, contributes to sustainable construction practices and long-term environmental stewardship efforts.

NR Guidance Suite Reference

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

Standards Reference

Network Rail Environmental Sustainability Strategy
NR/L2/ENV/015

Image 1.36 Gent Waste Brick is made from 63% recycled municipal waste with hydraulic lime

1.9.5 Safety

Fire

The external walls of all buildings forming part of Network Rail-owned stations should comply, as a minimum, with the guidance of BS 9999 and BS 9992 (in England and Wales) or the Non-Domestic Technical Handbook (in Scotland).

In addition, Network Rail generally does not support the use of external wall materials or components with a reaction to fire classification worse than Class B (in accordance with BS EN 13501–1). This includes components such as external surfaces and insulation.

National Standard

Fire Safety in the Design, Management, and Use of Buildings. Code of Practice
BS 9999

Fire Safety in the Design, Management and Use of Rail Infrastructure. Code of practice
BS 9992

Fire classification of construction products and building elements - Classification using data from reaction to fire tests
BS EN 13501-1

Building Regulations
Approved Document Part B - Fire Safety

Building (Scotland) Regulations
Building Standards Technical Handbook Non-Domestic

Furthermore, Network Rail expects that all parts of the external façade for sub-surface, Higher Risk and Medium Risk stations (in accordance with Section 3.2) achieve Class A1 or A2.

Often material data sheets list generic performance data which can vary depending on the exact detailing and application of the product. It is therefore important to obtain an applicable fire performance certificate from the supplier or manufacturer to demonstrate that the material is suitable for its intended application and proposed build-up.

Security

When specifying wall materials reference should be made to any SIDOS (Security In the Design Of Stations) requirements or location specific requirements from the project (TVRA) Threat and Vulnerability Risk Assessment.

NR Guidance Suite Reference

Fire Safety at Stations
NR/GN/CIV/300/03

Image 1.37 Material fire certification testing

1.9.6 Context

Historic

External walls can be found in almost every architectural style and type on the Network Rail estate. The materials used range from timber-clad, timber-framed structures to load-bearing brick and rusticated granite. When specifying new wall materials for a Network Rail asset with historical significance, care should be taken in considering the specific historical context in which new wall materials are to be introduced.

Local

The walls of a Network Rail asset can have a significant impact on its relationship with the surrounding local context. Wall materials should be specified which respond to the local context. Similarly, many Network Rail assets are historical and cultural assets themselves and care should be taken so that any new wall materials specified enhance rather than detract from their significance. External wall materials can be specified which reference:

- The local historical or cultural context
- The local landscape or geology
- The material context of the surrounding built environment

Image 1.38 London St Pancras International.

St. Pancras was constructed by the Midland Railway company to showcase the material quality of Midlands including Minton Tiles from Stoke on Trent and brick from Nottinghamshire.

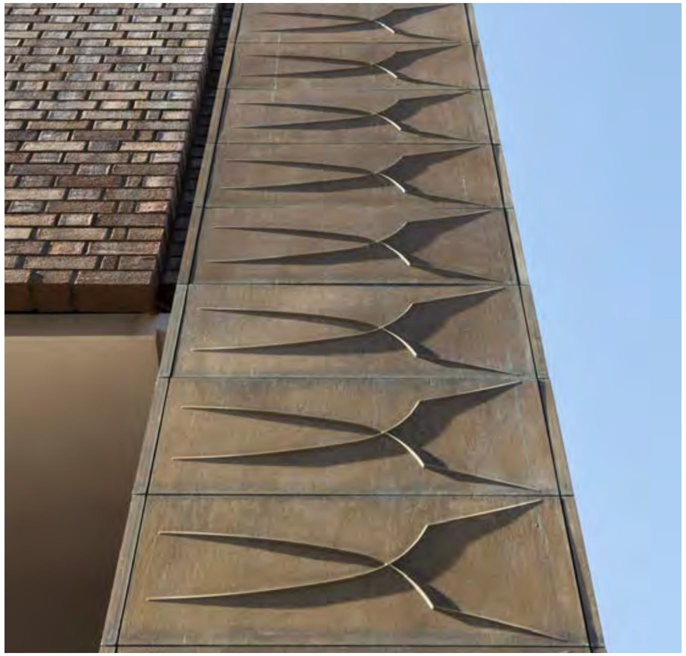


Image 1.39 Woolwich Elizabeth Line Station

Woolwich Station entrance incorporates over 350 cast bronze panels, each two metres wide and weighing more than 80kg. They express the 'Woolwich rifling' motif, which was developed on site in 1865

NR Guidance Suite Reference

Heritage: Care and Development
NR/GN/CIV/100/05

1.9.7 Inclusivity

When specifying a wall material consideration should be made to the other materials which surround it with regards to tonal, tactile and visual contrast. Walls should be in a tone that contrasts with the floor and the ceiling, so that the boundaries are clearly visible.

Where large areas of glass are used, they should be clear to all users and marked via with a contrasting tonal colour. Reference should be made to Approved Document Part K with regards to glass manifestations. Any highlighting and manifestations used to warn people of the surface should remain visible in different lighting conditions and against all background environments. Their appearance should be taken into account during daylight and at night.

The use of colour for manifestations rather than opaque is recommended as opaque manifestations are less effective for some visually impaired people. Etched or clouded glass should be avoided, as it looks like the misting of the visual field experienced by some people.

Where possible walls should not have a glossy or reflective surface as this often causes lighting to reflect and create disruptive patterns on the wall. Wall materials in public areas should also aim to create a relaxed and comfortable atmosphere through natural and warm tones in contrast to overly clinical and cold spaces.

Image 1.40 Paddington Elizabeth Line -
Non reflective, natural wall materials create a calm atmosphere

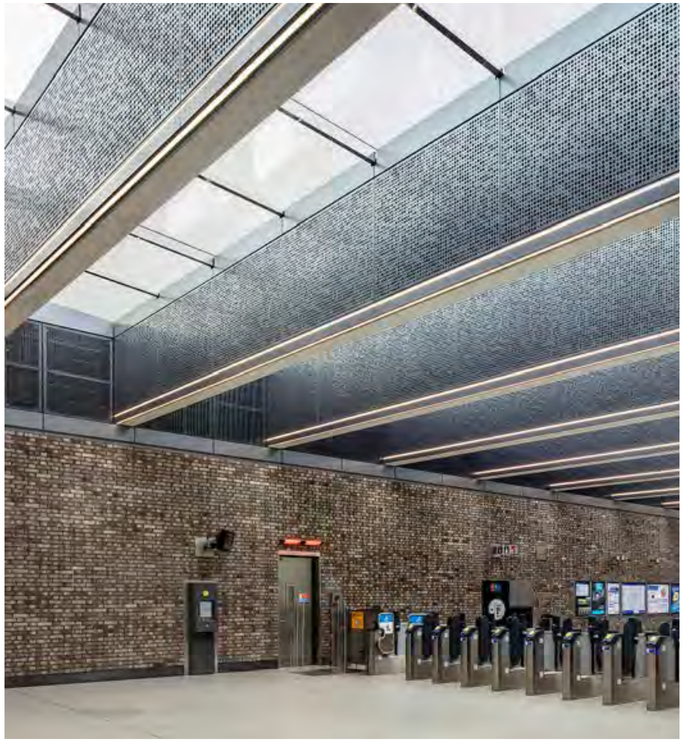


Image 1.41 Woolwich Elizabeth Line -
Visually contrasting walls with warm material tones.

NR Guidance Suite Reference

Inclusive Design
NR/GN/CIV/300/04

National Standard

Design for the mind. Neurodiversity and the built environment. Guide
PAS 6463

1.9.8 Innovation

It is important that any new materials undergo rigorous testing and certification for their specific application to assure safety and efficacy.

With this in mind opportunities should still be sought for any advancements in sustainable technologies and materials, and Design for Manufacture and Assembly (DFMA) and modularity.

Designers should explore innovative solutions such as carbon-capture technologies, eco-friendly alternatives, and emerging materials that have the potential to significantly reduce the environmental impact of railway infrastructure while maintaining safety and durability.

Image 1.42 Elizabeth Line - 1:1 scale prototypes of various elements

1.9 Walls

1.9.9 Buildability

It is important that any chosen material can be easily transported to the construction site and manoeuvred into place to avoid logistical challenges. This is particularly noteworthy for any materials which are susceptible to damage in-transit. Materials that are readily available from local suppliers can minimise transportation costs, carbon and also add a sense of local identity to the project.

Where possible components and processes should be standardised to reduce construction complexity. Materials that are easy to handle and install, such as prefabricated panels or modular components can reduce installation times but attention should be paid to ascertain that this doesn't result in generic spaces with a lack of identity.

Required build tolerances should be factored in when specifying wall materials as this can vary from product to product. The sequence of activities that take place on site and off-site, as well as any temporary works and weatherproofing should also be considered.

If a wall material is non-structural, compatibility between the material and proposed structural elements should be checked and cross referenced against the certified and tested applications of a given material.

1.9.10 Cost and Maintenance

The unit cost of materials should be weighed against the overall lifetime cost of maintenance, particularly given the demanding environment and design life required of Network Rail assets.

Wall materials should be specified that reduce future maintenance requirements as far as practicable. As access for repairs or maintenance can be limited and costly in station environments materials which require regular retouching or use applied finishes, such as paint, should be avoided.

Wall materials should be resistant to decay caused by moisture and mould with particular attention to material resistance if the wall is proposed in any below ground spaces. Humid, wet and coastal environments also have specific requirements for material specification to prevent deterioration over time.

Wall materials should be easy to clean and repair. Smooth surfaces or materials with protective coatings can be easily cleaned while modular systems or walls made of replaceable components can simplify repairs without requiring extensive refurbishment.

Wall materials should be compatible with common maintenance techniques and products. Additionally, consider the availability of maintenance professionals skilled in servicing the chosen material to assure efficient upkeep in the future.

Image 1.43 London Bridge Underground - Enamelled Cast Iron Panels

Image 1.44
Reading Station Footbridge
Ceiling Detail

1.10 Ceilings, Soffits and Roofs

1.10.1 Identity

Ceilings and soffits can often be an overlooked part of the materiality of a building but they are incredibly important to creating a sense of identity and consistency in a space and should be given just as much consideration as the walls and floors of a space.

While consideration should be given to the functional and maintenance requirements of a ceiling or soffit they should be seen also as opportunities to create interest and volume while breaking up the mass of often monolithic and utilitarian station spaces.

While identity is often created in roofs through shape and form this can also be enhanced through the material quality of both the internal and external finish as well as any supporting structure. The materiality of a roof should be expressed, elegant and contextual to the space.

The large train sheds and concourse spaces required of transport buildings present excellent opportunities to create a strong spatial identity. Certain colours and materials become a signature, indelibly linked to the station, and become part of its heritage, for instance the baby blue of St Pancras' Barlow train shed or the deep terracotta of Paddington Station.

Image 1.45 London St Pancras - Historic Barlow Train Shed Roof

Image 1.46 London Paddington - Train Shed Roof

Image 1.47 London St Pancras - 'Eye-Brow' ceiling of modern renovation

1.10 Ceilings, Soffits and Roofs

1.10.2 Aesthetic

Ceilings and soffits are excellent opportunities to break up the mass of a space and create visual interest in a station. Rather than being monolithic surfaces, materials and components can be used to foster a human scale within station environments.

Where possible ceilings and soffits should create warm tones and tactility so as to avoid feeling utilitarian and clinical. The red cedar wood slatted panels at London Bridge Station create a natural tone within a large station concourse and help bring a material softness and warmth to the space.

Ceilings, soffits and roofs are often used to house the major utilities and services and lighting required in station environments. It is therefore important these are seamlessly integrated into the roof and ceiling components so as not to appear disordered or ad-hoc. Access panels should be integrated into any material or component in a way which provides sufficient access without negatively impacting the material impact of ceilings, soffits and roofs.

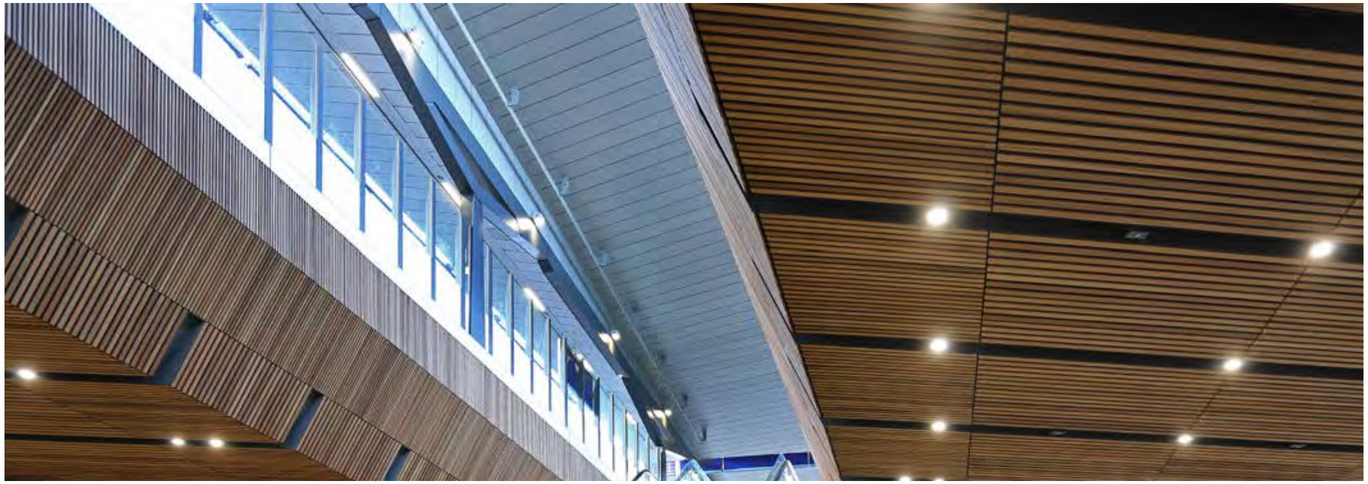


Image 1.48 London Bridge - Red Cedar Wood Acoustic Timber Ceiling

Image 1.49 Brent Cross West Station - Modular Ceiling Panels

1.10 Ceilings, Soffits and Roofs

1.10.3 Sustainability

While metal has a high embodied carbon, many metal ceiling products are now covered by Cradle to Cradle certification and some also offer hand back schemes for tiles and replacements. If specifying a metal ceiling these factors should be considered as well as the responsible sourcing and recycled content of any specified ceiling, soffit, and roofing components.

Alternatively, timber has a significantly lower embodied carbon than metal. Due to timber's natural combustibility this should be discussed and agreed with the Network Rail Fire Safety engineer but can offer a low-carbon alternative to steel and other metals. When specifying timber it is also important that the timber is responsibly sourced and appropriately certified.

Where there are opportunities to integrate green roofs or energy producing technology into roofs this should be considered. However, reference should be made to Network Rail's Fire Safety at Stations guidance on Photovoltaic (PV) Panels and Green Roofs.

Image 1.50 Abbey Wood Station - Larch and Spruce Glue-laminated timber roof and soffit

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

Standards Reference
Network Rail Environmental Sustainability Strategy NR/L2/ENV/015

1.10 Ceilings, Soffits and Roofs

1.10.4 Safety

There are key safety considerations to be made when specifying ceiling, soffit, and roof materials and components.

Security

Blast resistance of ceilings is an important aspect of choosing a material. Specifiers should consult the project's TVRA (Threat and Vulnerability Risk Assessment) and check that any ceiling materials and components comply with security requirements stated for the project. Reference should be made to the Network Rail Design Guidance document 'Security at Stations" which details the security requirements of ceiling materials and components in relation to SIDOS (Security in Design of Stations).

Fire

Ceiling, soffit, and roof materials should only be specified if they have the appropriate fire performance as defined in the project fire strategy. Reference should be made to the Network Rail Design Guidance document 'Fire Safety at Stations" with regards to material specification. Any materials and components specified should have their fire performance verified by fire test data and certification.

Image 1.51 SIDOS compliant ceiling at London Underground station entrance

NR Guidance Suite Reference
Security at Stations NR/GN/CIV/300/02

NR Guidance Suite Reference
Fire Safety at Stations NR/GN/CIV/300/03

1.10 Ceilings, Soffits and Roofs

1.10.5 Context

When specifying materials for ceiling soffits and roofs, context and history play pivotal roles. New buildings or additions should draw inspiration from the surrounding environment, architectural style, and cultural history and complement the surrounding context.

For the majority of historic buildings, the roof has a natural dominance. This is particularly so with railway stations, where it can be the major visual element in a landscape.The design integrity of the original should be respected even where a new material is introduced for structural reasons, as for example the new roof claddings in Manchester Piccadilly or Paddington.

Insensitive alterations, renewals or poor maintenance can have a disproportionate impact on a building, for example the removal of chimneys or replacement of original roof coverings with finishes that have a different scale.

Although most pitched roofs on listed properties are likely to be of slate or clay tile, there are many other materials in use throughout the rail network where most building styles and materials are represented. Shaped stone slates, tiles and the patterns and colours in which they are laid are often a distinguishing feature of roofs that might have geographical and regional importance.

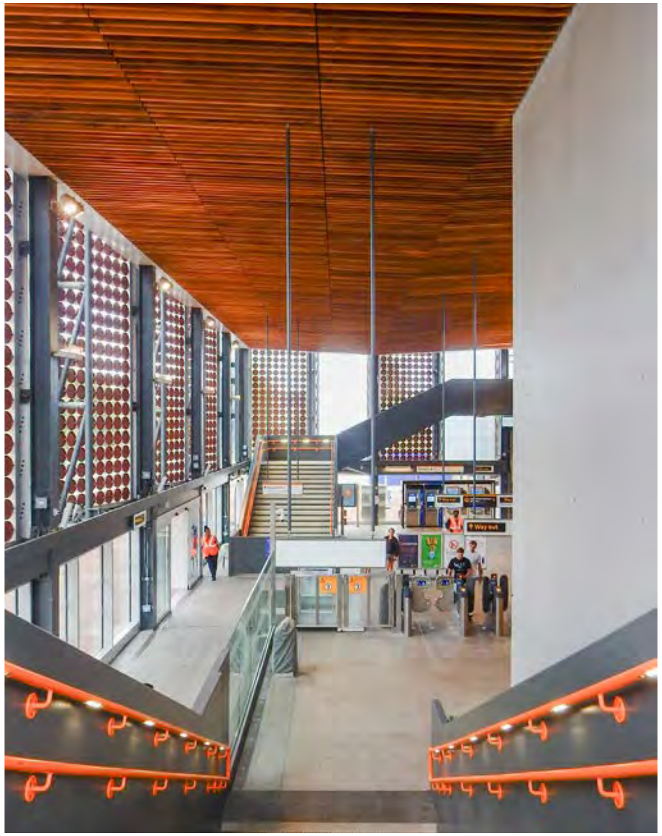


Image 1.52 White Hart Lane Station

Image 1.53 Peckham Rye - Restored Station Roof

NR Guidance Suite Reference

Heritage: Care and Development
NR/GN/CIV/100/05

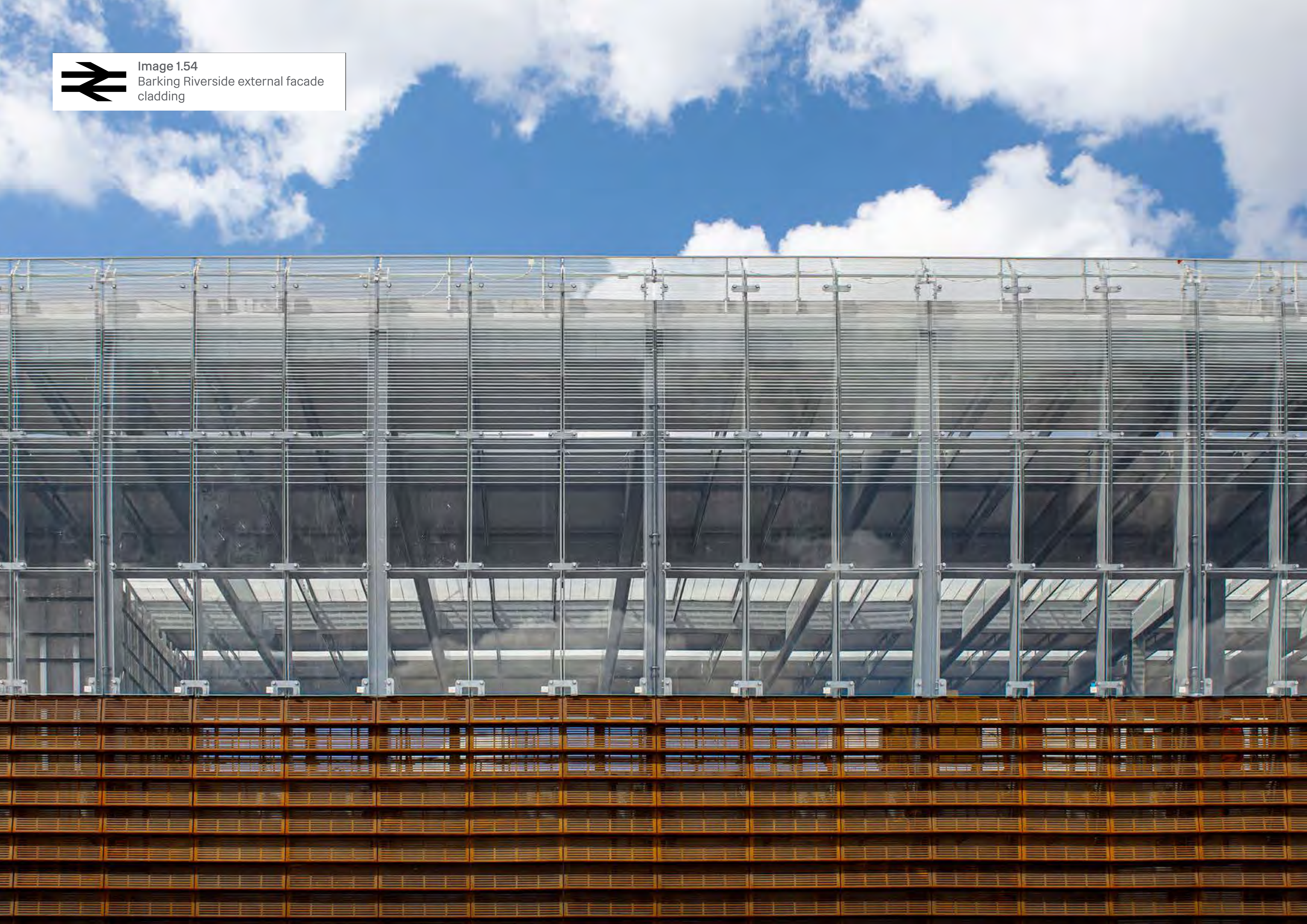


Image 1.54
Barking Riverside external facade cladding

Materials & Components

Section 2: Materials & Finishes

2

2.1 Reading guide

Material category — **Stones & Masonry - Embodied Carbon - kgCO2e/kg (Based on ICE database)**

Lowest EC material in category — Sandstone 0.06kgCO2e/kg

Highest EC material in category — Granite 0.70kgCO2e/kg

E-00.06 | E-BB.BB | E-CC.CC | E-00.70 | E-N/A — Information not available

Colour = Embodied carbon within category (Green=lowest, Red=Highest)
Number = Embodied carbon in 'Kilograms of Carbon Dioxide Equivalent per Kilogram'

Material reference image

Embodied Carbon - kgCO2e/kg (based on ICE database) — E-00.21

Material category & ID to NBS Uniclass 2024 — Ma_20_16

Material sub-category / Material name — **Clay - London Stock**

Possible applications — **Application:** Mainly heritage and visual-uses; facing walls

Material specific information — **Specification:**
Colour - Red, grey-brown
Finish - Rustic
Size - 215 x 102.5 x 65mm

Project or product example — Reference example - H.G. Matthews, handmade range

Note: Embodied carbon figures are indicative only. They are provided from baseline and are to be used as guide only. They should be considered together with a material's entire life span and end of life treatment.

Figures for specific materials may differ and should be assessed as part of the design process. The embodied carbon figures are derived from the Inventory of Carbon & Energy (ICE) database

2.2 Timber

2.2.1 Timber

Timber, one of the oldest building materials, remains crucial in construction due to its flexibility, variety, and beauty. Compared to materials like aluminium and steel, wood has lower embodied energy in its production. Trees require little energy to become usable timber, and young trees absorb carbon dioxide and release oxygen efficiently.

Hardwoods mature in about a human lifespan, while softwoods take half that time. Forests cover about 20% of the Earth's land, mostly with hardwoods in warmer areas and softwoods in colder regions. One-third of harvested wood is used for construction, while the rest is used for paper, fuel, or wasted during logging.

Using recycled and waste wood for timber products promotes efficient forestry. Timber framing, a modern method of construction (MMC) accounts for 22% of new homes in the UK. Emphasis should be placed on certification schemes like the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification PEFC which help to guarantee sustainable sourcing by tracking timbers chain of custody from source to user. Labels from the Canadian Standards Organisation (CSA) and American Sustainable Forestry Initiative (SFI) are also certified by the PEFC.

2.2.2 Hardwoods and Softwoods

Timbers are categorised as hardwoods or softwoods based on their botanical classification, not their strength.

Hardwoods

- → Come from broad-leafed trees, typically losing their leaves in autumn in temperate climates
- → Half of UK hardwoods come from temperate forests in North America and Europe, while the rest, including iroko, mahogany, sapele, and teak, are imported from tropical rainforests
- → Main hardwoods produced in the UK include oak, sweet chestnut, ash, beech, and sycamore.

Softwoods

- → Come from conifers, known for their needle-shaped leaves and mostly evergreen nature
- → Makes up about 80% of timber used in UK construction, with pine and spruce imported from Europe and North America
- → British forests supply over 40% of the UK's softwood, mostly machine graded to strength class C16

Image 2.1 Abbey Wood Crossrail Station

2.2.3 Strength Grading and Classes

Strength grading assesses the strength of individual timbers, assuring optimal use. It can be done visually as part of a skilled process or using a grading machine that tests flexural rigidity. BS EN 14081–1 provides guidelines for both visual and machine grading of timber, including marking requirements. The visual grading of hardwood should be performed in accordance with BS 5756, and BS 4978 for softwood.

Strength classes according to BS EN 338 range from C14 to C50 for softwoods (Coniferous) and D18 to D80 for hardwoods (Deciduous). The number denotes the characteristic bending strength in MPa. These classes also specify density and various strength and stiffness properties based on sample test values, without considering safety factors which typically form part of the design process. For trussed rafters, grades TR20 and TR26 outlined in BRE Digest 445: 2000 are relevant.

Standards Reference

Digest 416 - Specifying structural timber (1996)
Building Research Establishment (BRE)

Digest 445 - Advances in timber grading (2000)
Building Research Establishment (BRE)

2.2.4 Defects and Appearance Grading

Timber, being a natural material, commonly possesses imperfections known as defects. These defects are typically categorised into three main types: natural, conversion, and seasoning defects, depending on whether they originated in the living tree or during processing. Additionally, timber can deteriorate due to weathering, fungal and insect attacks, and fire damage.

BS EN 975 Part 1 and Part 2 establish guidelines for grading the appearance of hardwoods including oak, beech, and European poplars. These standards classify timber based on the presence, number, and size of defects visible on its surface. Similarly, BS EN 1611–1 specifies five grades for appearance grading of softwoods such as spruces, firs, pines, Douglas fir, and larches, considering observable defects.

National Standard

Sawn timber. Appearance grading of hardwoods - Oak and beech
BS EN 975-1

Sawn timber. Appearance grading of hardwoods - Poplars
BS EN 975-2

Sawn timber. Appearance grading of softwoods - European spruces, firs, pines and Douglas fir
BS EN 1611-1

2.2.5 Specification of Timber

In construction, timber serves various functions, ranging from structural components to decorative elements like claddings and trim. The selection of timber for each application often involves specifying the type of hardwood or softwood based on specific visual requirements. However, for most general purposes prioritising strength and durability, timber is designated by either a strength class or a combination of timber species and strength grade. When specifying structural timber, it's important to include details such as lengths, cross-section sizes, surface finish or tolerance class, moisture content, and any required preservative or special treatments. (BRE Digest 416: 1996). When specifying timber in the UK, specifiers should look for the FSC and PEFC certification schemes to help to guarantee sustainable sourcing.

National Standard

Timber structures. Strength graded structural timber with rectangular cross section - General requirements
BS EN 14081–1

Visual strength grading of temperate hardwood
BS 5756

Visual strength grading of softwood
BS 4978

Structural timber. Strength classes
BS EN 338

2.2.6 Specialist Timber Construction

Timber-frame Construction

Two standard forms of timber-frame construction are balloon frame and platform frame, with the latter being more common in the UK and a modern method of construction (MMC).

Timber Piles and Foundations

Timber pile foundations offer an economical and environmentally friendly alternative to concrete, acting as carbon dumps to mitigate global warming.

Historically, various softwoods and hardwoods have been used, but in the UK, Douglas fir is a standard material. Other suitable options include treated Scots pine or larch, oak (in non-salt-water soils), and elm, beech, and sycamore. Untreated timber below the water table is more resistant to decay due to lack of oxygen but vulnerable above it, necessitating preservative treatment for above-ground use. Preservative-treated timber piles, cut off below ground level and capped with concrete, can have a service life of roughly a century.

2.2.7 Modified Timber

The physical properties of timber can be altered through heat treatment to create thermal modified timber (TMT), or chemical treatment through impregnation. Thermal modification entails heating the timber in an inert atmosphere to prevent combustion outlined in British Standards document DD CEN/TS 15679.

Chemical modification involves impregnating permeable wood species with chemical reagents, resulting in reduced water absorption and increased dimensional stability.

National Standard

Thermal modified timber. Definitions and characteristics
DD CEN/TS 15679

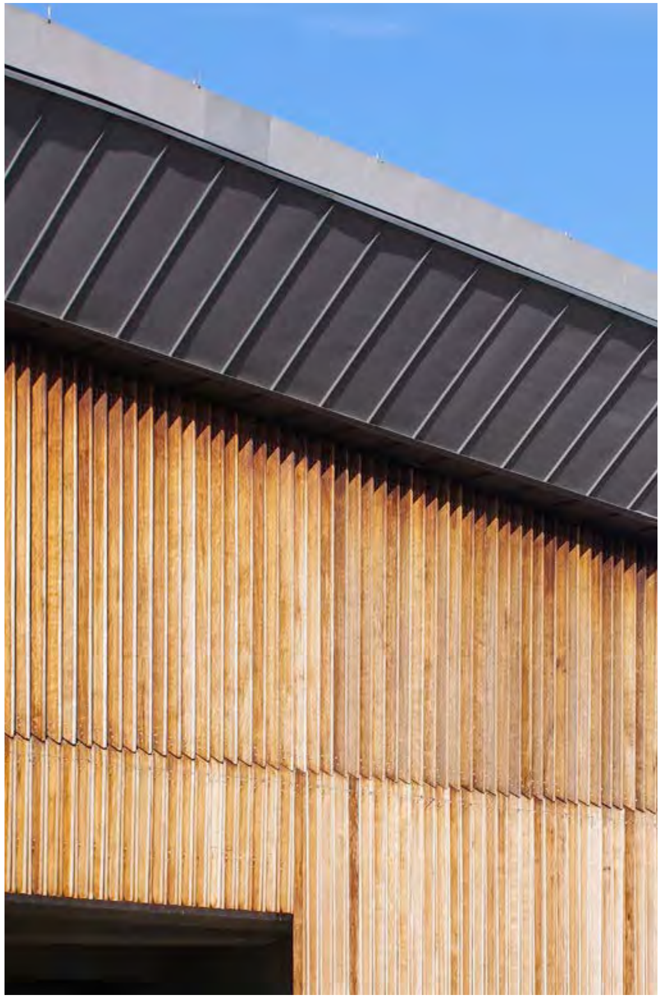


Image 2.2 Natural wood board facade

2.2.8 Cladding and Flooring

Softwood Cladding: Western Red Cedar has traditionally been favoured for external timber cladding due to its durability and warm colour. However, Larch and Douglas Fir are increasingly popular choices for softwood cladding driven by a growing emphasis on renewable resources from sustainable forests. Both Larch and Douglas Fir offer greater resistance to impact damage compared to Western Red Cedar, often eliminating the requirement for additional preservative treatment in cladding applications.

Hardwood Flooring: Hardwood flooring is renowned for its durability and aesthetic appeal. Options include solid timber and plywood laminates with a 4mm hardwood wearing layer. Standard timbers like European oak, beech, birch, ash, chestnut, walnut, and maple are widely available, with some imported hardwoods offering darker grain colours. Bamboo also provides interesting effects. Timbers are offered in variations with minimal knots and uniform graining, or as rustic with knots and more colour variation. Laminates are typically pre-finished, while solid timber may be sealed with oil or lacquer after installation.

2.2.9 Weathering

When exposed to sunlight, wind, and rain over time, external timbers lose their natural colours and turn grey. Repeated wetting and drying cycles cause moisture movements, which raise the surface grain, create surface checks and cracks, and increase the risk of fungal decay. Superficial weathering can be addressed by removing the denatured surface to restore the timber's original appearance.

2.2.10 Deterioration of Timber

Timber in construction faces deterioration from weathering, fungi, insects, and fire. Timber's natural durability is classified into five categories based on its resistance to wood-decaying fungi (BS EN 350):

- Class 1: Very durable
- Class 2: Durable
- Class 3: Moderately durable
- Class 4: Slightly durable
- Class 5: Not durable (perishable)

National Standard

Durability of wood and wood-based products. Testing and classification of the durability to biological agents of wood and wood-based materials
BS EN 350

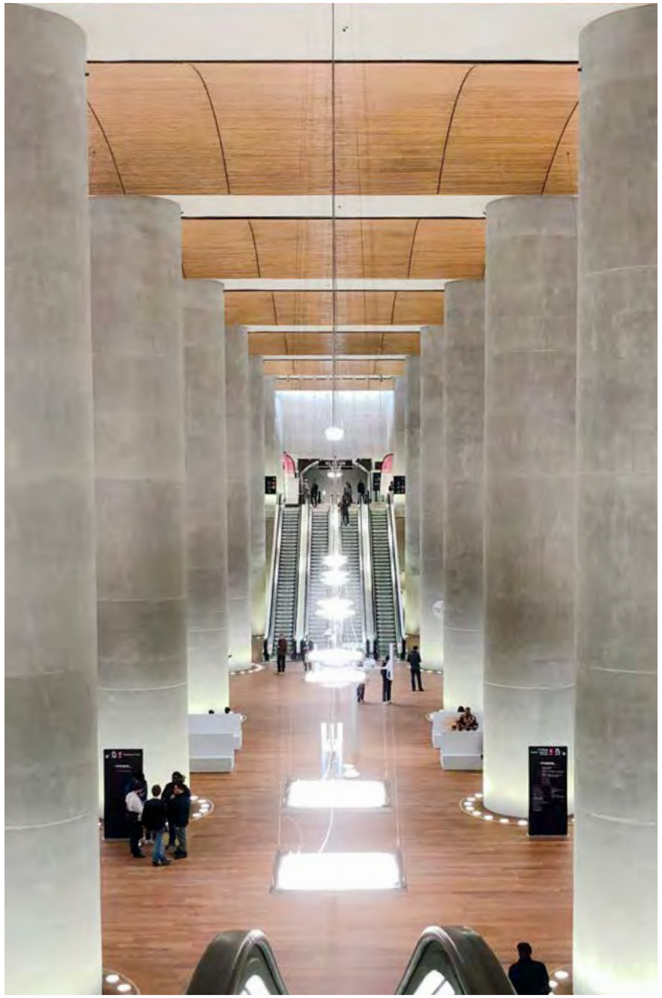


Image 2.3 Timber Floor and Soffit - Paris, La Defense RER E Station

2.2.11 Fire

Timber is becoming a common construction material for new stations, owing to its advantages in terms of embodied carbon and other sustainability metrics, and its use is to be supported where possible. However, timber is combustible, and the fire risk associated with the use of exposed timber requires consideration and assessment as part of the station design.

Exposed timber surfaces on station buildings should either comply with BS 9999, BS 9992, the Non-Domestic Technical Handbook (in Scotland), or achieve Class B in accordance with BS EN 13501-1 (whichever is more onerous).

National Standard

Fire Safety in the Design, Management, and Use of Buildings. Code of Practice
BS 9999

Fire Safety in the Design, Management and Use of Rail Infrastructure. Code of practice
BS 9992

Fire classification of construction products and building elements - Classification using data from reaction to fire tests
BS EN 13501-1

Building Regulations
Approved Document Part B - Fire Safety

Building (Scotland) Regulations
Building Standards Technical Handbook Non-Domestic

Timber used for the construction of canopies and other non-building station infrastructure should also generally achieve Class B.

With fire resistant treatment, timber can typically achieve a maximum of a Class B classification. However, there are practical limits to the types and sizes of timber elements that can be treated, and therefore fire-resistant treatments may not be feasible in all cases. In addition, fire resistant treatments often have limitations to their serviceable life and may require regular reapplication, particularly when used in an external environment.

Where exposed timber (or any other material) is proposed that does not comply with the guidance above, a detailed risk assessment should be carried out by a competent Fire Engineer to demonstrate that the life safety of station occupants is not affected. This assessment should consider the specific combustible design arrangement and its impact on means of warning and escape, internal and external fire spread, and firefighting access. This risk assessment should be submitted to the Network Rail Fire Safety Engineer for review and included in the station's Fire Strategy.

NR Guidance Suite Reference

Fire Safety at Stations
NR/GN/CIV/300/03

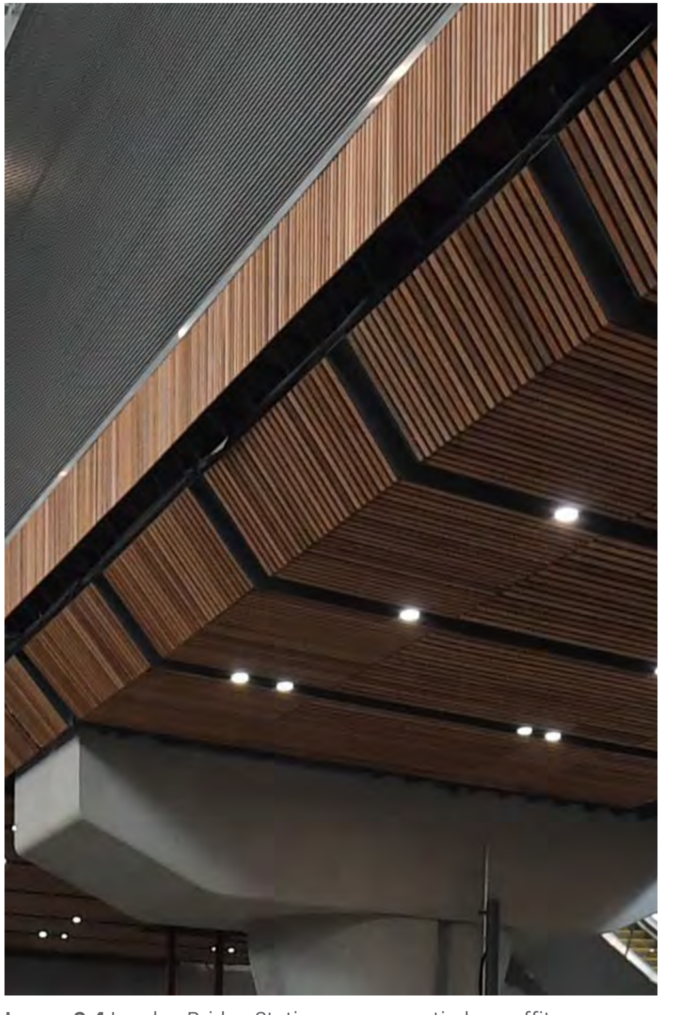


Image 2.4 London Bridge Station concourse timber soffit

2.2.12 Timber in Construction

Laminated Timber

Laminated Timber offers flexibility, combating challenges faced with traditional solid timber sections where limitations due to lumber availability and variability in strength across the material are present. Laminated timber is produced by bonding layers of precisely cut smaller timber sections using resin adhesive.

Laminates can be oriented vertically or horizontally. Compared to solid timber, laminated timber offers greater dimensional stability and fewer visual defects. It can be homogeneous, with all laminates of the same strength class, or combined, using lower strength class laminates in the centre of the units.

Cross-Laminated Timber (CLT)

CLT resembles conventional plywood but with thicker laminates. Most CLT is made from Grade C24 or C16 softwood, with large finger jointing across the full cross-sectional area permitted only in factory production. These structural panels, used for walls, roofs, and floors, can be easily clad with brickwork, tiling, or rendering as required.

Panel thicknesses typically range from 50-300mm, although up to 500mm can be achieved. Panel sizes are usually limited by transportation constraints, typically to 15x3m, although standard production allows up to 24m.

Designing with CLT requires careful coordination, as all window and door openings should be prefabricated. On-site the material should be kept dry and used above the damp-proof level. The thermal properties of CLT panels vary based on the timber used.

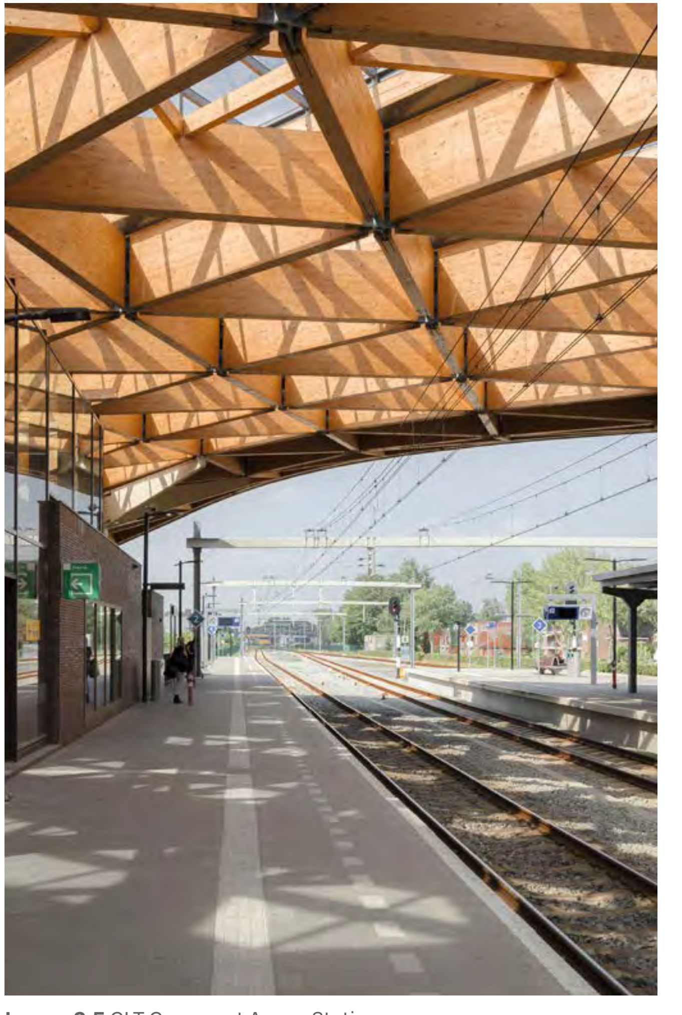


Image 2.5 CLT Canopy at Assen Station

Structural Insulated Panels (SIPs)

SIPs are prefabricated lightweight components for load-bearing walls and roofs, both internally and externally. Unlike cladding panels, they support significant vertical and horizontal loads without internal studding. Made of two high-density face layers separated by a lightweight insulating core, they are bonded to act as a single structural unit. Their strength depends on the outer layers' thickness and properties, while thermal efficiency relies on the core's depth and insulating properties.

SIPs are typically 1.2m wide by 2.4m high, offering rapid and airtight construction on-site, with joints typically using a tongue and groove system.

External cladding options include brickwork, wooden panelling, or rendering, with plasterboard as the standard internal finish.

SIPs are one of the UK government's promoted Modern Methods of Construction (MMC) to improve energy efficiency, currently making up about 10% of new construction methods.

Image 2.6 Prefabricated Structural Insulated Panels (SIPs)

Plywood

Plywood is made by layering thin timber plies to the desired thickness. Typically, plies have alternating grain directions to provide uniform strength and minimise moisture movement. However, in some cases, 'even plywood's' have parallel grains in the central layers. These layers, along with glue, are pressed, sanded, and trimmed to standard dimensions. Decorative veneers can be added to one or both faces.

Most plywood in the UK is softwood-based, sourced from North America and Scandinavia, although some comes from temperate hardwoods in Finland and Germany, and tropical hardwoods from various regions. Standard sheet sizes are typically 2440 x 1220mm, with some larger options available. Thickness for construction purposes typically range from 4 - 25mm.

Plywood is classified based on appearance, physical properties, and bonding adhesive durability. Adhesive bonding classes range from Class 1 to the most durable Class 3, allowing for external use without delamination if the timber itself is durable or adequately protected. Plywood should be labelled 'S' for structural or 'NS' for non-structural use to BS EN 636.

Laminated Veneer Lumber (LVL)

Laminated veneer lumber (LVL) is used for various applications including columns, beams, purlins, and trusses, and can be machined like solid timber. It offers cost efficiency with minimal waste in production.

LVL comes in three grades, made by laminating timber strands with resin under heat and pressure. In one method, logs are cut into 300mm long strands, treated with resin, aligned, and pressed into reconstituted wood billets. Another method involves coating 3mm thick timber strands or veneer sheets with waterproof adhesive, bundling them together with parallel grain, and pressing and curing them into structural timber billets or sheets up to 26 m long.

National Standard
Plywood Specifications
BS EN 636

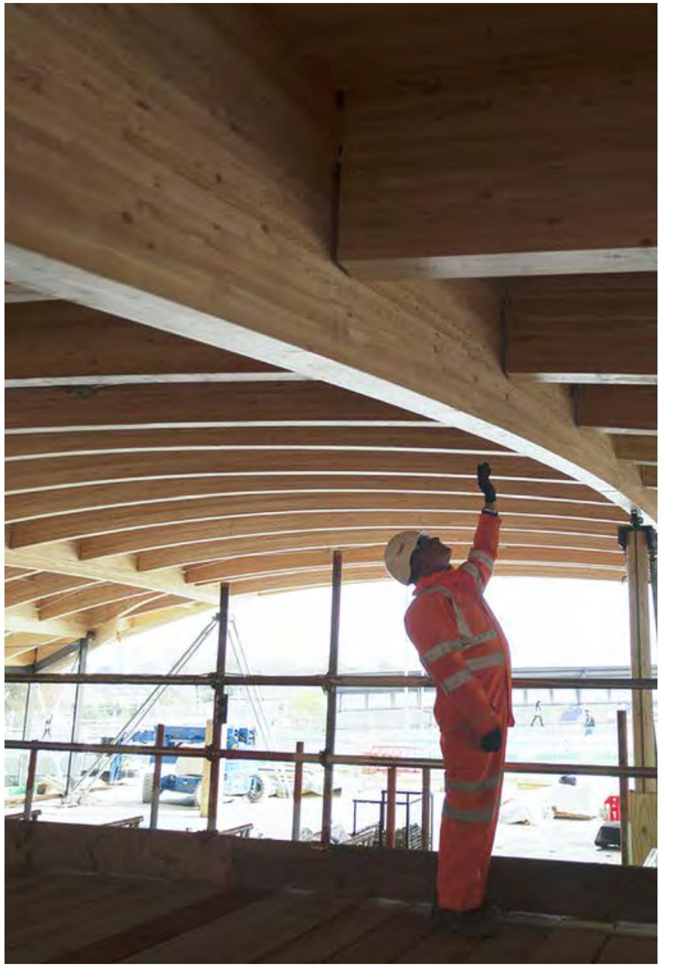


Image 2.7 Larch and Spruce Glu-Lam roof structure Abbey Wood Crossrail Station

Cement-bonded Particleboard

Cement-bonded particleboard offers excellent resistance to fire, water, fungal growth, and frost. It is made from a blend of wood particles (usually softwood) and cement, resulting in light grey boards with a consistent cement surface.

BS EN 634–2 describes one grade suitable for both indoor and outdoor use. The boards are typically colour-coded white (for non-load-bearing) and brown (for dry, humid, and exterior conditions), with 25mm vertical stripes near one corner.

BS EN 633 applies to both Portland and magnesium-based cements. While magnesite-bonded particleboard is used for lining, it lacks frost resistance and isn't suitable for humid conditions. Boards often feature a core of coarse wood chips sandwiched between finer materials, resulting in a smooth finish that can be further refined through sanding and priming. Due to its density, cement-bonded particleboard provides effective sound insulation.

National Standard

Cement-bonded particleboards. Specifications - Requirements for OPC bonded particleboards for use in dry, humid and external conditions
BS EN 634–2

Cement-bonded particleboards. Definition and classification
BS EN 633

Oriented Strand Board (OSB)

Oriented strand board (OSB) is commonly used as sheathing in timber-frame housing, with moisture-resistant grades suitable for roof sarking and higher-specification grades ideal for flat roof decking. Thicker panels are employed in heavy-duty flooring and in the production of Structural Insulated Panels (SIPs).

OSB is made from thick timber flakes that are tangentially cut, coated with wax and resin, and arranged in three (or sometimes five) layers. The outer faces of the boards have strands running parallel to the sheet, while the middle layer has strands oriented across or randomly. After curing under heat and pressure, the boards are sanded and packaged. Standard sizes are typically 2440 or 3660 x 1220mm.

OSB is available in thicknesses typically ranging from 6 to 40mm and is primarily manufactured from Scots pine and spruce in Europe. In the UK and Ireland, OSB is made from managed forest thinnings certified by the Forest Stewardship Council (FSC). OSB is graded based on expected loads and environmental conditions (BS EN 300).

National Standard

Oriented strand boards (OSB). Definitions, classification and specifications
BS EN 300

Image 2.8 Oriented Strand Board (OSB)

Grade	Loading	Conditions	Colour Code
OSB 1	General Purpose, Interior Fitments	Dry Conditions (Use Class 1)	White, Blue
OSB 2	Load -bearing	Dry Conditions (Use Class 1)	Yellow, Yellow Blue
OSB 3	Load-bearing	Humid Conditions (Use Class 2)	Yellow, Yellow Green
OSB 4	Heavy Duty, Load-bearing	Humid Conditions (Use Class 2)	Yellow, Green

Image 2.9 OSB Grading to BS EN 300

Flaxboard:

Flaxboard is made from a blend of at least 70% thin slices of flax shives and adhesive, sometimes mixed with other materials including wood flakes, chips, and sawdust which are moulded under heat and pressure to form boards. BS EN 15197 defines four types of flaxboard (FB1 – FB4) based on their intended use and environmental suitability.

Grade	Loading	Conditions
FB 1	General Purpose/ filling	Dry
FB 2	Non-load bearing/veneering	Dry
FB 3	Non-load bearing/interior fitment and furniture	Dry
FB 4	Non-load bearing	Humid

Image 2.10 Flaxboard Grading to BS EN 15197

Fibreboards:

Fibreboards are made from wood or plant fibres using heat and/or pressure. They are bonded either by the natural adhesive properties of the fibres or with the help of a synthetic binder. Medium-density fibreboard (MDF) incorporates a resin-bonding agent during production. Fibreboards are classified according to their production process, usage conditions, and typical applications in accordance with BS EN 316.

BS EN 622–5 describes nine grades of fibreboards based on their expected loading and environmental conditions. For improved moisture resistance, melamine-urea formaldehyde resin is used, although this material is not suitable for exterior applications. MDF sheets and mouldings can accept a wide range of finishes, typically paint, laminates and veneers.

National Standard

Wood-based panels. Flaxboards. Specifications
BS EN 15197

Wood fibre boards. Definition, classification and symbols
BS EN 316

Fibreboards. Specifications - Requirements for dry process boards (MDF)
BS EN 622–5

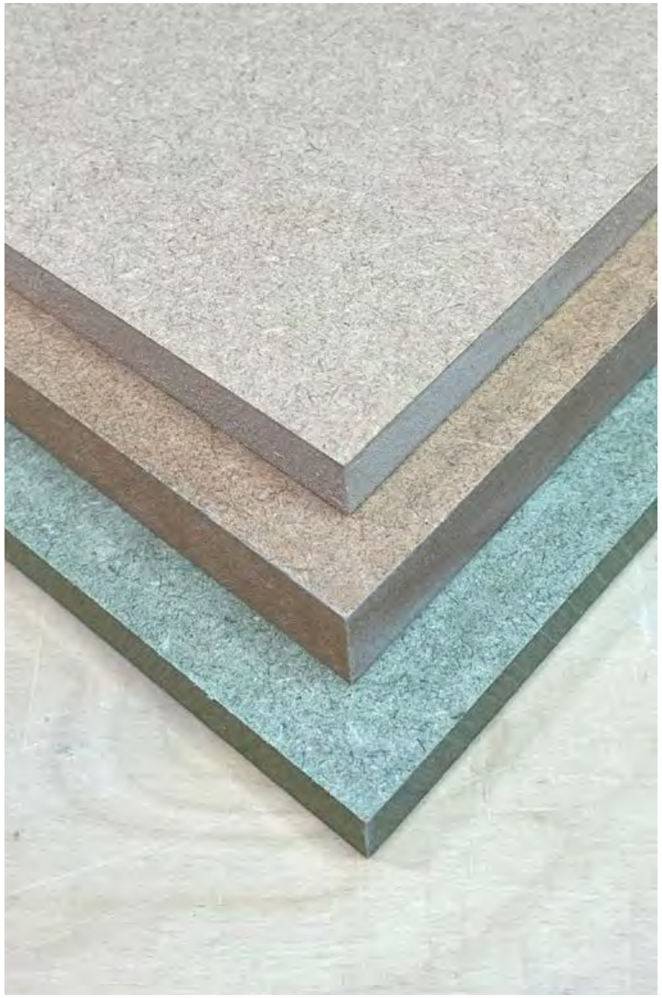


Image 2.11 Fibreboard

Hardboard:

Hardboards are the densest fiberboards typically ranging in colour from light to dark brown. They have one smooth surface and a mesh-textured underside, although smooth surfaces on both sides are available. BS EN 622–2 describes six grades of hardboard based on load-bearing properties and environmental conditions.

Standard hardboard is suitable for internal applications such as panelling, wall and ceiling linings, floor underlays, and furniture. Various surface textures including perforated, embossed, and textured options are available.

Tempered hardboards are also available which are denser and stronger than typical hardboards due to further modifications in the manufacturing process. Their increased robustness make them suitable for external and structural applications including cladding and lining for formworks.

Grade	Loading	Conditions	Colour Code
HB	General Purpose	Dry	White, White Blue
HB.H	General Purpose	Humid	White, White Green
HB.E	General Purpose	Exterior	White, White Brown
HB.LA	Load-bearing	Dry	Yellow, Yellow Blue
HB.LA1	Load-bearing	Humid	Yellow, Yellow Green
HB.LA2	Heavy Duty, Load-bearing	Humid	Yellow Green

Image 2.12 Hardboard grading to BS EN 622-2

Image 2.13 Hardboard with smooth and mesh textures

National Standard

Fibreboards. Specifications - Requirements for hardboards
BS EN 622-2

Mediumboard and Softboard:

Mediumboard (both high density and low density) to BS EN 622–3 and softboard possess a variety of physical attributes influenced by the level of compression applied during manufacturing.

Exterior grades (E) are suitable for general purposes including exterior cladding. Higher density grades (H) find application in wall linings, sheathing, partitioning, ceilings, and floor underlays. Low-density medium-board (L) is employed for wall linings, panelling, ceilings, and noticeboards. Softboard is typically employed for its acoustic and thermal insulation properties.

BS EN 622–4 describes five grades of softboard based on load-bearing requirements and environmental conditions.

Grade	Loading	Conditions	Colour Code
MBL	General Purpose	Dry	White, White Blue
MBH	General Purpose	Dry	White, White Blue
MBL.H	General Purpose	Humid	White, White Green
MBH.H	General Purpose	Humid	White, White Green
MBL.E	General Purpose	Exterior	White, White Brown
MBH.E	General Purpose	Exterior	White, White Brown
MBH.LA1	Load-bearing	Dry	Yellow, Yellow Blue

Image 2.14 Mediumboard grading to BS EN 622-3

Grade	Loading	Conditions	Colour Code
SB	General Purpose	Dry	White, White Blue
SB.H	General Purpose	Humid	White, White Green
SB.E	General Purpose	Exterior	White, White Brown
SB.LS	Load-bearing	Dry	Yellow, Yellow Blue
SB.HLS	Load-bearing	Humid	Yellow, Yellow Green

Image 2.15 Softboard grading to BS EN 622-4

National Standard

Fibreboards. Specifications - Requirements for mediumboards
BS EN 622-3

Fibreboards. Specifications - Requirements for softboards
BS EN 622-4

Wood Wool Slabs

Wood wool slabs are created by compressing long strands of wood fibres covered with Portland cement. It has a porous texture, suitable for various applications including spray painting, as a base for plastering, or can be left exposed. It also serves well as a permanent formwork for concrete. Standard sizes outlined in BS EN 13168.

Both plain-edged slabs or those with interlocking galvanized steel channels along the longitudinal edges are available. Thicknesses of 15-50mm are appropriate for partitions, linings, and permanent concrete formwork. Thicker grades, spanning 50-150mm, are suitable for roofing. Composite slabs incorporate additional insulation layers to improve thermal performance.

Wood wool slabs excel in sound absorption due to their porous surface, retaining this quality even after applying sprayed emulsion paint. Their acoustic properties are ideal for areas like partitions, internal walls, and ceilings.

National Standard

Thermal insulation products for buildings. Factory made wood wool (WW) products. Specification
BS EN 13168

Compressed Straw Slabs

Compressed straw slabs are created by compacting straw under heat and pressure, then encasing it in a fibreglass mesh and plaster-grade paper. The panels should be protected from moisture and are commonly used for internal partitioning, affixed to a timber sole plate and joined either with adhesive or dry fixings. Panels may include service holes at regular intervals, the entire partitioning system is finished with a layer of plasterboard.

Thatch

Thatch roofing in the UK primarily uses water reed, long straw (often wheat), and combed wheat reed. Water reed lasts longest, about 50-60 years, while long straw and combed wheat reed last around 20-30 years, depending on location and roof pitch. All thatched roofs require reridging every 10-15 years, often using saw sedge for water reed. Netting is commonly used to prevent bird damage. Combed wheat reed and water reed have a dense finish with straw ends forming the roof surface. Thatch roofs typically have a pitch of around 50°, with at least 45° being recommended for durability.

Thatch provides good insulation, keeping buildings cool in summer and warm in winter. While fire hazards are a concern, fire resistant coatings can be applied, though they may affect the material's integrity.

Image 2.16 Wood wool slab

Image 2.17 Thatch roof edge

Shingles:

Western red cedar is commonly used for roofing or cladding in the form of shingles or shakes. Shingles are cut to shape, while shakes are split, usually 10-13mm thick. They may be tapered or straight, typically 400-600mm long. Pressure treatment with preservatives enhances durability, and flame resistance are required to meet relevant fire ratings of BS 476–3.

A minimum pitch of 14° is required, with three layers usually required. While straight coursing is standard, staggered patterns and profiled shingles can add decorative effects, especially on steeper pitches. Shingles should be laid over a waterproof breather membrane for pitches between 14° and 22°. BS 5534 suggest a minimum side lap of 38mm for shakes and shingles.

National Standard

Fire tests on building materials and structures - Classification and method of test for external fire exposure to roofs
BS 476–3

Slating and tiling for pitched roofs and vertical cladding. Code of practice
BS 5534

2.2.13 Specialist Products

Brettstapel

Brettstapel, or 'Dowellam', is a solid wood construction method using softwood posts and hardwood dowels, without nails or adhesive. Typically found in Austria, Switzerland, and Germany, this technique involves fir or spruce posts joined by beech dowels, which expand to lock the posts together as moisture contents equalize. Units measuring up to 600mm wide and 80–300mm thick can span up to 8 m, with options for reducing laminate separation through diagonal dowels or cross-lamination.

Steko Blocks

Steko® is a wall system utilising precisely engineered hollow timber blocks that interlock without fixings or glue, forming load-bearing walls. Blocks consist of two 20mm-thick panels glued to horizontal battens, separated by vertical studs.

The blocks fit together with tongue and groove profiles and vertical dowels. Walls can be up to 20m long and 3m high without additional bracing, extending to four or five storeys high with proper horizontal bracing from intermediate floors and the roof. To avoid contact with surface water, Steko construction requires an upstand and external protection with breather paper during construction to prevent rain damage.

Image 2.18 Brettstapel wall panel

Translucent Timber Panels

Translucent timber panels comprise of wood laminates interspersed with glass fibres and bonded with high-strength adhesive. They come in various thicknesses from 4mm to 50mm, allowing for the transmission of sunlight or artificial light and customisable visual effects with applied graphics.

Flexible Veneers

Flexible veneers, backed with paper or fibre reinforcement, allow for easy handling without splitting and can be moulded onto profiled components of MDF or plywood.

Decorative Timbers

Decorative materials such as palm and coconut wood, along with coconut shell, serve as surface finishes, including flooring, with palm wood now utilised in palm plywood production.

2.2.14 Recycling Timber

The Timber Research and Development Association (TRADA) estimates that the UK produces around 4.1 million tonnes of timber waste annually, with less than 30% ending up in landfills, emitting methane as it decomposes. Roughly half of this waste comes from construction and demolition activities. Poor handling and storage on-site result in about 10% wastage of new timber products, but initiatives like Site Waste Management Plans aim to reduce this loss. Of the 2.8 million tonnes recycled, nearly half is used for particleboard production, a quarter as biomass fuel, and the rest for animal bedding and horticultural products.

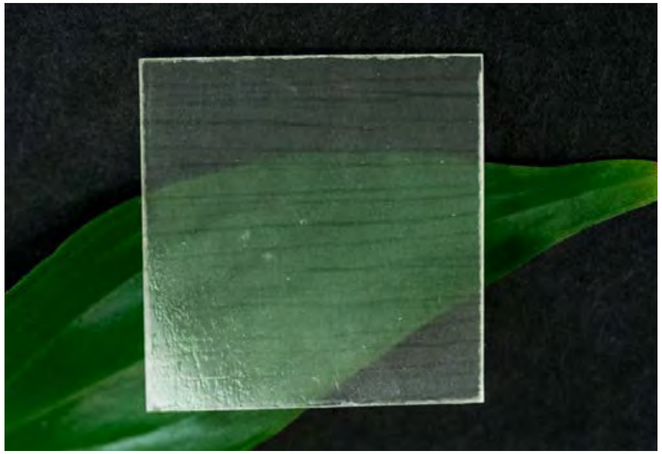


Image 2.19 Translucent timber

Image 2.20 Flexible wood veneer samples

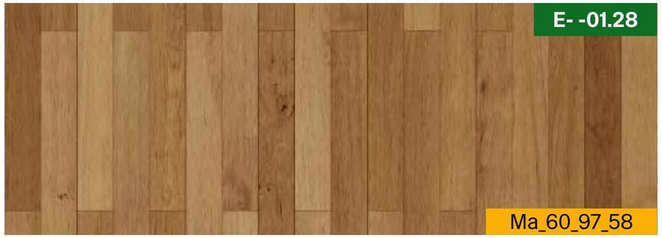
Section 2: Materials & Finishes

2.2 Timber - Floors

Hardwood - Ash

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Light
Finish - Natural, stained
Size - Varies
Reference example -



Hardwood - Oak

Application:
Various; structural, flooring

Specification:
Colour - Light, Mid-tone
Finish - Natural, stained
Size - Varies
Reference example -

Hardwood - Beech

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Light
Finish - Natural, stained
Size - Varies
Reference example -

Hardwood - Maple

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Mid-tone, Red
Finish - Natural, stained
Size - Varies
Reference example -

Hardwood - Walnut

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Mid-tone, Brown
Finish - Natural, stained
Size - Varies
Reference example -

Timber - Embodied Carbon - kgCO2e/kg
(based on ICE database)

Laminated Veneer Lumber
- 01.34kgCO2e/kg

GluLam
- 00.89kgCO2e/kg

E- -01.34 | E-BB.BB | E-CC.CC | E- -0.89 | E-N/A

2.2 Timber - Walls

Cross-Laminated Timber (CLT)

Application:
Structural Members

Specification:
Colour - Light
Finish - Natural, coated
Size - Varies
Reference example - KLH; cross laminated timber

Soft Wood - Douglas Fir

Application:
Internal and external wall finishes and claddings

Specification:
Colour - Light, Mid-tone
Finish - Natural, coated
Size - Varies
Reference example - Mafi; douglas fir

Soft Wood - Larch

Application:
Station facade and external cladding

Specification:
Colour - Light & brown (natural), silver / grey (weathered)
Finish - Natural, coated
Size - Varies
Reference example - Millworks; Siberian larch cladding

Timber Shingles

Application:
External cladding

Specification:
Colour - Varies
Finish - Natural
Size - 400 x 75-300mm
Reference example - Marley; Red cedar shingles

Pine - External Grade

Application:
External cladding

Specification:
Colour - Brown (natural), silver / grey (weathered)
Finish - Coated
Size - Varies
Reference example - Silva timber; ThermoWood pine cladding range

Charred Timber

Application:
External cladding

Specification:
Colour - Black
Finish - Charred
Size - Varies
Reference example - Permachar; charred timber cladding range

2.2 Timber - Ceilings & Soffits

Plywood

Application:
Various internal finishes

Specification:
Colour - Light
Finish - Natural, stained, coated
Size - Varies
Reference example - Garnica; pine range

Parallel Strand Lumber (PSL)

Application:
Structural Members

Specification:
Colour - Brown, Varies
Finish - Natural
Size - Varies
Reference example - Weyerhaeuser; Parallam PSL Beams

Dowel Laminated Timber (DLT)

Application:
Ceilings and internal roof construction

Specification:
Colour - Brown, Varies
Finish - Natural
Size - Varies
Reference example - Structure Craft; DowelLam range

Glued-Laminated Timber (Glulam)

Application:
Structural Members

Specification:
Colour -Light & Brown
Finish - Natural, Coated
Size - Varies
Reference example - Wiehag; GLT bearing systems

Laminated Veneer Lumber (LVL)

Application:
Mainly structural

Specification:
Colour -Light & Brown
Finish - Natural
Size - Varies
Reference example - Södra; laminated veneer lumber

Structural Insulated Panels (SIPs)

Application:
Loadbearing and non-loadbearing walls

Specification:
Colour - Light
Finish - Basic
Size - 200-1220 x 7500mm (maximum)
Reference example - Kingspan; TEK Building System

2.3 Brick

2.3.1 Overview

The history of brick is integral to the history of rail in the UK. From the 19th century the rapid expansion of the railways saw bricks used in enormous quantities to build railway infrastructure and so brick's materiality is often synonymous with railway infrastructure.

The standard metric brick size in the UK is 215 x 102.5 x 65mm (BS EN 771–1). Before the widespread adoption of the metric system bricks were measured in inches, 'imperial' brick sizes vary according to the period of their manufacture. A standard imperial size was introduced in the Victorian era of 228 x 114 x 70mm (9 x 4 ½ x 3").

Common, facing, and engineering bricks each serve individual purposes.

- → Common bricks are used for general building work and lack visual finish, they are typically covered, rendered, or used where they won't be visible.
- → Facing bricks are used for visible brickwork and offer an attractive finish. They vary in colour and texture based on clay blend and firing conditions.
- → Engineering bricks are dense and load bearing, with low water absorption. They are used for heavy loads and areas prone to impact or chemical damage.

Well-built brickwork is durable and low maintenance. Brick recycling is hindered by cement mortar, however crushed bricks are commonly reused as aggregate in further construction.

Brick colours in the UK range widely depending on clay and firing conditions, which determines the various textures and forms that are available. Brick specification includes criteria like form, durability, and appearance, with additional descriptions for specific uses, including dry density and thermal properties. Traditional brick classifications include origin, clay composition, variety, type, and appearance.

2.3.2 Durability

The primary measures of bricks durability are frost resistance, and soluble salt content. High-density clay masonry units, including bricks, are classified into three frost resistance categories: F2, F1, and F0.

- → F2 bricks are resistant to repeated freezing and thawing, even when saturated.
- → F1 bricks are durable except under saturated conditions, so they're not suitable for highly exposed areas but can be used for protected external walls.
- → F0 bricks should only be used when passively exposed, such as when protected by cladding or used internally.

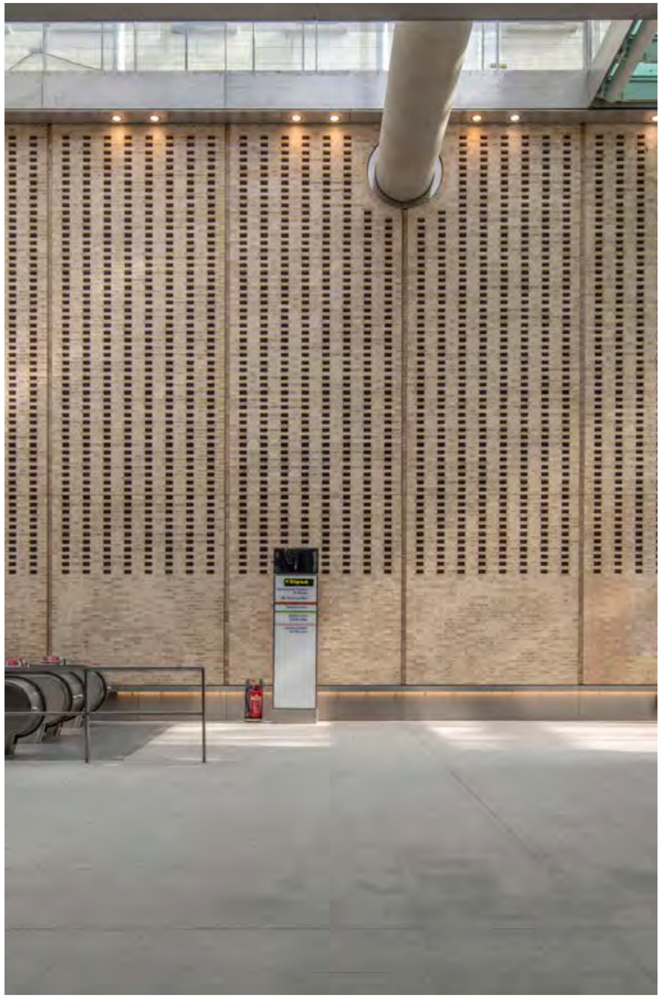


Image 2.21 Paddington Elizabeth Line - Modular Prefabricated Brick

The soluble salt content of clay masonry units, including bricks, is categorised as low (S2), normal (S1), or no limits (S0). S2 and S1 categories have defined maximum limits for salt contents. Soluble salts can lead to efflorescence and sulphate attack on mortar or rendering. If used in exposed situations, S1 and S0 bricks should be bonded with sulphate-resisting cement mortar.

Durability Designation	
Freeze/Thaw Resistance	
F2	Severe Exposure
F1	Moderate Exposure
F0	Passive Exposure
Active Soluble Salts Content	
S2	Sodium/Potassium 0.06%, Magnesium 0.03%
S1	Sodium/Potassium 0.17%, Magnesium 0.08%
S0	No Requirement

Image 2.22 Freeze/Thaw Resistance and Active Soluble Salt Content for Clay Bricks to BS EN 771

National Standard

Clay Masonry Units
BS EN 771

Common Brick Materials

2.3.3 Clay Bricks

There is a wide range of clays suitable for brick making in the UK, creating a variety of products. This diversity is furthered by blending clays, forming processes, surface finishes, and firing conditions. Most UK bricks are high-density (HD) fired-clay masonry units.

Brick-making clays primarily consist of silica and alumina, with varying amounts of chalk, lime, iron oxide, and other minor constituents. For example, Staffordshire Blues and Accrington Reds feature high iron content, while London stocks have a lower iron content coming from chalky clays.

Manufacturers aim to reduce environmental impact by improving the energy efficiency of the firing process and by incorporating recycled materials like quarry fines, pulverized fuel ash, blast furnace slag, and waste glass. External clay brick walls are typically rated A+ in ‘The Green Guide to Specification’. Despite the historical abundance of brickworks, modern transportation and industry mergers have reduced the number of major producers.

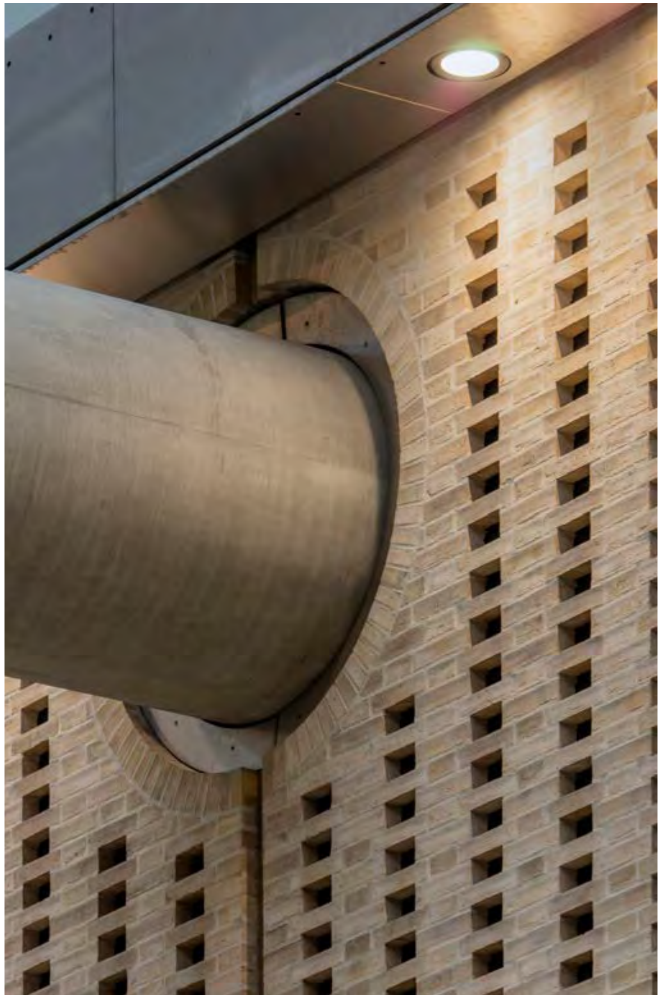


Image 2.23 Paddington Elizabeth Line - Modular Prefabricated Brick

2.3.4 Unfired Clay Bricks

Unfired Clay bricks are used for internal non-load-bearing applications and made from clays less suitable for standard fired bricks. They require low energy for drying and offer high recyclability. They also prevent condensation and regulate internal humidity.

Unfired bricks are traditionally laid with clay or moderately hydraulic lime mortar. Thinner walls may use sodium silicate or stabilised clay-based mortars for stronger bonds. Unfired clay bricks may be left exposed internally. Typical finishes include vapour-permeable renders or plasters made from clay or lime, including lime wash or vapour-permeable paint. Careful detailing is necessary for exposed areas. Offcuts can be used for clay mortar or discarded. Product options include vertically perforated bricks with keyed or smooth finishes.

2.3.5 Calcium Silicate Bricks

Also called sandlime or flintlime bricks, calcium silicate bricks were initially used for common brick applications and gained popularity in the 1950s.

Manufactured with precise shapes and dimensions, untextured calcium silicate bricks offer a smooth finish. They come in a wide colour range, including white, pastels, deep reds, blues, browns, greens, and yellows.

While calcium silicate bricks are unfired and therefore can take less energy to produce than ordinary brickwork, this can make calcium silicate bricks more susceptible to expansion and shrinkage. They should therefore not be used without proper consideration and detailing.

2.3.6 Reclaimed Bricks

Reclaimed bricks are usually suitable for domestic construction due to their strength and water absorption properties. They are often chosen for aesthetics, but their appearance doesn't guarantee durability.

Reclaimed paving bricks exposed to frost are typically durable, but walling bricks may not be suitable for paving. Frost resistance is uncertain, and testing a sample doesn't validate the entire batch. Imperial sizes vary, and some may have sulphate contamination or efflorescence from soluble salts.

Some buildings now use lime mortar to facilitate potential recycling of metric bricks at the construction's end. Lime mortar is easier to clean from bricks compared to modern cement mortar. Roughly two and a half billion bricks are demolished annually in the UK, of which only 5% are reclaimed, with nearly half crushed for hardcore fill.

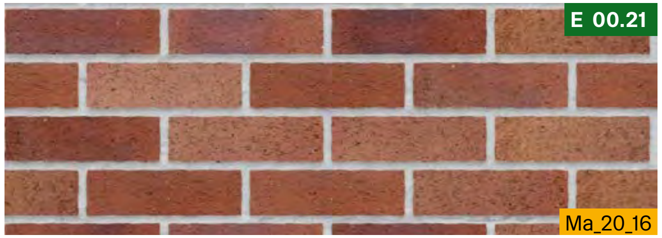
Image 2.24 Reclaimed Bricks

2.3 Brick

Brick - Common

Application:
Station interior; wall

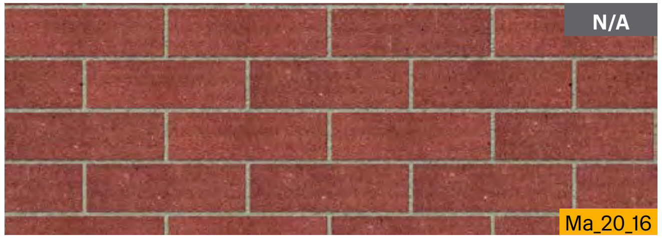
Specification:
Colour - Wide ranging
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - Ibstock; Weston Red Multi Stock Brick



Brick - Facing

Application:
Station interior; walls

Specification:
Colour - Wide ranging
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - Ibstock; Tradesman Wirecut Facing Brick



Brick - Engineered

Application:
Station interior; walls

Specification:
Colour - Typically Red or Blue
Finish - Smooth
Size - 215 x 102.5 x 65mm
Reference example - Weinerberger Engineering Brick - Class A / B

Brick - Recycled Content

Application:
Station interior - walls

Specification:
Colour - Wide ranging
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - Kenoteq; K-briq

Brick - Unfired

Application:
Heritage and visual-uses; facing walls

Specification:
Colour - Red, grey-brown
Finish - Rustic
Size - 215 x 102.5 x 65mm
Reference example - H.G. Matthews, handmade range

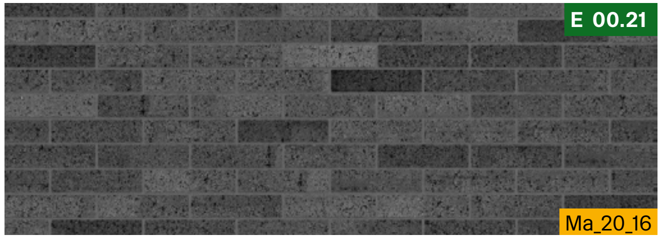
Clay Bricks - Embodied Carbon - kgCO_2e/kg (Based on ICE database)

Clay Brick
0.21kgCO_2e/kg

Brick Hollowcore Insulated
0.70kgCO_2e/kg

E-00.21 | E-BB.BB | E-CC.CC | E-00.30 | E-N/A

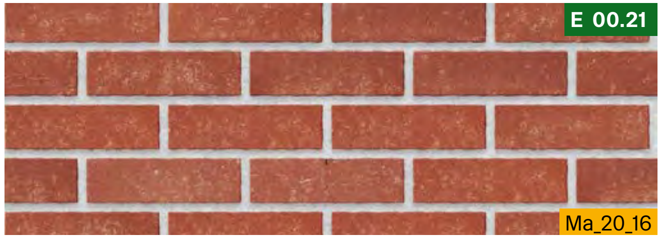
2.3 Brick



Clay - Staffordshire Blue

Application:
Non-visual uses; load-bearing walls, groundworks

Specification:
Colour - Blue/Grey
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - Wienerberger Staffordshire Smooth Blue Solid K10165s



Clay - Accrington Red

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Red
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - Forterra Abbey Red Mutli Brick

Clay - London Stock

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Yellow / Grey-Brown
Finish - Natural
Size - 215 x 102.5 x 65mm
Reference example - H.G. Matthews, handmade range

Brick - Sandlime / Calcium

Application:
Non-visual uses; load-bearing walls, groundworks

Specification:
Colour - White, Grey, Yellow, Red
Finish - Smooth
Size - 215 x 102.5 x 65mm
Reference example - Solent White Calcium Silicate Brick

Brick - Reclaimed

Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Varies
Finish - Aged and rustic
Size - Varies
Reference example - Watling Reclamation, reclaimed brick

2.4 Stone

2.4.1 Overview

Stone is broadly distinguished by the three major geological classifications: Igneous, Sedimentary, and Metamorphic rock, each of which contains various stones commonly used in construction.

Igneous Stone

2.4.2 Granite

Granite is known for its durability, water resistance, and resilience to impact damage, making it ideal for construction in various environments. The appearance of granite can be altered through different surface finishes such as sawn, punched, honed, or polished. The highly polished finish enhances the colours and reflective properties of the crystals. Some granite surfaces are flamed to create a spalled texture.

Granite is available in various colours, including grey and pink from quarries in Scotland, the North of England, Devon, and Cornwall. Other colours like black, blue, green, red, yellow, and brown are imported. Due to its cost, granite is commonly used as cladding material or cast directly onto concrete units for external and internal use. It's also used for flooring and hard landscaping like paving, setts, and kerbs.

2.4.3 Basalt

Basalt is a fine-grained stone similar in hardness to granite which can be melted and cast into tile units with a deep steel-grey colour. A slightly patterned finish can be created in this process by swirling the molten basalt within the mould.

Basalt forms a hard, low-maintenance surface with shades of green, red, and bronze which can be achieved by annealing in a furnace. Larger units available in honed or polished finishes can be fabricated to size.

Image 2.25 Installation of Granite cladding

Sedimentary Stone

2.4.4 Sandstone

Sandstones vary in texture from fine to coarse, depending on the original sand deposit. They are generally resistant to frost and come in colours ranging from white, buff and grey, to brown and red, depending on the natural cement.

Common finishes include sawn, split-faced, and clean-rubbed, with options for tooled finishes like broached and droved. Sandstone for cladding is typically 75–100mm thick and installed using non-ferrous cramps and corbels.

Sandstones are quarried in Scotland, the North of England, Yorkshire, and Derbyshire, including varieties like old and new red sandstones, York Stone, and Millstone Grit. Sandstone is also imported from Spain and Italy.

Name	Typical Colour		Source	Character
Doddington	Purple/Pink		Northumberland	Fine to Medium Grain
Darley Dale - Stancliffe	Buff		Derbyshire	Fine Grained
Birchover Gritstone	Pink to Buff		Derbyshire	Medium to Coarse Grained
York Stone	Buff, Fawn, Grey, Light Brown		Yorkshire	Fine Grained
Mansfield Stone	Buff to White		Nottinghamshire	Fine Grained
Hollington	Pale Pink, Dull Red, Pink with Darker Stripe		Staffordshire	Fine to Medium Grained
St Bees	Dark Red		Cumbria	Fine Grained
Blue Pennant	Dark Grey/Blue		Mid-Glamorgan	Fine Grained

Image 2.26 Typical character of UK Sandstone by region

2.4.5 Limestone

Limestones are primarily composed of calcium carbonate and categorised based on their formation. They come in various colours, including off-white, buff, cream, grey, and blue.

In England, limestone deposits are found in a belt stretching from Dorset, the Cotswolds, Oxfordshire, and Lincolnshire to Yorkshire. Additionally, limestone is imported from Ireland, France, and Portugal to expand the range of available colours.

Standard finishes for limestone include fine rubbed, fine dragged, and split-faced, with options for tooled finishes. It's important to avoid mixing or placing limestone above sandstones externally, as this can lead to rapid deterioration of the sandstone.

Name	Typical Colour		Source	Character
Ancaster	Cream to Buff		Lincolnshire	Spheroidal Grain, Variable shell content
Bath Stone	Pale brown to light cream		Avon	Spheroidal Grain
Clipsham	Buff to Cream		Rutland	Medium Spheroidal Grain
Doulting	Pale Brown		Somerset	Coarse Textured, Fossils uncommon
Hopton Wood	Cream or Grey		Derbyshire	Contains many fossils
Ketton	Pale Cream to Buff and Pink		Lincolnshire	Medium Spheroidal Grained with even texture
Portland Stone	White		Dorset	Exposed faces weather white
Purbeck	Blue/Grey to Buff		Dorset	Some shells

Image 2.27 Typical character of UK Limestone by region

Metamorphic Stone

2.4.6 Slate

Slate originates from fine-grained, sand-free clay sediments. To achieve a natural riven finish, it can be split into thin sections, typically 4–10mm thick for roofing. Alternatively, it can be processed through various methods such as sawing, sanding, fine rubbing, honing, polishing, flame texturing, or bush hammering. Slate comes in the distinctive colours of blue/grey, silver grey, and green from the Lake District, with various shades from regions like North Wales and Cornwall. Additionally, slate is imported from countries such as Ireland, Canada, France, India, China, Brazil, and Spain.

As a roofing material, slate is durable, acid- and frost-resistant, with a lifespan of up to 400 years. It's recommended for roofs with a minimum pitch of 20° under sheltered or moderate exposure, and 22.5° under severe exposure, using the longest slates available (400 to 600mm). Fixing nails should be made of copper or aluminium. Slate is also utilised for flooring, cladding, copings, cills, and stair treads, either fixed with non-ferrous fixings or cast directly onto concrete cladding units. Recycled Welsh slate is commonly used in conservation projects and new builds where an aged appearance is desired.

Image 2.28 New roof slates at Knaresborough station

2.4.7 Marble

Marble is metamorphosed limestone which exhibits various colours and veining patterns due to impurities in the original limestone. Colours range from red, pink, and violet to brown, green, beige, cream, white, grey, and black. Marble is susceptible to acid erosion, so honed surfaces are recommended for external applications. While generally hard and dense, some marbles may require filling of fissures and veins with epoxy resins.

Most marbles used in Britain are imported from Europe. For external cladding above the first-floor level, 40mm thick slabs are common, and 20mm thickness typically suffice for internal linings and lower-level external cladding. Fixing cramps and hooks are to be made of stainless steel, phosphor bronze, or copper.

2.4.8 Reconstituted Marble

Reconstituted marble is made from marble chippings and resin and crafted into tiles and slabs for wall and floor finishes. It mimics the colours of marble but lacks its characteristic veining.

Image 2.29 Marble floors and walls at the World Trade Centre - Transportation Hub in New York

2.4.9 Alabaster

Alabaster is composed of naturally occurring gypsum or calcium sulphate and traditionally used for carved monuments and ornaments in the UK. It typically appears white and translucent, though traces of iron oxide can introduce light-brown, orange, or red hues.

2.4.10 Quartzite

Quartzite is derived from metamorphosed sandstone and is highly durable and hard-wearing, and therefore primarily used for flooring. Its composition allows for easy splitting along smooth cleavage planes, resulting in a riven finish. Imported mainly from Norway and South Africa, quartzite comes in various colours such as white, grey, grey-green, blue-grey, and ochre.

Image 2.30 Reconstituted marble

Image 2.31 Quartzite

Composite Stone

2.4.11 Agglomerated Stone

Agglomerated stone is made from aggregates bound with cement or resin, and defined in BS EN 14618.

These aggregates can include natural stone or recycled materials like crushed ceramics or glass. It is cast into blocks or slabs for tiles, with surface finishes including polished, honed, sand-blasted, flamed, or sawn.

Terrazzo tiles (BS EN 13748) use crushed natural stone in a cement binder, either single-layered or with facing and base concrete layers.

2.4.12 Cast Stone

Cast stone is the replication of natural stones such as Bath, Cotswold, Portland, and York using stone dust, natural aggregates, and cement. Iron oxide pigments may also be added for colour matching.

Specialist manufacturers achieve high-quality finishes, often surpassing natural stone in strength and moisture resistance. Standard architectural components such as columns, capitals, and balustrades are available, with custom products also possible.

It can be homogeneous or bonded to a concrete backing, with a minimum facing thickness of 20mm as per BS 1217. Steel reinforcement should have at least 40mm cover or 30mm if galvanized, while corrosion-resistant metals require at least 10mm cover. Cast stone weathers similarly to natural stone, careful workmanship is necessary to avoid mortar staining.

National Standard

Cast Stone Specification
BS 1217

Agglomerated Stone. Terminology and Classification
BS EN 14618

Terrazzo Tiles - Terrazzo Tiles for Internal Use
BS EN 13748

Image 2.32 Composite Stone material samples in Charcoal, Light and Dark Grey and Portland colours

Typical Uses in Construction

2.4.13 Stone Cladding

In large commercial constructions, stone serves as a cladding material, adhered mechanically to the structural framework. BS 8298 2–5 outlines structural issues, including fixings, backup material, and joints. Cladding panel thickness is determined by stone strength; granites, marbles, and slate typically use 40mm slabs for external elevations above ground-floor level, while softer limestones and sandstones require a minimum thickness of 80mm.

Fixings should be stainless steel or non-ferrous metal, sized to support cladding dead loads and wind-induced stresses. Movement joints accommodate structural and thermal/moisture-related movements. Ground-level protection from impact damage is recommended.

2.4.14 Stone Faced Precast Cladding Systems

The integration of stone veneer on concrete panels acts as an alternative to traditional stone cladding. In this system, stone is affixed to concrete using inclined non-corroding dowels for mechanical fixing. For limestone and sandstone, a 50mm stone veneer is necessary, while granite, slate, quartzite, and marble typically require 30mm. Concrete panels should have appropriate reinforcement and fixings per BS 8298–3.

2.4.15 Gabions

Gabions are wire cages filled with crushed rocks or recycled concrete rubble that are commonly used in civil engineering for retaining walls. They can be stacked vertically or at an incline, transmitting compressive loads through the stones or rubble while spreading movement is restrained by the wire cage. Gabion cages are typically made of heavy gauge woven or welded steel mesh, coated with zinc, aluminium/zinc alloy, or PVC. For load-bearing building applications, stainless steel is recommended. Gabions are available filled or flat-packed for filling and fastening, usually with a helical binder in alloy-coated or stainless steel and come in various sizes typically based on a metre module.

2.4.16 Dressed Stone

Dressed stone serves as an alternative to brick or block in standard cavity construction for the external leaf. Limestone, sandstone, and locally available slate are common choices. While random rubble and hand-dressed stone can be sourced from suppliers, sawn-bedded stones, finished split-faced, pitch-faced, fine-rubbed, or sawn, are more readily available. Standard sizes typically range from 100 to 105mm on bed, with course heights varying from 50 to 300mm. Mortar for stone masonry should be weaker than the stone selected.

Image 2.33 Retaining wall constructed with gabions

National Standard

Stone-faced Precast Concrete Cladding Systems
BS 8298-3

2.4.17 Lightweight Stone Cladding

Thin-section stone is bonded to lightweight backing materials, significantly reducing dead weight compared to traditional techniques. Materials like sandwich panels with a honeycomb aluminium core faced with epoxy resin skins provide lightweight stone finishes while maintaining visual quality.

2.4.18 Stone Faced Masonry Blocks

Standard-sized concrete blocks with a veneer of polished marble or granite are fixed using frost-resistant adhesive. Special shapes like quoins and lintels are available with mitred-stone corner joints.

National Standard

Stone Cladding on Rainscreen Support Systems
BS 8298-4

2.4.19 Stone Rainscreen Cladding

Rainscreen systems feature stone panels fixed to the backing wall by durable metal framing, leaving a drained void space that is often filled with thermal insulation. Panels may be solid or laminated with lightweight concrete.

Prefabricated external and internal corner units match the facade. BS 8298–4 outlines drained and ventilated rainscreen and pressure-equalized systems.

2.4.20 Deterioration of Stone

Stone deterioration is primarily caused by soluble salt action, atmospheric pollution, frost, metal corrosion, and design/workmanship flaws.

Frost damage affects wet areas of a building like copings, cornices, and window hoods, and leads to stone separation. Limestones are more prone to frost damage than sandstones, while marble, slate, and granite are generally frost-resistant due to their low porosity.

Copper run-off can stain limestones green, while iron and steel cause rust staining and expansion, damaging stonework. New fixings should use stainless steel or non-ferrous metals.

Image 2.34 Farringdon Station - Stone rainscreen cladding

2.4.21 Cleaning

Granite, marble, and slate claddings require regular mild detergent cleaning. External marble should be washed biannually to maintain its polish.

Limestone, if not self-cleaned by rainwater, requires gentle water spray and brushing to remove deposits without damaging the surface.

Sandstone is typically cleaned with abrasive blasting or chemical methods, but caution is required to prevent damage.

Unpolished granite can be cleaned chemically or abrasively, while polished granite should only be treated with alkaline solutions and neutralized afterward.

BS 8221–1 recommends careful inspection and testing before full cleaning, especially for historic buildings, where specialist advice or permissions may be necessary.

National Standard

Code of Practice for Cleaning and Surface Repair of Buildings - Cleaning of Natural Stone, Brick, Terracotta, and Concrete
BS 8221-1

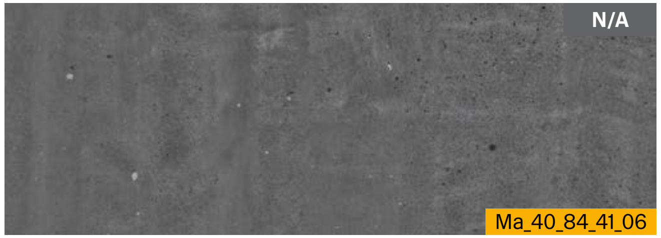
Image 2.35 Cleaning and maintenance of natural stone facade

2.4 Stone

Granite

Application:
Station exteriors and interiors; walls, flooring

Specification:
Colour - Grey, Pink, Black, Blue, Green, Red. Yellow, Brown
Finish - Varies
Size - As required



Basalt

Application:
Station exteriors and interiors; walls, flooring

Specification:
Colour - Grey
Finish - Varies
Size - As required

Sandstone

Application:
Station exteriors and interiors - High traffic station areas; waiting rooms, concourses, passages

Specification:
Colour - Pink, Buff, Grey, Brown, Red, Blue
Finish - Varies
Size - As required

Limestone

Application:
Station exteriors and interiors - High traffic station areas; waiting rooms, concourses, passages

Specification:
Colour - Buff, Brown, Grey, Pink, White, Blue/Grey
Finish - Varies
Size - As required

Slate

Application:
Station exteriors; Roofs

Specification:
Colour - Black / Grey
Finish - Natural
Size - Varies

Stone - Embodied Carbon - kgCO2e/kg (Based on ICE database)

Limestone
0.09kgCO2e/kg

Granite
0.70kgCO2e/kg

E-00.21 | E-BB.BB | E-CC.CC | E-00.70 | E-N/A

2.4 Stone

Reconstituted Marble

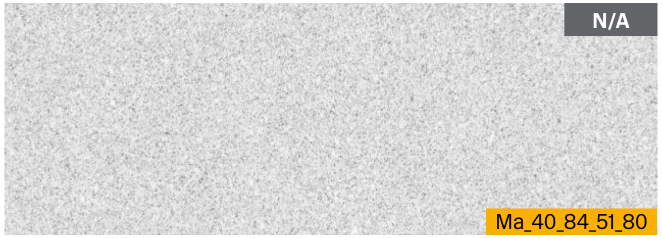
Application:
Mainly heritage and visual-uses; facing walls

Specification:
Colour - Varies
Finish - Polished
Size - Varies

Quartzite

Application:
Mainly heritage and visual-uses; facing walls

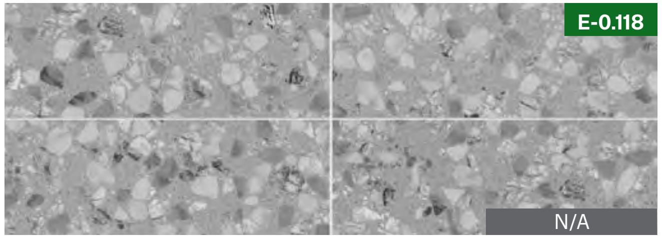
Specification:
Colour - White, Pink, Buff, Grey, Brown, Red, Ochre
Finish - Varies
Size - Varies



Cast Stone - Agglomerated

Application:
Non-visual uses; load-bearing walls, groundworks

Specification:
Colour - Varies
Finish - Varies
Size - Varies



Cast Stone - Terrazzo

Application:
Floors

Specification:
Colour - Varies
Finish - Natural, Smooth, Polished
Size - Varies

Stone - Rainscreen

Application:
Visual-uses; facing walls

Specification:
Colour - Varies
Finish - Varies
Size - Varies

Stone - Gabions

Application:
Generally external and landscaping

Specification:
Colour - Grey
Finish - As Supplied
Size - Typical Modules based on Metre

2.5 Ceramics

2.5.1 Overview

Ceramic materials made from firing clay form some of the oldest building materials. Different types of clay, produced by the weathering of rocks, are fired to make various traditional ceramic products for construction such as bricks, tiles, claddings, and fittings. Note that porcelain tiles are typically stronger than ceramic tiles, making them usually suitable for both walls and floors, while ceramic tiles are typically only suitable for walls.

2.5.1 Ceramic Rainscreen Cladding

Ceramic rainscreen cladding are rainscreen systems suitable for various construction types. They typically include a grid of aluminium extrusions creating an air gap for ventilation. Ceramic rainscreen units, along with other materials like stone laminate or metal, are shaped to shed water and can be easily removed for maintenance or repair.

2.5.2 Fireclay

Fireclay refractory products withstand high temperatures without deformation. They are primarily blends of alumina and silica with high silica and low iron oxide content. Dense products offer high flame resistance, while lower density insulating products are suitable for flue linings. White glazed fireclay is typically used for sanitaryware, floor channels, and industrial and laboratory sinks.

2.5.3 Brick Clays

Glazed bricks offer a low-maintenance, frost- and vandal-resistant material suitable for light-reflecting walls. They are available in various high-gloss, uniform, or mottled colours. Standard and purpose-made specials may be manufactured to order, with mortar joints potentially reduced from the standard 10 to 6mm to lessen their visual impact. For conservation work, firing glazed bricks a second time at a reduced temperature may be necessary to match existing materials.

2.5.4 Terracotta

Terracotta blocks were commonly used in nineteenth-century civic buildings for their durability, mouldability, and cost-effectiveness compared to stone. These blocks are often buff, brown, or red due to iron oxide content. Modern terracotta blocks are available for new construction or refurbishment, offering plain ashlar, profiled, or sculpturally embellished options. Terracotta is also used in floor tiles and decorative ridge tiles and finials.

2.5.5 Faience

Faience is glazed terracotta and was popular in the nineteenth century and is durable but susceptible to surface chipping from strong impacts. It withstands weathering, frost, and ultraviolet light exposure well.

Image 2.36 Edgware Road / Chapel Street sub-station clad in vitreous enamel panels

National Standard
Wall and Floor Tiling
BS 5385

2.5.7 Stoneware

Stoneware produces large ceramic cladding panels for façades and is made from fireclays blended with flux like feldspar. These units are colour-fast and frost- and fire-resistant and may be glazed or unglazed, coming in various colours and finishes.

Stoneware is also used for some floor tiles with low porosity and abrasion resistance classified according to BS EN 14411 standards. Slip resistance is assessed by the pendulum test (BS 7976). See section **1.8.5** for further information.

2.5.8 Earthenware

Wall tiles are commonly made from earthenware clay with added talc or limestone to provide a white burning clay. Standard sizes typically range from 100 to 250mm square or rectangular formats, though larger format sizes are also available.

National Standard

Ceramic tiles. Definitions, classification, characteristics, evaluation of conformity and marking
BS EN 14411

Determination of slip resistance of pedestrian surfaces. Methods of evaluation
BS EN 16165

Image 2.37 Haggerston Station - Decorative tiles

2.5.9 Vitreous China

Vitreous China has a glass-like body that limits water absorption, making it known for its impermeable nature. It is therefore used for sanitaryware and certain floor and wall tiles. Unglazed tiles may feature various textures for non-slip properties, with thickness usually in the range of 8–13mm.

Sizes vary from 200 x 200mm and 300 x 300mm square formats to rectangular and extra-large formats up to 3000 x 1000mm. Matching skirtings are usually available.

2.5.10 Heritage Decorative Tiles

Reproduction moulded ceramic wall tiles are encaustic tiles with vibrant colours, and geometrical floor tiles produced by manufacturers to match existing units for restoration work. These reproduction decorative tiles, made with attention to form, colour, and texture, serve both restoration and new-build projects.

2.5.11 Mosaics

Mosaics in glazed or unglazed porcelain are durable, frost-proof, and resistant to chemicals, with unglazed versions suitable for exterior and wet areas requiring slip resistance. They are often supplied attached to paper sheets for easy application and are also available in glass, stone, and stainless steel.

2.5.12 Ceramic Granite

Ceramic granite is a blend of ceramic and reconstituted stone. It is manufactured from feldspar, quartz, and clay, which is compressed under high pressure, and fired to produce hard, shiny slabs resembling natural marble or granite. Slabs, typically 20 - 30mm thick, come in various colours like ochre, off-white, grey, green, and blue, depending on the starting materials.

Image 2.38 Tottenham Court Road - London Underground mosaic

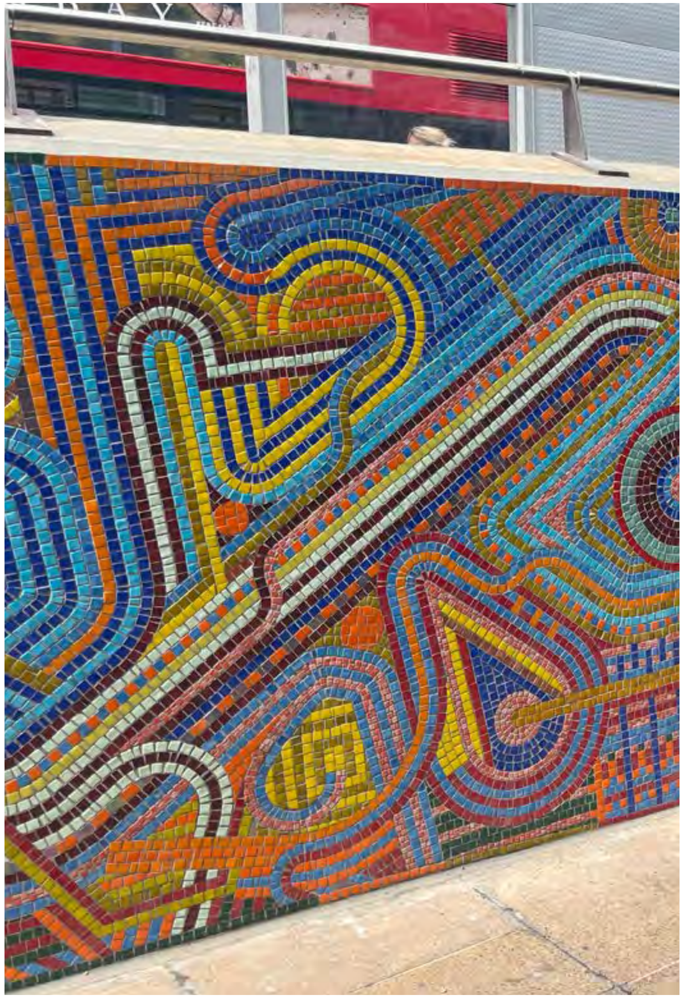


Image 2.39 London Bridge station - Mosaic tile feature wall

2.5 Ceramics

Ceramic - General

Application:
Station interiors; walls,

Specification:
Colour - Light, White, Cream, Buff, Various pigmented options
Finish - Natural, Glazed, Polished
Size - Varies

Porcelain - General

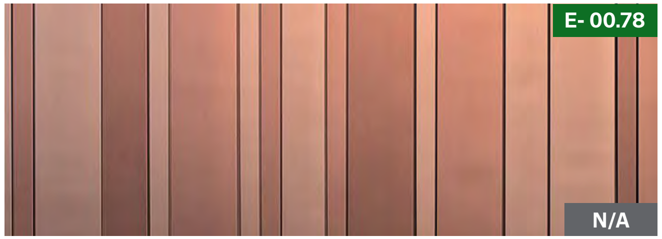
Application:
Station exteriors and interiors; walls, floors, ceilings

Specification:
Colour - Light, White
Finish - Natural, Glazed, Polished
Size - Varies

Fireclay

Application:
Station exteriors; roofing, cladding

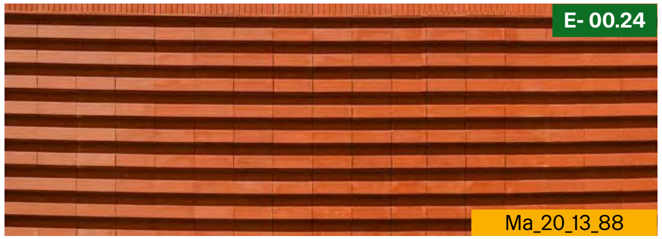
Specification:
Colour - Light, White, Cream, Buff
Finish - Natural, Glazed, Polished
Size - Varies



Ceramic Rainscreen Cladding

Application:
Various; roofing, external cladding, walls, floors

Specification:
Colour - Varies
Finish - Varies
Size - Varies
Reference example - Florim; Porcelain floor and wall tiles



Terracotta

Application:
Station façades

Specification:
Colour - Red brown
Finish - Varies
Size - Varies
Reference example - LOPO; Terracotta rainscreen cladding

Ceramics - Embodied Carbon - kgCO2e/kg (based on ICE database)

Ceramics, *General*	Sanitary Products
00.70kgCO2e/kg	01.61kgCO2e/kg

E- 00.70 | E-BB.BB | E-CC.CC | E- 01.61 | E-N/A

2.5 Ceramics

Ceramic Stoneware

Application:
Toilets and high traffic station areas

Specification:
Colour - Varies
Finish - Natural, Glazed, Polished
Size - 600 x 600mm or 300 x 600mm
Reference example - CTD Architectural Tiles

Specialist / Heritage Decorative Tiles

Application:
Station interior; flooring and walls in heritage environments

Specification:
Colour - Varies
Finish - Natural, Glazed, Polished
Size - Varies

Mosaic

Application:
Station interior; flooring and walls in heritage environments

Specification:
Colour - Wide ranging
Finish - Natura, Glazed, Polished
Size - As required

Faience

Application:
External and internal walls - typically heritage

Specification:
Colour - Varies
Finish - Glazed
Size - Varies
Reference example - Varla

Ceramic Granite

Application:
External facade systems

Specification:
Colour - Varies
Finish - Natural
Size - Varies

Earthenware Tiles

Application:
Station interior; flooring

Specification:
Colour - Varies
Finish - Natural, Glazed, Polished
Size - Varies

2.6 Concrete & Render

2.6.1 Overview

Concrete is an initially mouldable material which easily takes to the shape of the form-work. Once hardened, it can be dense and load-bearing or lightweight and insulating, depending on the aggregates used.

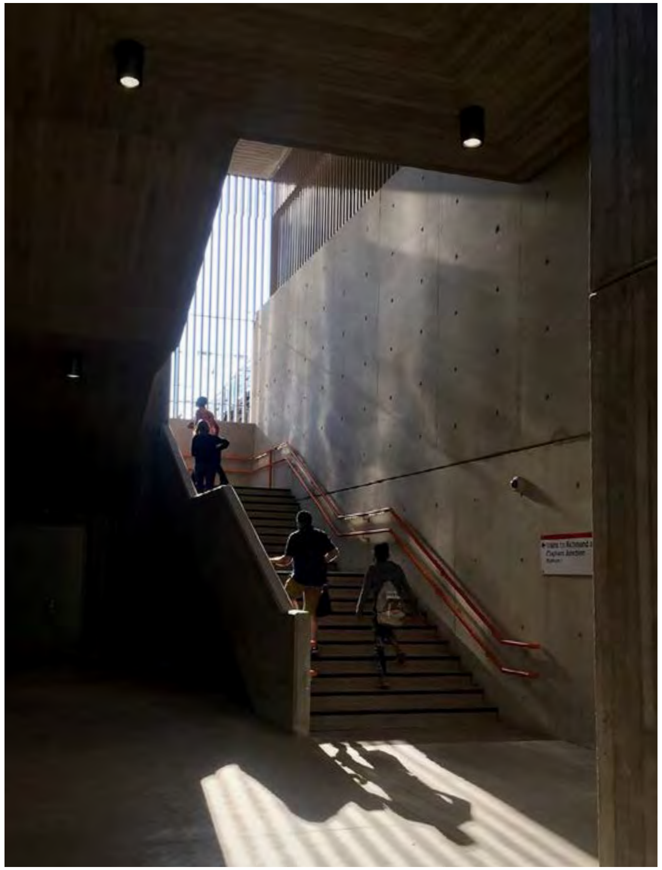
Concrete comprises of cement, aggregates, water, and optional admixtures to modify its properties. Reinforcement with steel is common, and at the end of its life, concrete is often recycled as hard core for new construction. Increasing the use of recycled aggregates in new concrete production can significantly reduce environmental impact by decreasing the requirement for new aggregate extraction.

2.6.2 Quality

Consistent concrete quality requires well-graded coarse and fine aggregates. Good grading provides efficiently filled voids, minimising excess cement. Coarse aggregates are typically graded continuously to fill voids effectively, while well-graded sands have various particle sizes to maintain stability. Excessive fine content increases water and cement requirements. Single-sized or gap-graded coarse aggregates are used for specific purposes like controlled blending or exposed aggregate finishes.

Sands are categorised as coarse (C), medium (M), or fine (F), with only coarse and medium sands suitable for heavy-duty concrete floor finishes.

Image 2.40 Hackney Wick station



Standards Reference

Network Rail - Specification for Concrete
NR/L2/CIV/140/1700C

2.6.3 Reinforced Aerated Autoclaved Concrete (RAAC)

Recent failures in structures constructed with Reinforced Aerated Autoclaved Concrete (RAAC) have raised significant concerns regarding its suitability and reliability. Structural integrity issues, including reinforcement corrosion and inadequate durability, have been observed indicating potential risks to safety and performance.

RAAC should therefore not be used and alternative construction materials and methods with proven reliability considered instead. If RAAC has already been used, thorough assessments of structural integrity should be conducted, and experts engaged for advice to mitigate risks.

2.6.4 No-fines Concrete

No-fines concrete consists of single-sized aggregate and cement paste. Dense or lightweight aggregates can be used, but care is required during placement so that the aggregate remains coated with cement paste. The rough surface provides an excellent base for rendering or plastering, necessary to prevent water, air, or sound penetration. Dense aggregate no-fines concrete can be used for load-bearing applications.

2.6.5 Ultra-High-Performance Concrete (UHPC)

UHPC boasts compressive strength six to eight times that of traditional concrete. It's made from Portland cement, crushed quartz, sand, silica fume, super-plasticizer, fibres, and water, with no aggregates larger than one millimetre. Steel or polypropylene fibres are commonly used, with steel for maximum strength and polypropylene for lower loads.

UHPC can be cast into traditional moulds, pumped, or injection-cast under pressure. Its self-levelling properties mean minimal external vibration of the formwork is required for complete filling. UHPC is designed for use without steel reinforcement bars.

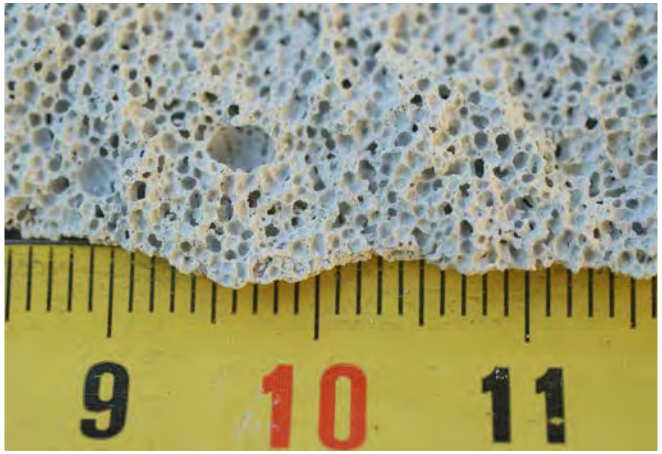


Image 2.41 Aerated concrete

Image 2.42 University of Southern Denmark UHPC facade

2.6.6 Reinforced Concrete

Concrete is strong in compression but weak in tension, with its tensile strength typically only 10% of its compressive strength. Steel reinforcement, due to its strength in tension and good bond with concrete, is universally used.

The placement of steel ‘tendons’ within reinforced concrete is important to allow proper transfer of tensile and shear forces. Longitudinal bars handle tensile forces, while links or stirrups address shear forces and secure the steel during concrete casting.

2.6.7 Visual Concrete

Concrete in construction is often hidden, however it can be used expressively and aesthetically. The production of visual concrete, whether precast or in situ, demands high-quality control in manufacturing and careful consideration of material specification and detailing for proper weathering. Four key factors affect its appearance:

- → Concrete mix composition
- → Formwork used
- → Surface treatment post-casting
- → Quality of workmanship

Producing large smooth concrete areas is challenging due to colour variations and surface blemishes. External smooth concrete weathers unevenly due to dirt build-up and rainwater flow, necessitating early design consideration for textured or profiled surfaces to manage rainwater flow. While precasting offers a wider range of finishes and quality control than in situ work, often both techniques are combined. External renderings provide alternative finishes for concrete and other substrates.

Benefits of visual concrete include removing the need to add further finishing materials, including their costs and waste, while maintaining the durable robustness of concrete.

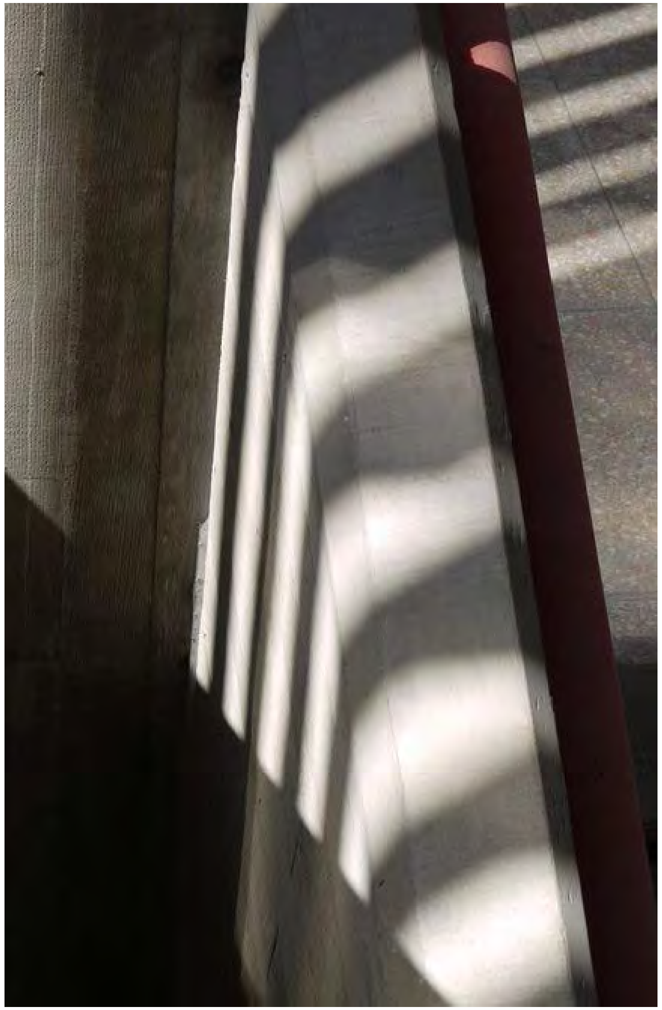


Image 2.43 Balustrade at Hackney Wick station

2.6.8 Precast Concrete

Precast concrete units can be cast vertically or horizontally, with most factory operations favouring horizontal casting for better quality control. Moulds, typically made from plywood or steel, should be tightly manufactured to assure product quality.

Fixing and lifting systems are incorporated into precast units, usually with steel reinforcement. Precast architectural claddings can extend design options, offering natural stone, brickwork, or tiled façades.

2.6.9 In-situ Concrete

The quality of in-situ concrete depends heavily on the initial formwork, as defects are transferred or mirrored in the concrete surface. The formwork should be able to withstand the pressure of fresh concrete pouring without distortion or deformation, with joints tight enough to prevent leakage and honeycombing. Various materials, including timber, metals, and plastics, are used to create formworks depending on the desired finish.

2.6.10 Concrete Finishes

Ribbed and Profiled Finishes

Typically cast in situ against moulds or vertical timber battens, offering sculptural designs. Soft ribbed appearance achieved by removing projecting concrete.

Textured Finishes

Achieved with manufactured moulds or by rough-sawn boards, with the grain effect enhanced by abrasive blasting. Plastic materials can create various patterns, reducing colour variations and blowholes.

Smooth Finishes

Surface texture and water absorbency of formwork or lining determine the final finish. Quality control is important to provide an acceptable finish. Different formwork materials may cause colour variations.

Unformed Finishes

Where a textured finish is required to an unformed surface, for example, to a floor slab the finish is applied immediately after placing concrete, typically by tamping or brushing.

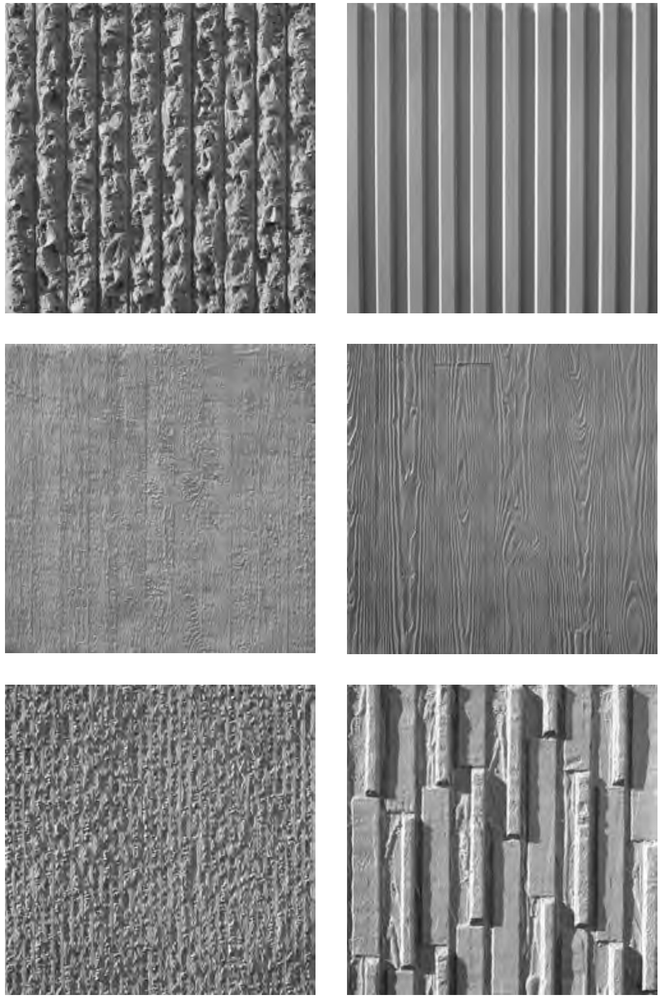


Image 2.44 Reckli® textured and ribbed concrete finish moulds

Tooled Concrete Finishes

Tooling hardened concrete by hand or mechanically provides various textures. Only deep tooling removes minor imperfections. Where deep tooling is required to achieve a desired finish, loss of encasement to any embedded reinforcement should be accounted for and mitigated as part of the initial design.

Abraded, Acid-Etched, and Polished Finishes

Abrasion or acid etching removes surface laitance, creating a stone-like finish. Polishing with carborundum abrasives produces a hard, shiny finish.

Exposed Aggregate Finishes: Coarse aggregate exposed by removing surface smooth layer, providing durability and aesthetics. Stones can be laid in moulds or pressed into the surface.

Coloured Concrete Finishes

Coloured finishes to concrete are typically achieved by dry mixing of integral pigment, alternatively by application of dry-shake topping, or surface-applied stain.

Weathering of Concrete Finishes

Local microclimate, concrete finish, and rainwater mitigation detailing impact weathering. However environmental exposure naturally varies across a buildings separate elevations resulting in differing weathering effects.

Image 2.45 Tooled concrete finish by pick and bush-hammering to expose the aggregate at the Barbican, London

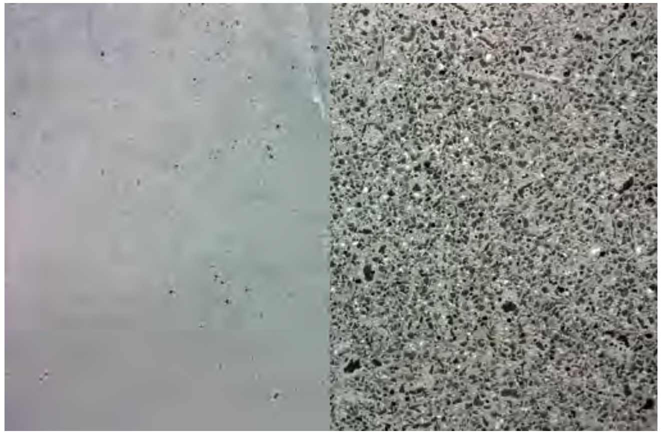


Image 2.46 Smooth concrete surface next to acid etched finish

2.6.11 Concrete Components

Concrete has a widespread use in the production of large in situ and precast units and concrete bricks and blocks. However, the material is also extensively used in the manufacturing of small components, particularly concrete tiles, slates, and paving slabs.

Concrete Paving Slabs and Tiles

Grey concrete paving slabs come in pressed or cast varieties, offering textured or smooth surfaces, simulated riven stone, terrazzo, or textured finishes. Additionally, tooled textured-finished slabs and related products serve visually sensitive areas. They are derived from Portland cement mixes with added pigments to yield standard buff, pink, and red shades.

Standard sizes include 900x600mm and 600x600mm. Beyond standard square and rectangular units, a diverse range of decorative designs such as hexagonal shapes, simulated bricks, and edging units are readily available.

Paving tile units

Designed for external pedestrian areas, frost-resistant Portland cement concrete tiles are manufactured in square and hexagonal designs, featuring standard red, brown, and buff colours. These tiles are suitable for installation on asphalt, bitumen membrane roofing, inverted roofs, and sand/cement screed. Various standard sizes are available with thicknesses typically between 25 and 50mm.

Grass block systems

These systems provide stabilised surfaces for light pedestrian and vehicular traffic while facilitating rainwater infiltration into the ground, thereby contributing to Sustainable Urban Drainage Systems (SUDS) schemes and mitigating flash flooding.

Concrete Roofing Tiles and Slates

Concrete plain and interlocking slates and tiles constitute a competitive array of pitched roofing materials, with concrete interlocking tiles retaining their status as one of the most economically viable and visually acceptable pitched-roof products. These tiles, including plain and feature double-lap and interlocking variants, are crafted in various designs, many of which mimic traditional clay tile forms. Colour ranges typically encompass granular and through-colour finishes, typically brown, red, and grey.

Image 2.47 Concrete paving slabs

Image 2.48 Grass block paving system

2.6.12 Cement

Portland Cement

Portland cement is made from crushed limestone or chalk and an argillaceous material like clay, marl, or shale. The UK produces over 10 million tonnes of Portland cement annually, and most of this production relies on limestone, with chalk used in some regions. Minor elements like iron oxide or sand may be added based on raw material composition and desired product.

Manufacturing methods vary depending on raw material moisture content, with semi-wet, semi-dry, and dry processes in use.

Cements are classified by main constituents, like Portland cement or blast furnace cement, with minor constituents and additives permitted within specified limits. The standard BS EN 197–1 identifies five main types:

- → CEM I Portland cement
- → CEM II Portland-composite cement
- → CEM III Blast furnace cement
- → CEM IV Pozzolanic cement
- → CEM V Composite cement

These types allow a wide range of permitted constituents, and not all are widely available in the UK.

Factory Made Composite Cements

Composite Portland cements encompass not just masonry cement, tailored for specific purposes, but also various other materials categorised in the European Standard EN 197–1.

Masonry Cements

Masonry cements containing water-retaining mineral constituents like ground limestone or hydrated lime, along with air-entraining agents, offer better workability than pure Portland cement. Portland cement mortar, being excessively strong, concentrates any movement discrepancies within brickwork or blockwork into prominent cracks, which are both unsightly and may heighten the risk of rain penetration. In contrast, masonry cement yields a weaker mortar that accommodates some movement differences, dispersing cracks into fine lines within joints, thus maintaining the integrity of the bricks and blocks. Generally, they should not be mixed with additional admixtures but rather with building sand following manufacturer guidelines, depending on the exposure level of the brick or blockwork.

The air entrained during mixing enhances the durability and frost resistance of the solidified mortar. Masonry cement can also be used for renderings but is not suitable for floor screeds or concreting. It is commonly employed as a substitute for a mixture of Portland cement with hydrated lime or plasticizer.

Image 2.49 Portland Limestone

National Standard

Cement - Composition, Specification and Conformity Criteria for Common Cements
BS EN 197-1

European Standard

Cement - Composition, Specification and Conformity Criteria for Common Cements
EN 197-1

Portland Slag and Blast Furnace Cements

Granulated blast furnace slag (GBS) is a cementitious material derived from the steel industry's iron-making process. When combined with Portland cement and suitable aggregates, it produces durable concrete.

In factory-made cements, there are three types of blast furnace cements (CEM III/A, B, and C) outlined in the standard BS EN 197–1 containing varying slag contents with A containing the lowest, and C the highest amounts.

Substituting half of the blast furnace slag for Portland cement in a standard mix reduces carbon dioxide emissions in the overall concrete production process. Concrete incorporating blast furnace slag exhibits lower permeability than Portland cement concrete alone, enhancing resistance to sulphate attack and chloride ingress. This makes it more resistant to corrosion, especially in marine environments and areas exposed to de-icing salts.

National Standard

Supersulfated Cement - Composition, Specification and Conformity Criteria
BS EN 15743

Supersulphated Cement

Supersulphated cement described in BS EN 15743 is made from granulated blast furnace slag, calcium sulphate, and a small amount of Portland cement. It exhibits lower heat of hydration and early strength compared to other cements but offers high resistance to chemically aggressive environments, particularly against sulphates.

Portland-Fly Ash and Pozzolanic Cements

Portland-fly ash cement sets and generates heat at a slower rate compared to Portland cement, making it suitable for mass concrete applications to mitigate the risk of thermal cracking.

Natural volcanic pozzolanas are rarely employed in the UK, whereas fly ash, a by-product of coal-fired electricity generation, is utilised either pre-mixed with Portland cement or blended on-site. Typically, up to 30% fly ash is incorporated, resulting in darker concrete with robust sulphate-resistant properties.

Minor Additional Constituents

Minor additional constituents (MAC) are described in EN 197–1, MAC of up to 5% of the cement's weight can be incorporated into cements. These materials should not increase the water requirements of the cement. MAC can include permitted alternative main constituents such as granulated blast furnace slag, pozzolanas, fly ash, burnt shale, silica fume, kiln dusts, or limestone. Additionally, other inorganic materials may be used if they are not already present as one of the main constituents. Common materials used include limestone and raw meal or partially processed material from cement production.

2.6.13 Low Environmental Impact Cements

Lime-Pozzolan Cement

Lime-pozzolan cement combines natural hydraulic lime with pozzolanic waste materials to control setting and strength. It can achieve concrete compressive strengths similar to Portland cement with approximately 10% less embodied energy.

Belite Cement

Belite cement, made from finely ground raw materials, contains less CO2 emissions compared to alite cement. While it has good long-term properties, it develops strength slowly, so it's often blended with more active components to enhance its potential.

Novel Cements

Innovative cements with lower carbon footprints than Portland cement are being developed in Australia and the USA. These include alkali-activated cements using materials like fly ash, slag, or municipal solid waste incinerator ash (MSWIA). In Japan, MSWIA is also utilised in a process to produce traditional Portland cement, where half of the raw materials are MSWIA or sewage sludge, and waste oils and non-recyclable plastics provide the heat source.

2.6.14 Lime

Lime is made by heating natural calcium carbonate, typically hard-rock carboniferous limestone. This mineral is quarried, crushed, ground, washed, and sifted to the required size. It's then heated in kilns resulting in various lime products depending on the materials used. Limestone and chalk make non-hydraulic or air limes, while mixtures of limestone and clay make hydraulic limes. Further processing creates various additional lime products.

The standard BS EN 459–1 outlines the full range of building limes. Generally, air or non-hydraulic lime is classified based on its calcium and magnesium oxide content, while hydraulic lime is classified based on its compressive strength. Hydraulic cements and limes harden through internal chemical reactions when mixed with water. Non-hydraulic materials harden slowly by absorbing carbon dioxide from the air.

Image 2.50 Lime powder

National Standard

Building Lime - Definitions, Specification and Conformity Criteria
BS EN 459-1

Hydraulic Limes

Hydraulic limes are made from chalk or limestone with varying clay levels. They have properties similar to Portland cement and partially harden through hydration rather than just carbonation like non-hydraulic lime. Those with more clay set faster.

Natural hydraulic limes are categorised as eminently, moderately, or feebly hydraulic based on clay content. Eminently hydraulic lime mortar is for exposed masonry, moderately hydraulic for standard use, and feebly hydraulic for conservation and solid wall construction.

Some grey semi-hydraulic lime is made in the UK from chalk with clay, used with soft bricks and for conservation work. Hydraulic lime is blended with cement, slag, or fly ash, and is often imported from France for historic building restoration.

Lime Mortar

Lime-based mortars offer several advantages over Portland cement mortars. They require less energy to produce, reducing greenhouse emissions, and the carbonation process removes CO2 from the atmosphere. Lime mortars are flexible, allowing for thermal and moisture movement, and minor cracks are healed by rainwater.

Recycling bricks and blocks is easier due to lower mortar adherence. Lime mortar construction is more breathable and more resistant to sulphate attack compared to standard Portland cement mixes.

Hemp Lime / Hempcrete

When combined with hydraulic lime, hemp forms a cement mixture that sets rapidly and solidifies due to the hemp hurd's high silica content forming hempcrete. Hemp is primarily grown in France and yields fibre for paper production. The remaining 75% of the stalk, called hemp hurd or shiv, resembles fine wood chips.

Hempcrete has properties akin to cork as it provides excellent thermal insulation. It's used for floors, non-load-bearing walls, blocks, and panels, often in timber frame construction for added moisture protection. However, it's not suitable for below-ground applications.

External Lime Rendering

External lime rendering typically involves a two or three coat application, building up to a total thickness of around 30mm. In areas prone to weather exposure, hydraulic lime is preferred, the initial coat may be reinforced with horsehair for added strength. The final coat can be trowelled for painting or left rough for pebble dash or rough cast finishes.

Image 2.51 Hempcrete wall

Image 2.52 External lime rendering

2.6 Concrete & Render

Concrete - UHPC (Ultra High Performance)

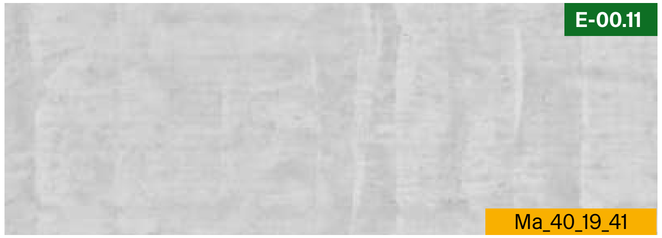
Application:
External and Internal Walls

Specification:
Colour - Grey
Finish - As specified
Size - As required
Reference example -

Concrete - Reinforced

Application:
Various; Structural, Walls, Floors

Specification:
Colour - Grey
Finish - As specified
Size - As required
Reference example -



Concrete - Visual Concrete

Application:
Station interior; Walls

Specification:
Colour - Grey
Finish - As specified
Size - As required
Reference example -

Note: While per kilogram, concrete has a relatively low embodied carbon, due to the vast quantities of concrete often used this can have a large impact on a project's overall embodied carbon.

Concrete - Embodied Carbon - kgCO2e/kg (based on ICE database)

Concrete, General
0.11kgCO2e/kg

Concrete, Aerated
0.48kgCO2e/kg

E-00.11 | E-BB.BB | E-CC.CC | E-00.48 | E-N/A

Concrete - Pre Cast

Application:
Various; Structural, Walls, Floors

Specification:
Colour - Grey
Finish - As specified
Size - As required
Reference example -

Concrete- Lime Rendered

Application:
External Walls

Specification:
Colour - White, Light Grey
Finish - Natural
Size - As required
Reference example -

2.6 Concrete & Render

Hempcrete

Application:
Visual-uses; facing walls

Specification:
Colour - Grey/Brown
Finish - Natural
Size - Varies
Reference example -

Concrete (Self-healing)

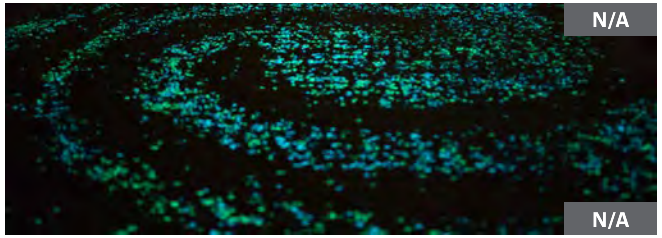
Application:
Various; structural, walls, floors

Specification:
Colour - Grey
Finish - As specified
Size - As required
Reference example - Basilisk; self healing concrete

Carbicrete

Application:
Cement-free concrete blocks; floors , walls

Specification:
Colour - Grey
Finish - Natural
Size - 190 x 190 x 390mm
Reference example - CarbiCrete; cement-free CMUs



Light Generating Cement

Application:
Internal and external floors

Specification:
Colour - Dark
Finish - N/A
Size - As required
Reference example - Studio Roosegaarde; Van Gogh Path

2.7 Metals

2.7.1 Overview

Iron, steel, aluminium, copper, lead, and zinc are examples of the variety of ferrous and non-ferrous metals and their alloys which are common in construction. There's also a shift towards more durable alloys and the use of coatings for protection and aesthetic variation.

While metal production demands significant energy input, their long lifespan and recyclability offset this. In the UK, steel recovery rates from demolition sites are high, with structural steelwork at 99% and all steel products at 94%. About 60% of current steel production comes from scrap, and steel can be recycled indefinitely without quality loss.

National Standard

Hot finished structural hollow sections of non-alloy and fine grain steels - Technical Delivery Requirements
BS EN 10210-1

Cold formed welded structural hollow sections of non-alloy and fine grain steels - Technical Delivery Requirements
BS EN 10219-1

2.7.2 Steel
2.7.3 Structural Steels

Refer to BS EN 10210–1 and BS EN 10219–1 for the standards hot and cold formed structural steels and hollow sections should conform to.

2.7.4 Standard Sections

Standard steel sections encompass a variety of shapes including flat plates, I-sections, channels, angles, universal columns and beams, along with cellular and castellated beams.

Customised production often includes long-span cellular and plated beams used as floor beams spanning 8–24 m and roof rafters extending up to 60 m.

2.7.5 Hollow Sections

Circular, oval, semi-elliptical, square, and rectangular hollow sections are typically formed from flat sections that are progressively bent until they approach a round shape. These sections can be further processed by reheating and hot rolling into various shapes. Cold-formed hollow sections exhibit different material characteristics compared to hot-finished sections and adhere to BS EN 10219.

	Copper (and its alloys)	Lead	Stainless Steel	Cast Iron	Steel	Aluminium	Zinc
Copper (and its alloys)	N/A	Light Corrosion	Moderate Corrosion	Severe Corrosion	Severe Corrosion	Severe Corrosion	Severe Corrosion
Lead	Light Corrosion	N/A	Light Corrosion	No Corrosion	No Corrosion	No Corrosion	Moderate Corrosion
Stainless Steel	Moderate Corrosion	Light Corrosion	N/A	Severe Corrosion	Severe Corrosion	Moderate Corrosion	Severe Corrosion
Cast Iron	Severe Corrosion	No Corrosion	Severe Corrosion	N/A	Moderate Corrosion	Moderate Corrosion	Severe Corrosion
Steel	Severe Corrosion	No Corrosion	Severe Corrosion	Moderate Corrosion	N/A	Severe Corrosion	Severe Corrosion
Aluminium	Severe Corrosion	No Corrosion	Moderate Corrosion	Moderate Corrosion	Severe Corrosion	N/A	Moderate Corrosion
Zinc	Severe Corrosion	Moderate Corrosion	Severe Corrosion	Severe Corrosion	Severe Corrosion	Moderate Corrosion	N/A

Key				
Severe Corrosion	Moderate Corrosion	Light Corrosion	No Corrosion	N/A

Image 2.53 Corrosion between paired metals in construction

2.7.6 Cast Sections

Certain components, such as nodes for rectangular and circular hollow-section constructions, as well as large pin-joint units, are directly manufactured as individual castings. They are then welded onto standard milled steel sections to provide structural continuity. BS EN 10340 lists appropriate structural steels suitable for casting. Alloy steels used for casting may undergo treatments like quenching and tempering, normalising, or annealing based on specific component requirements.

2.7.7 Steel Frame Construction

Light steel frame construction offers efficiency benefits compared to traditional load-bearing masonry and serves as a viable alternative to traditional timber-frame technology. This is a Modern Method of Construction (MMC) that primarily involves cold-formed galvanized steel channel sections which are factory assembled and then bolted together on-site. Panel units, typically measuring 600mm in width and spanning the height of a storey, are lined with a vapour check layer and plasterboard.

National Standard

Steel Castings for Structural Uses
BS EN 10340

Steel Products

2.7.8 Profiled Steel Sheeting

Most profiled sheet steel is manufactured by shaping pre-coated strips through rollers to gradually form the desired section without damaging the applied coating. These standard sections typically have a regular trapezoidal profile, with the depth of the section determined by the loading and span requirements. Stiffeners are incorporated into the profile in cases where there is a risk of buckling. Curved profiled sheets for eaves and soffits are pressed from the same coated strip. While trapezoidal profiles may be crimped during this process, sinusoidal sheets and shallow trapezoidal sections can be curved without such effects. The rigidity of curved sections reduces their flexibility and affects the tolerances of these components.

2.7.9 Steel Cables

Steel cables for suspended structures or pre-stressed concrete are manufactured by twisting individual wires into a strand, then weaving a series of strands around a central core of steel or fibre strand to form a rope. Multiple ropes are then woven to produce cables according to required specifications. Typical configurations utilise 7 or 19 strands or ropes to create heavy-duty cables.

Image 2.54 North Melbourne Station - Stainless Steel

2.7.10 Perforated Steel Sheets, Meshes, and Nets

Perforated steel sheets are available in mild steel, galvanized steel, and stainless steel for use in architectural features, sunshades, balustrades, as well as wall and ceiling panels. These sheets, also offered in aluminium, copper, brass, and bronze, feature round, square, or slotted holes in various sizes and spacings to achieve desired aesthetic effects. Metal sheets are either punched or plasma profile cut. Care should be taken to avoid any perforations or holes becoming potential finger traps or other hazards in public areas.

Stainless steel meshes come in flexible or rigid self-supporting weaves, offering a wide variety of patterns suitable for external façades, sun screening, internal space dividers, balustrades, wall coverings, and suspended ceilings. Patterns range from traditional weave and expanded metal to chainmail, offering diverse textures and transparency levels. Some patterns are available in mild steel and non-ferrous metals. Stainless steel netting can be creatively used to construct open tent and canopy structures.

2.7.11 Weathering Steel

Weathering steels, also known as Cor-Ten, are structural steels alloyed with small amounts of copper. This alloying creates a brown rust coating that adheres tightly to the surface. Careful detailing is necessary to prevent rainwater run-off from impacting other materials, particularly concrete or glass, which may lead to severe staining during initial exposure to the elements.

2.7.12 Stainless Steel

Stainless steels are alloys containing chromium, offering corrosion resistance due to the immediate formation of a natural passive film on the surface. Ferritic stainless steel, containing only chromium, is suitable for internal building use where corrosion is less important. Various grades for construction are listed in BS EN 10088–4 for flat products and BS EN 10088–5 for sections, bars, and rods.

Stainless steel comes in square, rectangular, oval, and circular hollow sections, in addition to standard sections for structural work. Widely used in roofing, cladding, interior, and exterior trim, stainless steel is valued for its strength, low maintenance, and visual appeal. Grades for self-supporting profile sheet and tile roofing systems are outlined in BS EN 508–3.

Cleaning of exposed exterior stainless steel should be undertaken according to the manufacturers recommendations to maintain surface characteristics, particularly for brushed finishes which can attract more dirt over time. It's important to note that not all stainless steel grades require regular cleaning for corrosion protection, as stainless steel is inherently much more resistant to corrosion than mild steel. However, using inappropriate grades in aggressive or marine environments may lead to pitting corrosion, crevice corrosion, or stress corrosion cracking under high tensile load.

Any maintenance requirements for the cleaning of exterior stainless steel surfaces, which may be necessary to maintain surface characteristics, should be specified at the AiP stage, so the Asset Manager is aware of maintenance needs throughout the structure's lifetime.

National Standard

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
BS EN 10088-4

Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes
BS EN 10088-5

Roofing and Cladding products from Metal Sheet. Specification for self-supporting products of steel, aluminium or stainless steel sheet - Stainless Steel
BS EN 508-3

2.7.13 Coated Steels

Coating steel with metal or organic finishes help prevent corrosion. Metallic finishes are typically applied through hot-dipping steel into molten metal, covered under the standard BS EN 10346, while aluminium-coated steel is specified in BS EN 505. Organic coatings (BS EN 10169) include liquid paints, powder coatings, and films, suitable for interior applications.

2.7.14 Polyester and Polyester/Acrylic Bead Coating

Economical polyester coatings offer medium-term life in non-aggressive environments, while polyester with acrylic bead finishes can last up to 40 years with good scratch resistance, suitable for both marine and inland environments.

2.7.15 Polyurethane Coating

Applied as a primer and topcoat to zinc/aluminium alloy-coated steel, polyurethane coatings offer up to 30 years of protection for roofs and cladding in solid and metallic colours.

2.7.16 Enamel Coating

Suitable for internal use as wall and roof linings, organic enamel-coated steels offer good light reflectance and easy cleaning, typically applied to hot-dip zinc/aluminium alloy-coated steel.

2.7.17 Organic Coated Steels

Since the 1960s, various heat-bonded organic coatings for steel have been developed, such as PVC plastisol (Colorcoat), polyvinylidene fluoride (PVDF), polyesters, and PVC film (Stelvetite). PVC plastisol dominates the UK market for cladding and roofing. BS EN 10169 lists the full range of organic coatings and their designation system for proper specification within environmental contexts.

2.7.18 PVC Plastisol Coating

Applied to aluminium/zinc-coated steel, PVC plastisol provides a tough, lightly textured finish available in various colours. The reverse side is coated with a corrosion-resistant primer and polyester finish.

2.7.19 PVDF Coating

Applied to zinc-coated steel, PVDF offers colour stability at high temperatures, making it suitable for global use. The finish is smooth and self-cleaning, requiring careful handling to prevent damage.

2.7.20 Paints

Various paints listed in BS EN ISO 12944–5 protect steel from corrosion, typically applied in three coats for corrosion protection and aesthetic finish. Further guidelines on paint system suitability for environmental conditions and durability are provided in the standard.

2.7.21 Coating Fire Resistance

Coatings can vary with regards to fire performance. Consideration should be made with regards to the specific reaction to fire of coatings when specifying metal finishes as this can affect the overall fire resistance and surface spread of flame.

National Standard

Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions
BS EN 10346

Roofing products from metal sheet. Specification for fully supported roofing products of steel sheet
BS EN 505

Continuously organic coated (coil coated) steel flat products. Technical delivery conditions
BS EN 10169

Paints and varnishes. Corrosion protection of steel structures by protective paint systems - Protective paint systems
BS EN 12944-5

2.7.22 Aluminium

Aluminium is widely used for its durability, especially in secondary components due to aluminium's ductility, allowing for complex shapes and easy forming and machining processes. It is a relatively recent addition to construction materials, having been available for the past 100 years. On Network Rail projects aluminium should typically be anodised.

2.7.23 Aluminium Alloys

Aluminium alloys are categorised as either cast or wrought, with wrought alloys often subjected to heat treatment. The choice of alloy and its composition depends on the desired physical properties. Aluminium finds applications in roofing, cladding, curtain walls, rainwater goods, and various interior components. Minimum sheet thicknesses for self-supporting and fully supported aluminium roofing and cladding are specified by BS EN 14782 and BS EN 14783 respectively.

Finishes for Aluminium

2.7.24 Surface Textures

Various surface textures, such as bright polished, matte, etched, and pattern-rolled, are achieved through mechanical and chemical processes before anodizing.

2.7.25 Metallic Coatings

Zinc-coated aluminium offers the appearance of pre-weathered zinc with the durability of aluminium, typically with a standard sheet thickness of 1mm.

2.7.26 Paint

When painting aluminium for decorative purposes, appropriate primers should be used after abrasion or etching to allow proper paint adhesion, except for cast aluminium which is typically rough enough to receive paint without abrasion or etching.

2.7.27 Organic Coatings

Polyester coatings, available in a wide range of colours, are used for cladding panels, rainwater goods, and double-glazing systems. Other options include PVC, PVDF, and simulated wood grain finishes. BS EN 508–2 describes various factory-applied organic coatings suitable for roofing systems.

2.7.28 Maintenance

Regular cleaning with mild detergent solution is necessary for long-term durability of external aluminium finishes, typically at intervals not exceeding three months. While damaged paint coatings can be touched up on site, factory-applied finishes offer superior durability.

Image 2.55 Lisbon Oriente Station

National Standard

Self-supporting metal sheet for roofing, external cladding and internal lining
BS EN 14782

Fully supported metal sheet and strip for roofing, external cladding and internal lining
BS EN 14783

Roofing and cladding products from metal sheet. Specification for self-supporting products of steel, aluminium or stainless steel sheet - Aluminium
BS EN 508–2

2.7.29 Lead

The use of lead should be avoided due to the long recognised health hazard the material presents. The Control of Lead at Work (CLAW) Regulation states that employees be protected against risks from lead.

However, for some conservation work, sand-cast lead sheet is still produced using the traditional method, where molten lead is poured onto a prepared bed of damp sand. This process often incorporates recycled lead.

Lead sheet thickness is described in BS EN 12588, focusing solely on rolled lead and specifying thickness rather than the code system still sometimes used within the UK. BS EN 14783 defines the minimum thickness for fully supported lead sheet roofing and cladding.

Handling lead requires careful on-site management due to its weight and the toxic fumes produced during lead burning.

National Standard

Lead and lead alloys. Rolled lead sheet for building purposes
BS EN 12588

Fully supported metal sheet and strip for roofing, external cladding and internal lining
BS EN 14783

Image 2.56 Traditional lead roof at St. Laurence's Church, Ludlow

Standards Reference

Health and Safety Executive
Control of Lead at Work Regulations

2.7.30 Copper

Copper comes in various forms such as wire, rod, tube, foil, sheet, and plate. Unlike zinc, copper remains ductile at any temperature. Modern copper façade materials feature textured surfaces, profiled sheets, perforated sheets, and woven mesh. Standard sheet thicknesses are specified by BS EN 1172. The minimum thickness for self-supporting sheet copper is described in BS EN 14782 and for the fully supported material in BS EN 14783.

2.7.31 Weathering

Patina

Exposed copper develops a green patina over time, depending on environmental conditions. On roofs in marine or industrial environments, this patina forms within eight years. Accelerating this process on-site is unreliable, but pre-patinated copper sheets are available where an immediate effect is required.

Corrosion

Copper itself is corrosion-resistant, but rainwater run-off may cause staining on adjacent materials and corrosion to other metals. Specific precautions are required to prevent corrosion in contact with certain materials like steel and aluminium.

Protective Coatings for Copper

Clear coatings are available for copper to retain its original colour and surface finish, but long-term exposure leads to patina formation, which should be considered in the design.

2.7.32 Copper in Building

Traditional and Long-Strip Systems

Copper roofing systems can be traditional or long strip. Traditional systems use standing seams or batten roll jointing depending on pitch and appearance requirements with bays of up to 600mm achievable. Long-strip systems offer cost benefits and can cover larger areas between 8-14m bays without additional supports.

2.7.33 Copper Alloys

Copper may be alloyed with zinc, tin, aluminium, nickel, or silicon to produce a range of brasses and bronzes, the full range is listed in PD CEN/TS 13388.

2.7.34 Anti-Microbial Properties

Copper and its alloys possess natural antimicrobial properties, making them beneficial in combating microbes in frequently used touch points and fixtures in buildings.

Image 2.57 Copper clad Central Signal Box, Basel

National Standard

Copper and copper alloys. Sheet and strip for building purposes
BS EN 1172

Copper and copper alloys. Compendium of compositions and products
PD CEN/TS 13388

2.7.35 Titanium

Titanium is a suitable material for construction owing to its exceptional corrosion resistance. It withstands acids, alkalis, industrial, and marine environments effectively. With a density falling between aluminium and steel, titanium boasts a favourable strength-to-weight ratio.

2.7.36 Properties and Applications

Titanium exhibits a low coefficient of expansion, approximately half that of stainless steel and copper, and one-third of aluminium. This characteristic minimises thermal stress risk, allowing for the installation of longer titanium roofing sheets compared to other metals. Utilising relatively thin roofing and cladding panels (0.3–0.4mm) reduces both dead load and structural support requirements. Beyond roofing and cladding, titanium finds application in fascias, panelling, and protective cladding for piers and columns.

2.7.37 Surface Finish

The standard oxide film on titanium can be thickened through heat treatment or anodizing, resulting in permanent colours spanning from blue and mauve to cream and straw. Stringent control is necessary to maintain colour consistency within a project. Surface finishes vary from reflective bright to soft matte and embossed.

Image 2.58 Titanium cladding - Glasgow Science Centre

2.7.38 Titanium Alloys

The broad spectrum of titanium alloys is categorised by enhanced corrosion resistance, increased strength, or higher temperature resistance. However, current usage primarily revolves around aerospace, industrial, and medical domains. In architectural cladding, the standard material is typically pure titanium (grade 1 or grade 2).

2.7.39 Zinc

Zinc sheet is produced through continuous casting and rolling to a variety of thicknesses. The two primary products available are pure zinc and its alloy, containing titanium and copper. The alloy variant offers enhanced strength, creep resistance, and reduced thermal expansion, allowing for the construction of roof bays up to 10 meters, and in some instances, up to 16 meters in length depending on bay width.

The zinc-copper-titanium alloy (BS EN 988) can be folded or curved to create interlocking cladding panels suitable for vertical, horizontal, or diagonal installation. The minimum nominal thickness for self-supporting zinc alloy is described in BS EN 14782, and BS EN 14783 for fully supporting zinc roofing and cladding.

2.7.40 Weathering of Zinc

Bright zinc undergoes tarnishing in the atmosphere, resulting in the formation of a thin oxide film. This patina acts as a protective layer, halting further degradation of the surface. It's crucial not to mix ordinary zinc with alloyed sheet within the same construction, as they develop different blue-grey patinas. Factory-produced patinas typically appear grey or black, but mineral pigments integrated into the surface and coated with a protective film yield subtle pre-weathered finishes in red, blue, green, or brown.

The longevity of zinc directly correlates with its thickness. A 0.8mm roof sheet can endure approximately 40 years in urban settings, while the same sheet used as cladding, washed clean by rain, may last up to 60 years. Zinc-titanium alloy, offering significantly enhanced durability, boasts a predicted lifespan of up to 100 years in rural environments, contingent upon the application's pitch.

2.7.41 Zinc Finishes

Factory-applied heat-treated polyester lacquer finishes on zinc allow for a variety of colour options including white, brown, gold, terracotta, red, green, grey, and blue. Alternatively, organic coatings such as acrylic, silicone-polyester, polyvinylidene fluoride, and PVC plastisol (to BS EN 506) are available.

2.7.42 Corrosion

To prevent corrosion, zinc should not be in contact with copper or areas where rainwater is draining from copper, or its alloys may discharge onto zinc. However, it can be used alongside aluminium. When in contact with steel or stainless steel, zinc should be the primary component to prevent significant corrosion effects. Prolonged dampness on the underside of zinc sheet due to condensation can lead to pitting corrosion and eventual failure.

It is necessary to design the substructure with appropriate measures such as vapour barriers, insulation, and ventilation to mitigate interstitial condensation. Polluted atmospheres impede the formation of the protective carbonate film, leading to corrosion.

National Standard

Roofing products from metal sheet. Specifications for fully supported roofing products of zinc sheet
BS EN 501

Nominal Thickness (mm)	0.6	0.65	0.7	0.8	1.0	1.2	1.5
No.	4.3	4.7	5.0	5.8	7.2	8.6	10.8

Image 2.59 Typical Zinc / Copper / Titanium Sheet Thicknesses and Weights

Grade Classification	Z1	Z2	Z3	Z4	Z5
Zinc Content (%)	99.995	99.99	99.95	99.5	98.5
Colour Code	White	Yellow	Green	Blue	Black

Image 2.60 Zinc Grades

National Standard

Zinc and zinc alloys. Specification for rolled flat products for building
BS EN 988

Roofing products of metal sheet. Specification for self-supporting products of copper or zinc sheet
BS EN 506

2.7.43 Zinc in Building

Zinc Roofing Systems

Roll cap and standing seam systems are suitable for fully supported zinc and zinc alloy roofing (BS EN 501). Welted joints are customary across bays with pitches steeper than 15°; drips are necessary for pitches below 15°. Pitches exceeding 7° are typically self-cleaning, preventing dirt accumulation and enhancing service life.

Ideal substructures for zinc include timber roof boarding, oriented strand board, or plywood; chipboard is unsuitable except cement-bonded particleboard for cladding. Concrete substrates should be sealed against trapped moisture.

2.7.44 Zinc Cladding Systems

Welted, standing seam and roll cap systems may be utilised for vertical joints for cladding. The maximum bay length for cladding is 6 m, although 3 m is often more practical. Titanium zinc rainwater systems are available with a comprehensive range of standard components. Zinc can also serve as the surface material for interlocking façade panel systems affixed to a sub-frame of timber, aluminium, or stainless steel. A variety of colours are available with a lacquered finish.

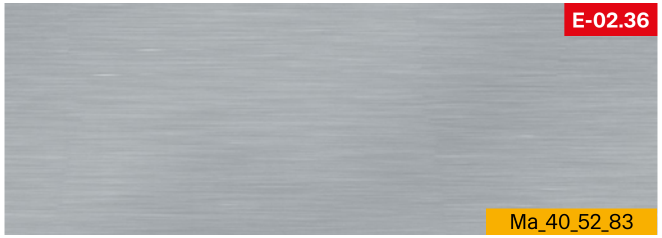
Image 2.61 Zinc cladding - Edinburgh Gateway station

2.7 Metals

Aluminium

Application:
Roofing elements, window frames, shading elements, fixings

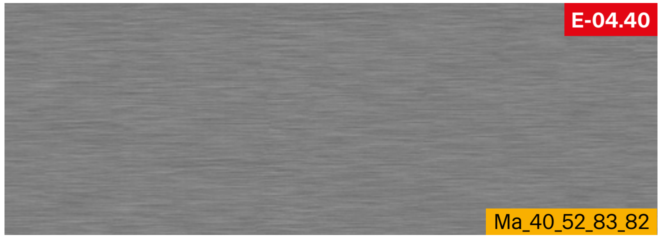
Specification:
Colour - Light & grey
Finish - Powder coated, brushed, mirrored
Size - As required
Reference example - Kalzip; aluminium roof systems



Steel

Application:
Various; structural, internal construction uses

Specification:
Colour - Grey
Finish - Basic
Size - As required
Reference example - Barrett Steel



Stainless Steel

Application:
Various; structural, cladding, fixings, handrails, roofing, skirting

Specification:
Colour - Grey
Finish - Polished, brushed, mirror
Size - As required
Reference example - Thyssenkrupp

Weathering Steel

Application:
External Cladding

Specification:
Colour - Brown
Finish - Weathered
Size - As required
Reference example - Barrett Steel

Iron

Application:
Various; structural, typically heritage uses

Specification:
Colour - Dark
Finish - Natural, Painted
Size - Varies
Reference example - Ballantine Castings

Metals - Embodied Carbon - kgCO2e/kg (based on ICE database)

Lead	Titanium
1.67kgCO2e/kg	14.70 - 42.50 kgCO2e/kg

E-00.11 E-BB.BB E-CC.CC E-14.70 E-N/A

Copper

Application:
Various; roofing, cladding, flashings, copings

Specification:
Colour - Orange (natural), green (oxidised)
Finish - Matt, Brushed, Mirror
Size - As required

Zinc

Application:
Various; roofing, cladding

Specification:
Colour - Grey (natural), Brown (oxidised)
Finish - Natural, Pre-weathered
Size - As required
Reference example - Rheinzink; zinc cladding facade systems

Brass

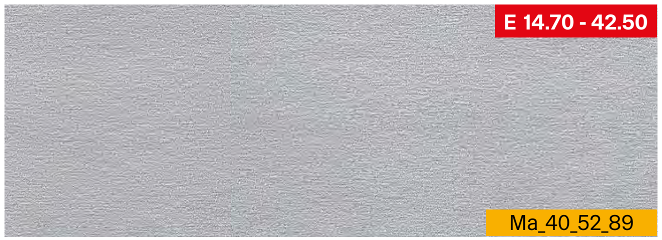
Application:
Fixings, hardware, plumbing

Specification:
Colour - Light & brown
Finish - Polished, Brushed, Antique
Size - As required
Reference example - Prestige metal supplies; architectural brass

Lead

Application:
Mainly heritage uses; roofing, cladding, flashings, copings

Specification:
Colour - Dark
Finish - Smooth
Size - As required
Reference example -



Titanium

Application:
External cladding

Specification:
Colour - Grey
Finish - Matt, Brushed
Size - As required
Reference example - NobelClad

2.8.1 Overview

Modern standard glass is crafted from sand (silica), soda ash (sodium carbonate), and limestone (calcium carbonate), with additional small quantities of saltcake (calcium sulphate) and dolomite (magnesian limestone). While most raw materials are locally available in the UK, some dolomite is imported. Although the production process demands significant energy input, its appropriate utilisation in energy-conscious design results in environmental benefits Borosilicate glass typically comprises 70–87% silica. Borosilicate glass is considerably more resistant to thermal shock, particularly in fire scenarios. Ceramic glass is defined by a near-zero coefficient of expansion, endowing it with high resistance to thermal shock.

Note that all glass used on Network Rail projects should at minimum be laminated and comply with any TVRA and SIDOS requirements. For bomb blast requirement of glass refer to the NR Security at Stations Guidance document.

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

National Standard

Department for Transport
Security in the Design of Stations (SIDOS)

2.8.2 Non-Sheet Glass Products

Cast Glass

Glass can be cast and shaped for applications such as glass blocks and extruded sections.

Profiled Sections

Profiled sections cast from clear or coloured glass are manufactured in a range of sizes. These sections, which may or may not include stainless steel longitudinal wires, can be used horizontally or vertically, for single or double glazing, and as part of roofing systems spanning up to 3 m. They allow for large radius curves as well as the standard straight butt jointed system, with joints sealed using translucent silicone. Profiled glass is described in BS EN 572–7.

Glass Fibres

Continuous glass fibres are produced by continuously feeding molten glass from a furnace into a forehearth. These are passed over a size applicator and are assembled as a bundle. This material finds use in various forms such as rovings, chopped strand, or woven strand mats for manufacturing glass fibre-reinforced materials like glass fibre-reinforced polyester (GFRP), glass fibre-reinforced cement (GFRC), or glass fibre-reinforced gypsum (GFRG).

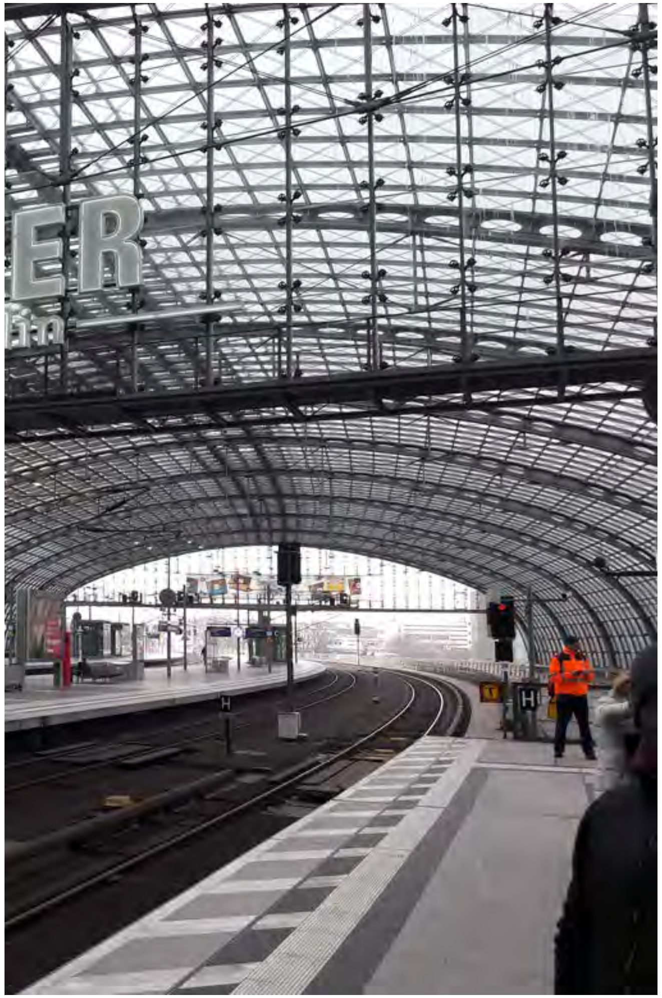


Image 2.62 Berlin Central Station - Glass Roof

Glass Pavers

Glass pavers come in single-layer lenses, shells, and hollow blocks for insulation purposes, while its surfaces may be clear or sand-blasted for enhanced grip. Installation on-site typically requires reinforced concrete construction, allowing for appropriate joint spacing between blocks and expansion joints around panels. Precast panels offer higher standards of quality control and ease of installation. Standard sizes range from 120 to 190mm square, with varying depths.

Glass Blocks

Glass blocks are made by casting two half-blocks and joining them together, followed by annealing. They are intended for non-load-bearing walls and partitions. Standard block sizes include 115, 190, 240, and 300mm squares, with thickness options of 80, 100, or 150mm. Rectangular and circular blocks are also available, with colours ranging from blue, green, and grey to pink and bronze. Blocks with solar-reflective glass or incorporating white glass fibres offer additional solar control.

National Standard

Glass in building. Basic soda lime silicate glass products - Wired or unwired channel shaped glass
BS EN 572-7

2.8.3 Sheet Glass Products

Traditional Blown and Drawn Glasses

Traditional blown and drawn glasses are commercially available in clear and various colours. Drawn glass offers optical clarity but may have variable thicknesses, including sizes of up to 1600 x 1200mm. It is suitable for conservation work where old glass requires replacement. Blown glass, characterised by variable air bubbles and thickness variations, provides an antique aesthetic. When laminated glass is required, these traditional glasses may only be bonded to float glass with resin due to their thickness variations.

Standard Float Glass

Float glass is available in standard thicknesses ranging from 3 to 25mm, with typical maximum sheet sizes of 3.2 x 9 m. However, larger sizes of up to 3.3 x 18 m have been produced for triple 10mm-layer units, weighing 4.5 tonnes. Transportation and on-site handling of units of this size are subject to logistical constraints.

Image 2.63 Sunderland Station - Glass Blocks
Platform 5 (2011) by Jason Bruges Studio, image by James Medcraft.

Curved Sheet Glass

Curved glass, defined by standards, is manufactured by heating annealed glass until it softens and sags to the shape of a supporting mould. Sheets up to 3 x 4m or 2 x 5m can be bent with curvature in one or two directions, with standard thicknesses ranging from 4 to 19mm. Various types of glass, including patterned, textured, tinted, clear white, and pyrolytic-coated solar-control glasses, can be curved using this technique. Curved glass can undergo further treatments such as sandblasting, toughening, or lamination, with the inclusion of coloured interlayers if desired. Refer to BS ISO 11485–1 and BS 952–2.

Self-Cleaning Glass

Self-cleaning glass features an invisible hard coating with special properties. The surface incorporates titanium dioxide, which is photocatalytic, absorbing ultraviolet light to break down or loosen organic dirt when combined with oxygen from the air. Additionally, the surface is hydrophilic, aiding in the cleaning process.

Screen Printed Glass

When white or coloured ceramic frit is screen printed onto clear or tinted float glass which is then toughened and heat soaked, the ceramic enamel fuses permanently into the glass surface. This process is used to create standard patterns or individual designs, offering the desired level of solar transmission and privacy. Screen-printed glass, known for its colourfastness and abrasion resistance, is typically installed with the printed side facing the interior of conventional glazing systems.

Patterned Glass

Patterned glass is manufactured to BS EN 572–5, with a wide range of commercially available. Varying levels of obscuration are offered depending on the pattern depth and design. Patterned glass's privacy levels are classified differently across manufacturers, typically ranging from 1 to 5 (highest) for Pilkington and 1 to 10 (lowest) for Saint Gobain. The degree of privacy depends not only on the pattern but also on lighting levels and proximity to objects. Maximum stock sheet sizes are typically 2140 x 1320mm or 2160 x 1650mm.

Patterned glass can be toughened, laminated, or incorporated into double-glazing units for various considerations such as thermal, acoustic, or safety requirements. Some options are available in bronze tinted glass, and wired patterned glass to BS EN 572–6 with a square mesh is also available.

Image 2.64 Paddington Station - Printed Glass Roof

National Standard

Glass in building. Curved glass - Terminology and definitions
BS ISO 11485-1

Glass for glazing - Terminology for work on glass
BS 952-2

Glass in building. Basic soda lime silicate glass products - Patterned glass
BS EN 572-5

Glass in building. Basic soda lime silicate glass products - Wired patterned glass
BS EN 572-6

Decorative Coloured Glass

Coloured polyvinyl butyral interlayers within laminated glass allow for various colour effects and tones, with patterns including geometric designs, photographs, text, or logos. These laminated coloured and patterned glasses offer the same impact resistance and acoustic insulation as standard clear laminated glass.

Coloured polyester or vinyl film and lead strip acrylic can also simulate these effects on a single sheet of clear glass. The base glass may be toughened or laminated, and decorative coloured glass laminates can be incorporated into standard double-glazing units.

Traditional coloured glass windows are made with lead cames and soldered intersections, and utilise uniform pot, surface flashed, or painted glasses. Support for new work is provided by lead cames with a steel core and non-corroding saddle bars of bronze or stainless steel. Three-dimensional effects are achieved by fixing coloured bevelled glass to clear or coloured sheet glass, with thin edges covered with adhesive lead strip.

Decorative Etched and Sand-Blasted Glass

Plain acid-etched glass has a low obscuration factor and is not recommended for use in areas with high humidity, as condensation or water may temporarily obscure the pattern.

Etched glasses may be toughened or laminated; when laminated, the etched side should face outward to preserve the pattern effect. In double-glazing units, the etched glass forms the inner leaf with the etched face towards the air gap. Sandblasting techniques can also achieve similar visual effects, albeit with a less smooth surface finish. Patterns may be clear on a frosted background or vice versa, depending on the desired aesthetic and level of privacy. Textured and etched finishes are available for glass surfaces.

Etched glass is available in various thicknesses, comes in stock maximum sheet sizes of 3210 x 2400mm, often with a selection of patterns. Handling of etched glasses on-site requires care, as oil, grease, and fingerprints can be difficult to remove.

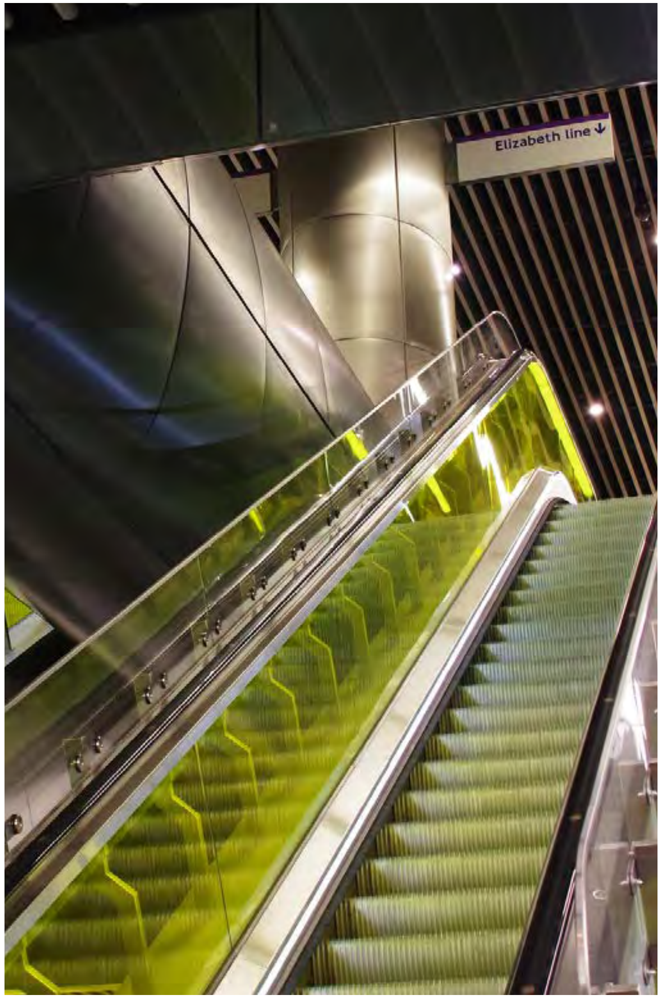


Image 2.65 Canary Wharf Elizabeth Line Station - Coloured Glass Balustrades

Painted Glass

Painted or 'back-painted' glass requires specialized equipment and expertise to guarantee durability and quality. The process involves cutting toughened glass, cleaning and taping the edges to prevent flaws, the chosen color is then evenly sprayed onto one side and cured in a specialized oven to secure adhesion. A protective coating is applied and heat-treated to bond the layers. Low-iron glass is used to avoid the greenish tint from iron deposits, ensuring the paint color appears clear and unaltered.

Georgian Wired Glass

Georgian wired glass is produced by rolling steel wire mesh between two ribbons of molten glass, resulting in a standard cast 7mm sheet suitable for situations requiring obscuration.

Although not stronger than annealed glass, the wire mesh allows Georgian wired glass to hold together when cracked. While the wire mesh dissipates some heat in a fire, the glass may crack, particularly if sprayed with water when hot. However, the wire mesh retains the glass in position, maintaining integrity and preventing the passage of smoke and flame. While easily cut and laminated to other glasses, Georgian wired glass cannot be toughened. Certain laminates or products with increased wire thickness may meet safety glass standards and should be appropriately marked.

Heat Strengthened Glass

Heat-strengthened glass is manufactured by a process similar to toughening, but with a slower rate of cooling, which produces only half the strength of toughened glass. On severe impact, heat-strengthened glass breaks into large pieces like annealed glass and therefore alone is not considered a safety glass.

Toughened Glass

Toughened glass is up to four or five times stronger than standard annealed glass of the same thickness. Toughened glass can withstand considerable extremes of temperature and sudden shock temperatures. In case of breakage, it shatters into small granules that are less likely to cause serious injuries compared to annealed glass.

The form of breakage for toughened glass is defined in BS EN 12600. To be classified as safety glass, toughened glass should be tested and marked according to the required standard BS 6206.

All standard float, coated, rough-cast, and some patterned glasses may be toughened. It cannot be cut or worked after toughening, so all necessary cutting, drilling of holes, and grinding or polishing of edges should be completed beforehand. Toughened glass is defined by the standard BS EN 12150–1.

Image 2.66 London Waterloo Station- Toughened Glass Balustrades

National Standard

Glass in building. Pendulum test. Impact test method and classification for flat glass
BS EN 12600

Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings
BS 6206

Glass in building. Thermally toughened soda lime silicate safety glass - Definition and description
BS EN 12150-1

Laminated Glass

Laminated glass is produced by bonding two or more layers of glass together with a plastic interlayer of polyvinyl butyral (PVB) sheet. This lamination process significantly increases impact resistance over annealed glass of the same thickness. On impact, the glass laminations crack without splintering or disintegration, being held together by the interlayer. The form of breakage for laminated glass is defined in BS EN 12600. Laminated glass may be classified as safety glass provided it meets the appropriate class standard to BS 6206.

Plastic Film Laminates

A range of transparent and translucent plastic films can be readily applied internally or externally to modify the properties of glass. These include patterned films for privacy, manifestation films to prevent accidental collisions with clear glass screens or doors, and reflective films to reduce solar gain and glare. Similarly, anti-shatter film allows glass damaged by accidental impact or vandalism to remain in place. For bomb blast requirements refer to the Security at Stations Guidance document. SIDOS requirements and TVRA project specific recommendations should be referred to whenever specifying glass in stations.

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

Low Emissivity Glass

Low-emissivity glasses are manufactured from float glass by applying a transparent low-emissivity coating to one surface. They function by reflecting longer wavelength heat energy back into the building while allowing shorter wavelength solar energy transmission. The incoming solar energy is absorbed by internal walls and re-radiated as longer wavelength energy, which is then trapped by the low-emissivity coating on the glass.

Fire Resistant Glass

The fire resistance of glass is measured by the glass's ability to conform to the criteria of integrity and insulation within a fire. However, achieving a specified performance in fire requires assuring that the appropriate framing, fixings, and glass have all been used, as fire resistance depends on the entire glazing system, not just the glass itself.

Variable Transmission (Smart) Glasses

Variable transmission or smart glasses alter their optical and thermal characteristics under the influence of light (photochromic), heat (thermochromic), or electric potential (electrochromic). These glasses offer the potential for highly responsive dynamic climate control for building façades. Smart materials, including thermotropic products, are also available as plastic laminates for incorporation into laminated glass systems.

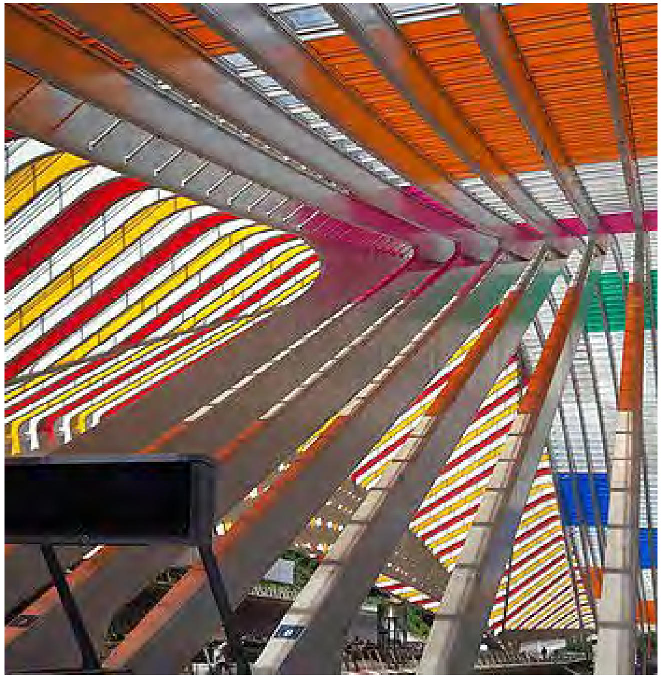


Image 2.67 Liège-Guillemins Station - Film laminate coated glass

National Standard

Glass in building. Pendulum test. Impact test method and classification for flat glass
BS EN 12600

Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings
BS 6206

Intelligent Glass

Intelligent glass admits useful solar gain in cooler conditions but cuts out excessive infrared solar gain under hot conditions. Conventional glass coatings reduce both light and heat transmission. However, a coating based on tungsten-modified vanadium dioxide always allows visible light through but reflects infrared radiation at temperatures above 29°C. Thus, heat penetration through the glass is blocked at higher temperatures.

Another system uses micro-lamella layers of transparent steel in the glass, positioned to reflect sunlight from high angles during hot summer months while allowing sunlight from low angles to enter relatively unimpeded, maintaining internal light levels during winter.

National Standard

Fire resistance tests for loadbearing elements
BS EN 1365

Glass in building. Structural sealant glazing - Assembly rules
BS EN 13022-2

Glass in building. Product standard for structural and/or ultra-violet resistant sealant
BS EN 15434

Structural Glass

Glass columns often serve as fins to restrain excessive deflection caused by wind and other lateral loads on glass façades. Glass used as a load-bearing element should adhere to the structural and fire performance requirements of the relevant parts of BS EN 1365.

Typically, storey-height fins are made of toughened glass, fixed into aluminium or stainless-steel shoes to the floor and/or glazing head. A soft interlayer between the metal fixing and the glass prevents stress concentrations on the glass surface and accommodates differential thermal movement between the glass and metal. Fixings between facade glazing and fin units usually consist of stainless-steel clamps bolted through preformed holes in toughened or laminated glass, though silicone adhesives may also be used.

BS EN 13022 stipulates that the outer seal of any structural glazing unit exposed to UV light should be UV resistant. BS EN 15434 specifies that silicone adhesive is the only structural adhesive suitable for fixing glazing units exposed to UV light.

Image 2.68 Structural Glass Curtain Walling

2.8 Glass

Transparent Glass

Application:
Internal; retail fronts

Specification:
Colour - None
Finish - Clear
Size - Varies
Reference example - TuffX

Opaque Glass

Application:
External cladding

Specification:
Colour - Varies
Finish - Opaque, digitally printed
Size - Thickness - 27mm
Reference example - Alsecco; Airtec Glass

Sandblasted Glass

Application:
Various; roofing, external cladding, walls, floors

Specification:
Colour - Varies
Finish - Translucent
Size - Max. 3000 x 6000mm
Reference example - IQ Glass; Sandblasted Glass

Self-Cleaning Glass

Application:
Windows, external cladding

Specification:
Colour - Varies
Finish - Glazed
Size - Thickness; 8.8 - 24mm
Reference example - Glass Solutions; Bio-clean range

Glass Blocks

Application:
Internal; typically heritage purposes

Specification:
Colour - None
Finish - Clear
Size - Varies
Reference example - TuffX

Glass - Embodied Carbon - kgCO2e/kg (based on ICE database)

Glass, *General*
01.44kgCO2e/kg

Glass, *Multi-Layer Safety, Filled Core, Toughened*
02.08kgCO2e/kg

E- 01.44 | E-BB.BB | E-CC.CC | E- 02.08 | E-N/A

2.8 Glass

Toughened Glass

Application:
Station interior

Specification:
Colour - None
Finish - Clear
Size - Varies
Reference example -

Wired Glass

Application:
Typically door vision panels

Specification:
Colour - None
Finish - Clear
Size - Varies
Reference example - TuffX

Safety Glass, Multi Layer

Application:
Station interior

Specification:
Colour - None
Finish - Clear
Size - Varies
Reference example -

2.9 Composites

2.9.1 Composites Overview:

Composite materials i.e., plastics, in construction are typically low-density and non-load-bearing. They are resistant to corrosion but susceptible to degradation from sunlight, which leads to reduced strength. Many plastics are flammable unless treated and emit toxic fumes in fires. Subsequently, when specifying composites reference should be made to the Network Rail Fire Safety at Stations guidance document and the recommendations of BS 9992.

About 20% of UK-produced plastics are used in construction, with Polyvinyl chloride (PVC) representing 40% of this, mainly in pipes but also in cladding, electrical cable insulation, windows, doors, and flooring.

2.9.2 PTFE

Polytetrafluoroethylene (PTFE) is coated glass fibre woven fabrics which find application in permanent tensile membrane structures. PTFE emits toxic combustion products in a fire, but only at temperatures where any fabric would have already failed and vented heat and smoke. The surface of PTFE has low-friction and exhibits self-cleaning properties. The translucent fabric provides well-lit internal spaces during the day and striking glowing surfaces at night. Standard BS EN ISO 12086–1 outlines the designation system for fluoropolymers.

2.9.3 PVC, PVC-U, and PVC-UE

Polyvinyl Chloride (PVC) is a prevalent plastic in construction, available in both unplasticised (PVC-U) and plasticised forms. Plasticised PVC finds extensive use in floor coverings, roofing systems, electrical cable insulation, and injection-moulded building components. PVC-U is commonly employed for rainwater goods, soil and waste-pipes, and extruded window frames. Extruded cellular unplasticised PVC (PVC-UE) is utilised for cladding, fascias, and other components. The material is described in standard BS 7619.

NR Guidance Suite Reference

Fire Safety at Stations
NR/GN/CIV/300/03

National Standard

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

Extruded cellular unplasticised white PVC (PVC-UE) profiles. Specification
BS 7619

Plastics. Fluoropolymer dispersions and moulding and extrusion materials - Designation system and basis for specifications
BS EN ISO 20568-1

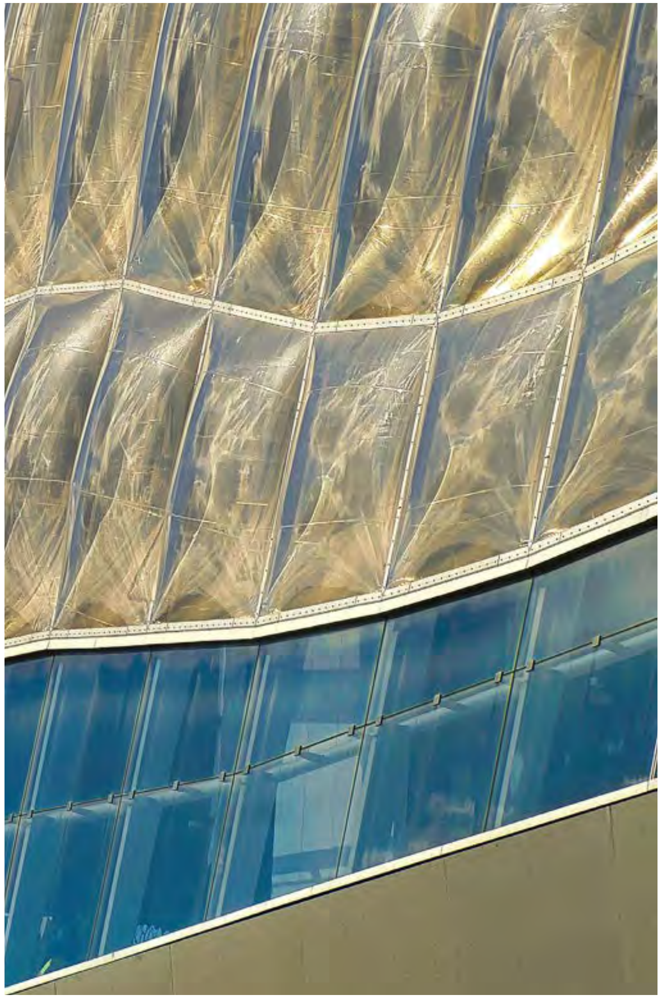


Image 2.69 Mechelen Train Station - ETFE Cushion facade

2.9.4 Polycarbonate

Polycarbonates (PCs) serve as vandal-resistant glazing due to their high impact resistance, optical transparency, and low ignitability. Polycarbonate offers a lightweight alternative to cast glass blocks and are typically used for roof lights, domes, smoking shelters, carports, walkways, and road barriers.

Sections can be cured on site to manufacturer specifications with their protective outer surface that prevents ultraviolet degradation for 10 years. The standard BS EN ISO 7391–1 outlines the designation system for polycarbonate.

2.9.5 ETFE

Ethylene tetrafluoroethylene copolymer (ETFE) serves as a translucent foil for low-pressure pneumatic metal-framed building envelope cushions. ETFE offers advantages over glass as it provides higher thermal insulation, and greater transparency to UV light when used in two- to five-layer air cushion systems. Strong and shatter-proof, ETFE is also significantly lighter and less expensive than glass, offering cost savings in structural support.

With an expected lifespan of 25 years, ETFE withstands maintenance loads, is easily repairable, and recyclable. Minimal pumping, powered by photovoltaic cells, is required to maintain air-filled ETFE cushions. Automatic smoke venting of atria can be achieved by wiring integrated into cushion frames to release them in case of fire creating an open light well.

National Standard

Plastics. Polycarbonate (PC) moulding and extrusion materials - Designation system and basis for specifications
BS EN ISO 21305-1

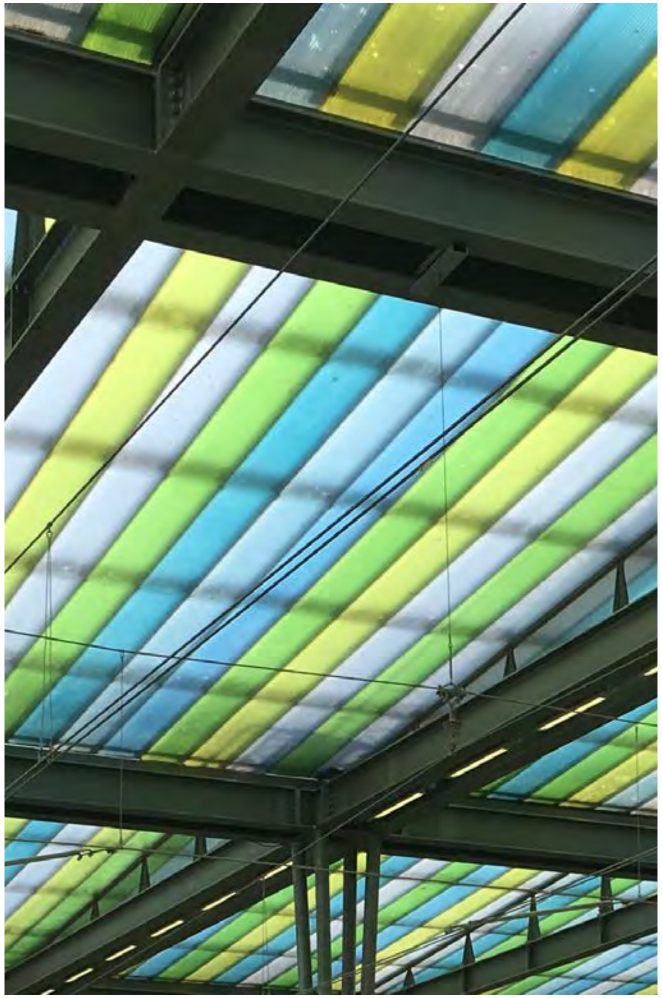


Image 2.70 Translucent polycarbonate canopy, Oostende station, Belgium

2.9.6 Glass Fibre Reinforced Composites

Glass Fibre Reinforced Plastic (GFRP)

Glass fibre reinforced plastics have a lightweight nature, making them ideal for large cladding panels and custom-moulded structures.

GFRP cladding panels require significant initial investment in high-quality moulds, typically made from timber, steel, or GFRP itself. Moulds are reused multiple times with minor adjustments, minimising production costs. During fabrication, a release agent is applied to prevent bonding and damage to the finished panel surface. Curing may take up to two weeks before the unit is stripped from the mould, trimmed, and fitted out.

Finishes can be self-coloured or incorporate a natural stone aggregate. Additionally, GFRP can be pigmented to mimic various materials such as timber, slate, or stone, as well as lead or copper. Composite cladding panels made from glass fibre-reinforced resins, incorporating stone granules, are impact and fire resistant, available with various finishes.

GFRP is commonly used for architectural features like barge boards, dormer windows, columns, and entrance canopies. It's also used to manufacture small building components like baths, valley troughs, roof edge trim, and drainage systems.

Glass Fibre Reinforced Concrete (GFRC)

Glass fibre reinforced concrete comprises alkali-resistant glass fibres, Portland cement, sand aggregate, and water and was developed in the early 1970s by the Building Research Establishment.

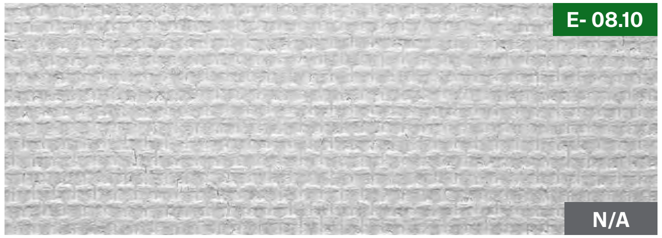
Standard GFRC resembles concrete but offers a wide range of colours, textures, and simulated materials. Gloss finishes should be avoided due to craze potential. Specific aggregates and grinding can mimic marble, granite, or terracotta, while acid etching produces smooth or tooled effects. Exposed aggregate finish is achieved through additives in the mould, followed by cleaning and brushing.

Less permeable to moisture than regular concrete, GFRC exhibits good resistance to chemical attack and freeze/thaw cycling. GFRC can also serve as permanent formwork for standard concrete mixes, fire-resistant partitioning, and manufacturing small components like slates, tiles, and decorative ridge tiles. Fibre-reinforced cement slates replicate the texture and colour of natural slate.

GFRC finds extensive use in cladding and soffit panels for its lightweight and mouldable properties. It also serves in conservation work as a natural stone replacement and in architectural mouldings. GFRC was also extensively used as part of the Elizabeth Line linewide design material palette.

Image 2.71 Elizabeth Line GFRC panels

2.9 Composites



Glass Fibre Reinforced Plastics (GFRP)

Application:
Loadbearing and non-loadbearing walls

Specification:
Colour - Grey
Finish - As specified (Weathered, Smooth, Stone, Patina, Etc.)
Size - 200-1220 x 7500mm (maximum)
Reference example - Stromberg Architectural

Composite Floor Panel

Application:
Internal floors

Specification:
Colour - Light
Finish - Timber
Size - Varies
Reference example - Garnica; G-brick range

Glass Fibre Reinforced Concrete (GFRC)

Application:
Internal and Externall Walls`

Specification:
Colour - Light (natural) Pigmented (as specified)
Finish - As specified
Size - Varies

Energy-generating Paving

Application:
Internal and external flooring

Specification:
Colour - Wide-ranging
Finish - Basic
Size - As required
Reference example - Pavegen

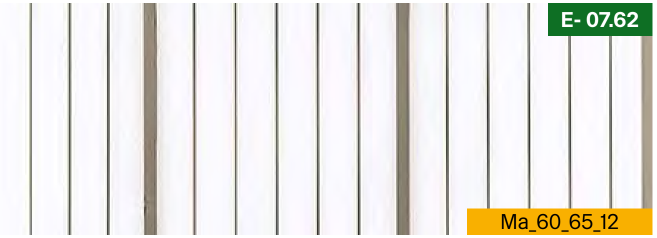
Various - Embodied Carbon - kgCO2e/kg (based on ICE database)

Ceramics, *General*
00.70kgCO2e/kg

Sanitary Products
01.61kgCO2e/kg

E- 00.70 | E-BB.BB | E-CC.CC | E- 01.61 | E-N/A

2.9 Composites



Polycarbonate Wall Panels

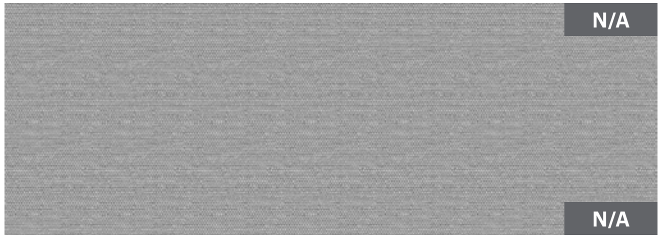
Application:
Station façades

Specification:
Colour - Vaires
Finish - As specified
Size - Varies
Reference example - Kalwall; Wall systems

Ethylene Tetrafluoroethylene (ETFE)

Application:
Station Roofs

Specification:
Colour - None
Finish - Smooth
Size - Varies
Reference example - Seele; ETFE Film



PTFE Coated Glass Fabric

Application:
Permanent roof structures

Specification:
Colour - Gray
Finish - As supplied
Size - Varies
Reference example - Fiberflon; PTFE Coated Glass Fabrics

Composite Cladding Panels

Application:
External Walls

Specification:
Colour - Varies
Finish - Various material coatings
Size - Varies
Reference example - Kingspan; Eurobond Rockspan wall panel

Glass Reinforced Gypsum

Application:
Decorative internal walls

Specification:
Colour - White
Finish - Smooth
Size - Varies
Reference example - Design Visual; GRG Wall Panels

2.10 Flat Roofing Materials

2.10.1 Flat Roofing Materials Overview

Flat roofing materials serve as impermeable water barriers. They encompass reinforced bitumen membrane systems, mastic asphalt, single-ply plastic membranes, and liquid coatings. These materials necessitate continuous support on a suitable roof decking system. Green roofs are often viewed as extensions of standard roofing systems.

2.10.2 Cold Roofs

In cold roof construction, the weatherproof layer is applied directly onto the rood decking, typically particleboard or plywood. This is then supported directly by the roof structure, often by timber joists. Thermal insulation is placed over the gypsum plasterboard ceiling, leaving cold void spaces between structural timbers or steel. This construction poses a significant risk of condensation formation beneath the decking, potentially compromising the structure.

Adequate ventilation of the cold voids is necessary, and if ventilation proves inadequate during remedial work, conversion to a warm roof or inverted roof system may be advisable. Cold roof construction is discouraged for new building work according to the Code of Practice (BS 8217).

2.10.3 Warm Roofs

In warm roof construction, thermal insulation is positioned between the roof deck and the weatherproof covering. This setup insulates the roof deck and its supporting structure from temperature extremes, mitigating potential damage due to excessive thermal movement. Given the insulation's proximity to the waterproof layer, it should be able to withstand foot traffic associated with roof maintenance.

Mechanical fixing or ballasting is required to prevent detachment of the waterproof and insulation layers in strong winds. Warm roof construction is therefore the preferred method for lightweight roofs.

National Standard

Reinforced bitumen membranes for roofing. Code of practice
BS 8217

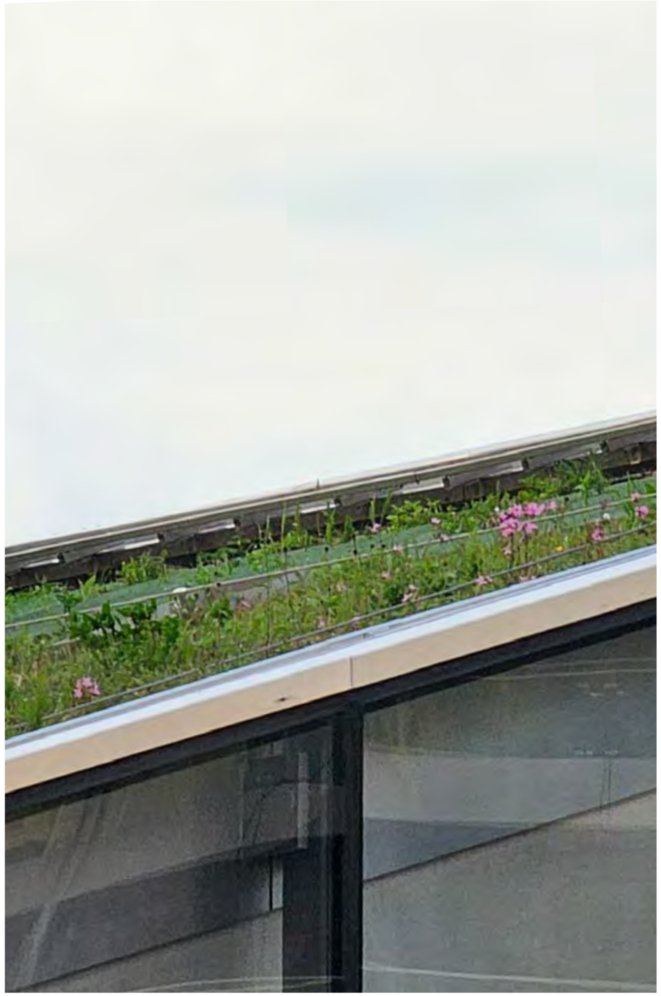


Image 2.72 Extensive Green Roof at Old Street station

2.10.4 Inverted Roofs

In inverted roof construction, both the structural deck and the weatherproof membrane are shielded by externally applied insulation. This design insulates the entire roof system from temperature extremes and damage caused by solar radiation and maintenance traffic. Typically, the insulation layer is ballasted with gravel, paving slabs, or roof garden finishes.

Drawbacks of inverted roof construction include increased dead weight and challenges in detecting leaks beneath the insulation layer. Additional insulation may also be necessary to compensate for water drainage cooling effects. However, inverted roof construction remains the preferred method for concrete and other heavyweight roof systems.

National Standard

Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics
BS EN 13707

Reinforced bitumen membranes (RBMs) for roofing. Guide to selection and specification
BS 8747

2.10.5 Reinforced Bitumen Membranes

Reinforced bitumen membranes for roofing systems are categorised based on various physical properties by BS EN 13707, and without specific reference to manufacturing materials.

BS 8747 provides guidance on the key physical properties such as tensile strength (S class) and puncture resistance (P class), correlating them with different product types.

The appropriate membrane performance requirement is determined through risk analysis, considering roof geometry, access, and degree of protection.

BS 8747 includes a matrix guiding the specification of the required membrane classification, applicable to both single-layer and multi-layer reinforced bitumen membrane systems. For multi-layer systems, at least one layer should meet the minimum S2P2 classification.

Image 2.73 Welded application of reinforced bitumen membrane

2.10.6 Mastic Asphalt

Mastic asphalt, a blended bitumen-based product, combines bitumen with limestone powder and fine limestone aggregate to create various roofing types specified in BS 6925. Among the most commonly specified are the BS 988 T25 and polymer-modified grades. Typically, mastic asphalt arrives as blocks for on-site melting before laying, although hot molten asphalt is sometimes supplied for larger contracts. While laid mastic asphalt is brittle in cold conditions, it softens in hot, sunny weather.

Paving-grade mastic asphalt serves as a wearing layer over the standard roofing grade material for mastic asphalt roofs exposed to foot or vehicle traffic. Two key grades, S and H, are available: the softer grade (S) suits footways and rooftop car parks, while the harder grade (H) is suitable for heavily stressed areas.

Type	Composition
BS 988B	100% Bitumen
BS 988 T25	75% Bitumen, 25% Lake Asphalt
BS 988 T50	50% Bitumen, 50% Lake Asphalt
Specified by Manufacturers	Polymer-Modified Grades

Image 2.74 Types of Mastic Asphalt to BS 6925

2.10.7 Single Ply Roofing Systems

Single ply roofing systems encompass a continuous membrane covering for flat or pitched roofs. Waterproofing relies on a single membrane, therefore impeccable workmanship is crucial and typically provided by specialist installers. The diverse range of membrane materials used generally falls into thermoplastic and elastomeric categories.

BS EN 13956 Annex E provides an extensive list of flexible sheet materials (plastics, rubbers, and thermoplastic rubbers) utilised for roofing systems across Europe. However, in the UK, the market for non-bitumen-based products is predominantly dominated by plasticized PVC and EPDM. Life expectancies are commonly cited as 25 years.

National Standard

Specification for mastic asphalt for building and civil engineering (limestone aggregate)
BS 6925

Flexible sheets for waterproofing. Plastic and rubber sheets for roof waterproofing. Definitions and characteristics
BS EN 13956

Image 2.75 Levelling of mastic asphalt

2.10 Flat Roofing Materials

2.10.8 Green Roofs

Green roofs, whether flat or low-pitched, involve landscaping over the waterproofing layer. This landscaping may incorporate some hard surfaces and allow access for leisure and recreational activities as well as routine maintenance. Green roofs shield the waterproofing layer from damage, ultraviolet light, and temperature fluctuations, extending its life expectancy. They also provide additional usable space.

Their environmental advantages include reduced and delayed rainwater runoff as part of a Sustainable Drainage System (SuDS), along with significant benefits in environmental noise reduction, thermal control, air quality improvement, and wildlife habitat creation. Waterproofing for green roofs can be achieved using modified-bitumen high-performance membrane systems, single-ply membrane systems, or mastic asphalt. Green roofs are typically categorised as either extensive or intensive systems.

2.10.9 Extensive Green Roofs

Extensive green roofs are designed to be lightweight, relatively inexpensive, and requiring minimal maintenance, and are therefore not intended for recreational use. They primarily serve ecological or environmental masking purposes. Planting on extensive green roofs typically consists of drought-tolerant, wind-resistant, and frost-resistant species such as sedums, herbs, and grasses. Instant cover can be achieved with pre-cultivated vegetation blankets for immediate visual impact. Alternatively, a mixture of seeds, plant cuttings, mulch, and fertilizer can be sprayed onto the growing medium, maturing into a finished green roof within one to two years.

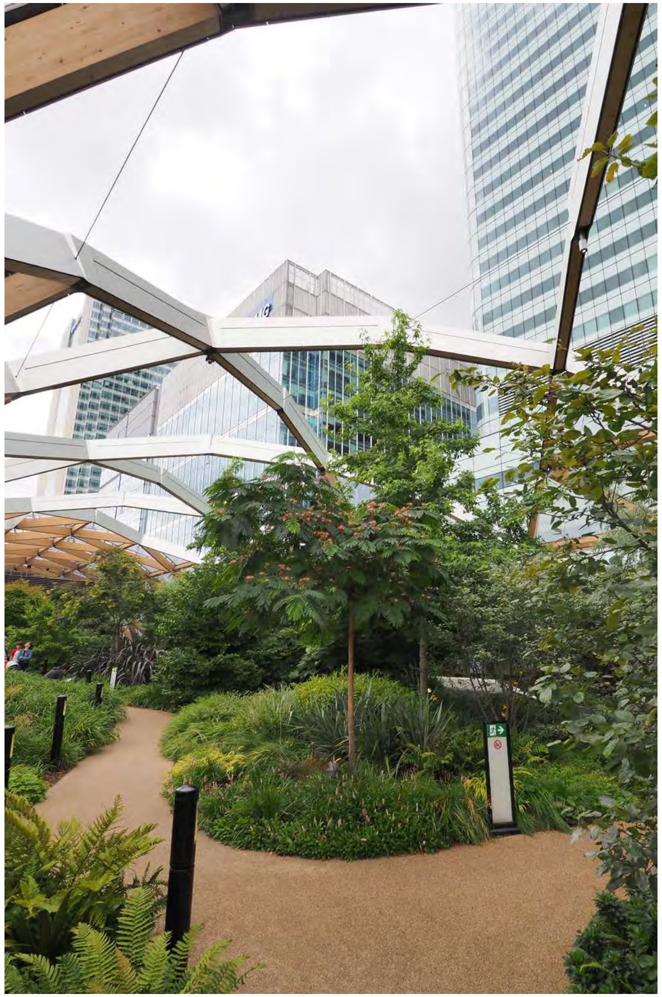


Image 2.76 Canary Wharf Elizabeth Line roof garden - an intensive green roof

2.10.10 Intensive Green Roofs

Intensive green roofs are designed to accommodate recreational activities and a wider range of vegetation, from grasses and herbs to shrubs. They may incorporate both soft and hard landscaping, and slopes of up to 20° are feasible.

For areas where trees are desired, soil depths may be required to increase up to 750–1000mm, resulting in a higher overall weight. Care should be taken to prevent damage to the roof membrane from gardening tools. Intensive green roofs require careful plant selection to withstand exposed conditions and ongoing maintenance, including weeding, pruning, and pest control.

Compliance with Health and Safety regulations necessitates incorporating edge protection, such as handrails, or fall-arrest systems, like harness attachment points, into the design.

2.10.11 Green Walls

Green walls, also known as living walls, feature growing medium contained in matting or blocks affixed directly to the building facade. The entire system requires periodic refurbishment, and provision for watering and maintenance is necessary. Green walls created from climbing plants supported on stainless steel rods, ropes, and mesh are options that are easier to irrigate and maintain.

Image 2.77 Birmingham New Street Station - Green Wall

2.10 Flat Roofing Materials - Roofs

Bitumen

Application:
Permanent roof structures

Specification:
Colour - Dark, Black / Grey
Finish - Smooth
Size - Varies

Mastic Asphalt

Application:
Permanent roof structures

Specification:
Colour - Light. White / Grey
Finish - Smooth
Size - Varies

Single Ply Systems

Application:
Permanent roof structures

Specification:
Colour - Varies
Finish - Smooth
Size - Varies

Green Roof - Extensive

Application:
Permanent roof structures

Specification:
Colour - None
Finish - None
Size - As required

Green Roof - Intensive

Application:
Permanent roof structures

Specification:
Colour - None
Finish - None
Size - As required

Green Walls

Application:
Internal and External covered spaces

Specification:
Colour - None
Finish - None
Size - As required

2.11 Applied Finishes

2.11.1 Applied Finishes

In high-traffic transport environments, applied finishes that can wear away, such as paint, should generally be avoided due to their short lifespan and the frequent maintenance they require.

However, certain applied finishes remain suitable, particularly those designed for protection. Anti-graffiti coatings are effective in maintaining cleanliness and aesthetic appeal, as they facilitate the easy removal of vandalism.

Other protective coatings, such as those offering enhanced durability and resistance to environmental damage, can be beneficial in preserving the integrity and appearance of surfaces in these demanding settings.

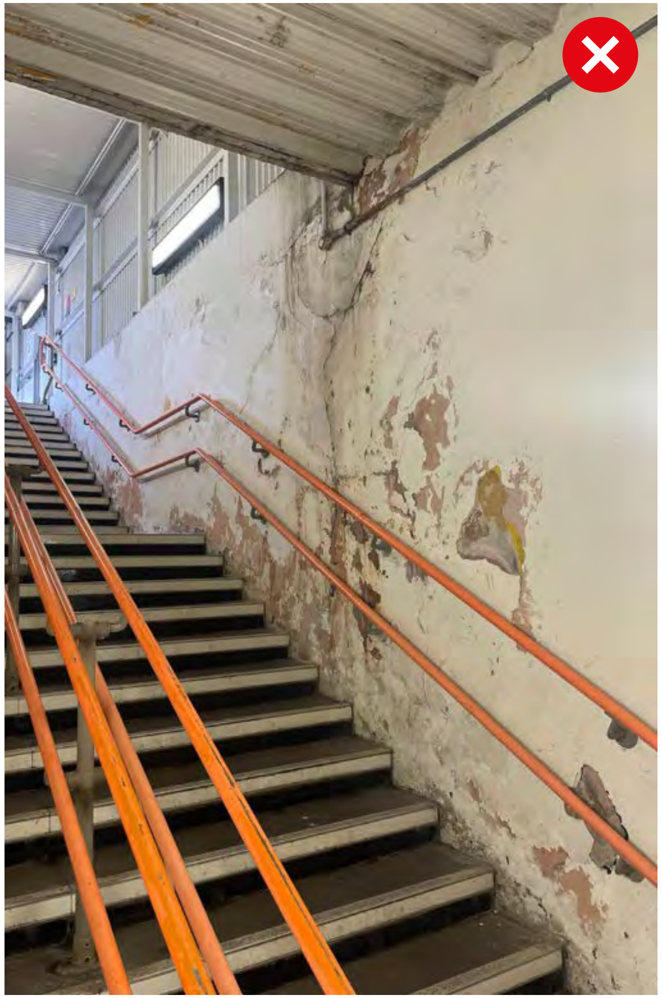


Image 2.78 Applied finishes such as paint often wear quickly in high traffic environments

Anti-Graffiti Coating

Application:
External walls

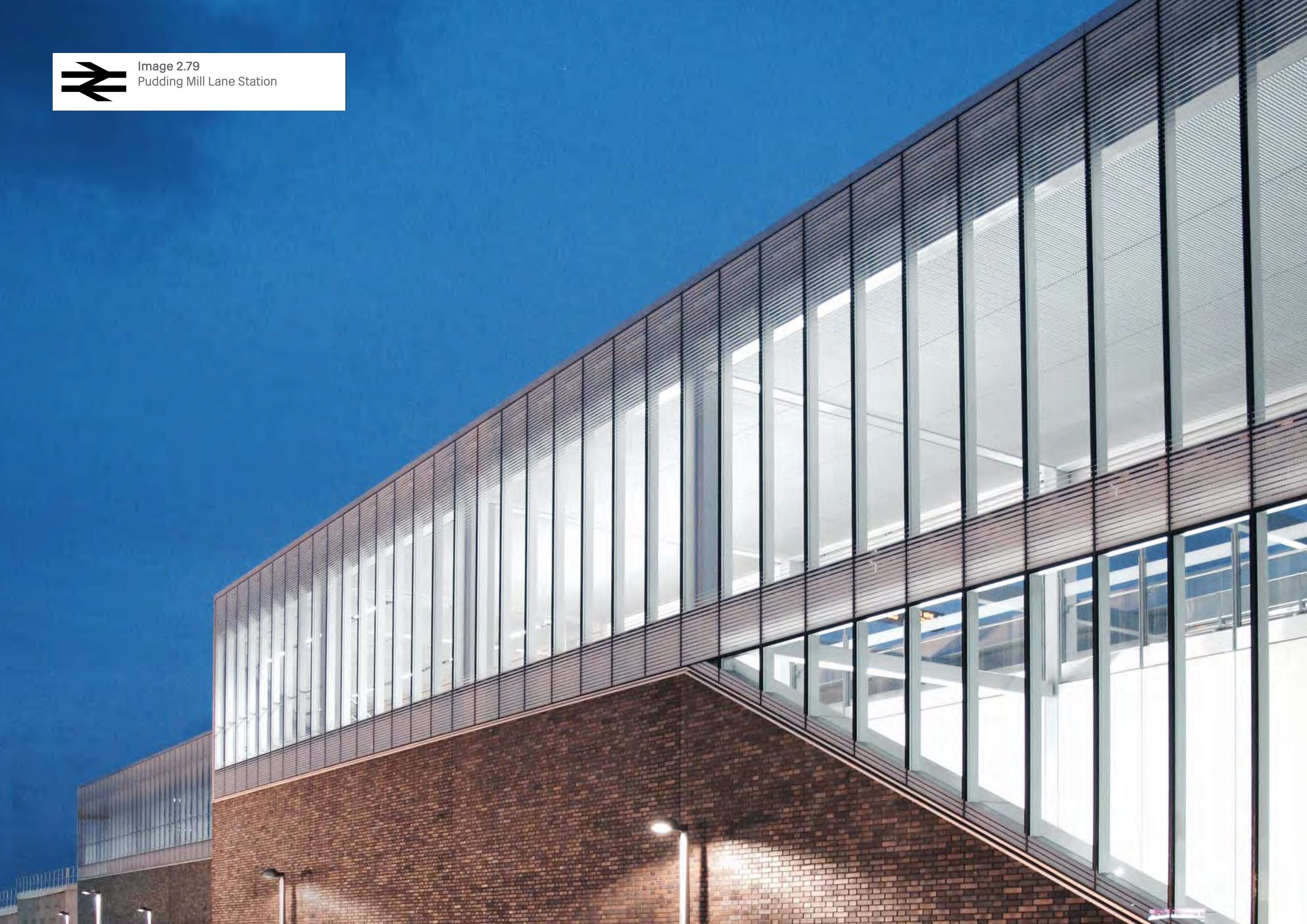
Specification:
Colour - None
Finish - Clear
Size - As required
Reference example - Hydron; Protective coatings

Anti-Graffiti Film

Application:
Glazing

Specification:
Colour - None
Finish - Clear
Size - As required

Image 2.79
Pudding Mill Lane Station



3

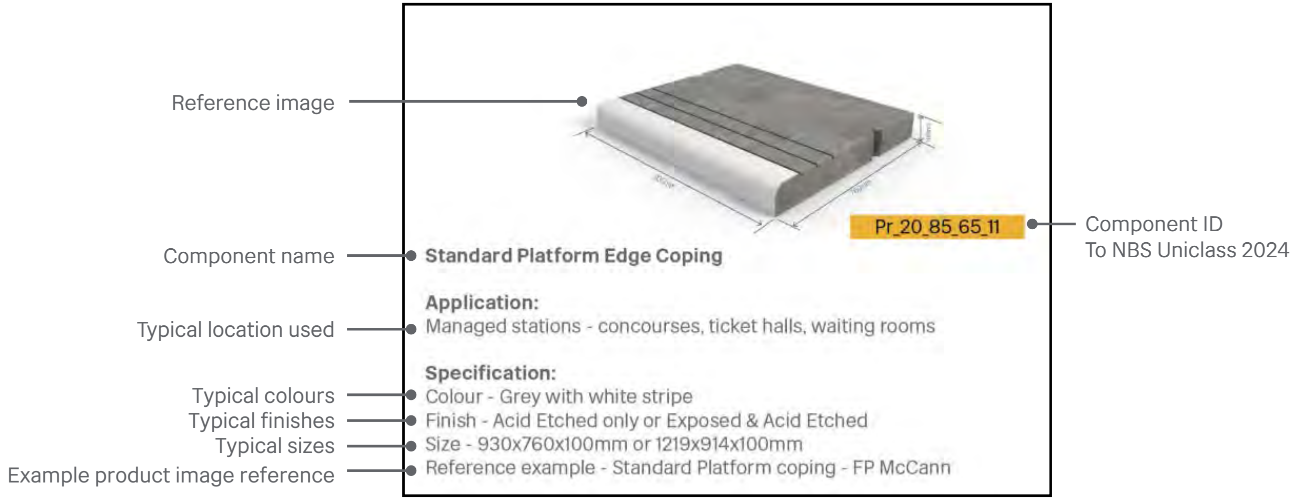
Materials & Components

Section 3: Components & Fixtures

3.1 How to read this section - Components

3.1 Reading guide

A typical component entry within this chapter, displaying relevant information.



Section 3: Components & Fixtures

3.2 Platform

3.2.1 Platform Components

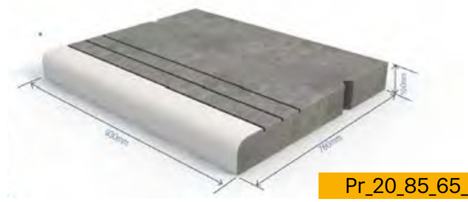
Platforms and prefabricated modular platform components should facilitate safe and equally accessible transfers between trains and other areas of the station. They should allow free movement and clear visibility, widths should safely accommodate peak passenger volumes in accordance with the relevant standards and guidance. See NR/L3/CIV/030 for further requirements.

Platform copings are available in two standard sizes 930x760mm and 1219x914mm. Dual copings are available in two standard sizes 930x1160mm and 930x1260mm. Requests for non-standard product sizes and colours can be accommodated.

Floor slip resistance can change with seasons and patterns of wear. Remedial treatments like coatings, carborundum strips, and surface etching can address degradation. However, the impact on cleanability and appearance, and the material's lifespan, should be carefully assessed after treatment.

NR Guidance Suite Reference

Tactile Wayfinding
NR/GN/CIV/300/06

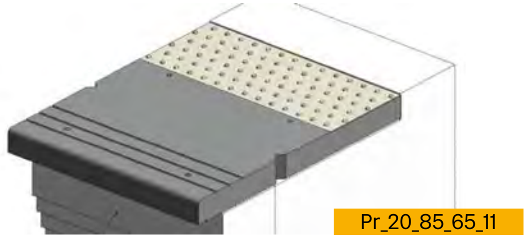


Pr_20_85_65_11

Standard Platform Edge Coping

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Grey with white stripe
Finish - Acid Etched only or Exposed & Acid Etched
Size - 930x760x100mm or 1219x914x100mm
Reference example - Standard Platform coping - FP McCann

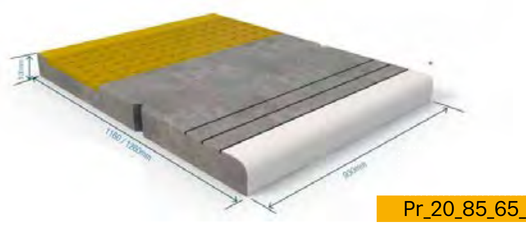


Pr_20_85_65_11

Low-Carbon Platform Edge Coping

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Grey with buff tactile
Finish -
Size - 930mm x 1165mm
Reference example - G-Tech Copers



Pr_20_85_65_11

Dual Platform Edge Coping

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Grey with white stripe and yellow tactile
Finish - Acid Etched only or Exposed & Acid Etched
Size -930 x 1160 x 100mm or 930 x 1260 x 100mm
Reference example - Dual Platform coping - FP McCann

Standards Reference

Department for Transport
National Technical Specification Notice (NTSN): Persons with Reduced Mobility (PRM) 2021

Design of an accessible and inclusive built environment - Buildings. Code of practice
BS 8300

Platform Components & Prefabricated Construction Systems
NR/L3/CIV/030

Interface between Station Platforms, Track, Trains and Buffer Stops
RIS-7016-INS

3.3.1 Shelters and Canopies

A variety of prefabricated shelter products are available to meet individual station requirements. These typically include:

→ Free standing screens
→ Cantilevered
→ Gullwing
→ Enclosed types.

Provision should be determined in accordance with relevant standards and guidance. Shelters should be installed according to manufacturer's specification. Care should also be taken to confirm that design responsibility for foundations and anticipated loadings lie with suitably qualified professionals.

Where practicable, columns should be strategically positioned to allow integration with other services, such as canopy drainage or cable runs.

NR Guidance Suite Reference

Station Capacity Planning
NR/GN/CIV/100/03

Security at Stations
NR/GN/CIV/300/02

Inclusive Design
NR/GN/CIV/300/04

Ss_25_50_75_10

Free standing - Glazed wind-break

Application:
Platform shelters

Specification:
Colour - Varies
Finish - Varies
Size - As required
Reference example - Trueform Shelters; Crossrail platform shelter

Ss_20_10_70_62

Waiting shelter - Enclosed semi-glazed

Application:
Platforms; waiting areas

Specification:
Colour - Varies
Finish - Varies
Size - As required
Reference example - Natural Shelter

Ss_25_50_75_10

Free standing Gullwing - Glazed wind break

Application:
Platform shelters

Specification:
Colour - Varies
Finish - Varies
Size - As required
Reference example - Trueform Shelters; Victoria gullwing canopy

Ss_25_50_75_10

Free standing Cantilever - Glazed wind break

Application:
Platform shelters

Specification:
Colour - Varies
Finish - Varies
Size - As required
Reference example - NR Hub Station Canopy

3.4.1 Seating

Whether standard or bespoke, seating provision should accommodate a range of different needs and be equipped with features like tables and charging points.

Where significant amounts are provided at least half should have accessible features.

Standing rest bars should be provided for those who find standard seating difficult to use, bars should be 700mm above finished floor level, and ≥1400mm in length.

Perch Bench

Application:
Urban realm; external station areas

Specification:
Colour - Grey
Finish - Aluminium
Size - 350 x 1350 - 3630mm
Reference example - OMK Design; Seville

Raised Seating (PRM)

Application:
Internal station areas

Specification:
Colour - Wide ranging
Finish - Polyurethane
Size - height; 785mm, depth 700mm
Reference example - OMK Design; Trax

Floor Mounted Benches

Application:
Platforms

Specification:
Colour - Wide ranging
Finish - Timber, Stainless steel
Size - As required
Reference example - Crossrail Bench

Lean Bar

Application:
Urban realm; external station areas

Specification:
Colour - Grey
Finish - Aluminium
Size - As required
Reference example - London Underground Jubilee Line

Combined Standard and Bespoke Elements

Application:

Specification:
Colour - Wide ranging
Finish - As specified
Size - As required
Reference example - Paddington Elizabeth Line

Modular timber slatted seating installed at a number of managed stations has received positive customer feedback.

These systems are comprised of linear and curved units which can be combined to create bespoke layouts which benefit passenger flow and reduce congestion.

Station seating should be visually contrasting and with rounded edges. Designs should allow clear views underneath and behind for security purposes.

Materials and finishes should be durable, non-reflective, and inviting i.e., not cold to touch.

Seating represents a key tactile contact point for the passenger experience and so its material quality should be seen as an important part of the overall station look and feel.

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

Inclusive Design
NR/GN/CIV/300/04

Station Facilities & Amenities
NR/GN/CIV/200/03

Pr_40_50_12_07

Metal Modular Seating

Application:
Internal and external station waiting areas

Specification:
Colour - Wide ranging
Finish - Aluminium and upholstered options available
Size - 2440mm (w) x 735mm (d) x 780mm (h) - (Standard 4 seat module)
Reference example - OMK Design; Flite range

Standards Reference

Department for Transport
Design Standards for Accessible Railway Stations: A Code of Practice (ACoP)

National Technical Specification Notice (NTSN): Persons with Reduced Mobility (PRM) 2021

Furniture. Strength, durability and safety. Requirements for non-domestic seating.
BS EN 15373

Design of an accessible and inclusive built environment - Buildings. Code of practice
BS 8300

Pr_40_50_12_07

BENCH - Modular timber & back

Application:
Internal and external station areas

Specification:
Colour - Various timber colours, various matt colours
Finish - Natural hard wax oil
Size - 1000Wx1282Lx872Hmm
Reference product - Green Furniture Concept Nova C double back

Pr_40_50_12_07

BENCH - Modular timber

Application:
Internal and external station areas

Specification:
Colour - Various timber colours, various matt colours
Finish - Natural hard wax oil
Size - 1000Wx612Lx463Hmm, 1500Wx612Lx463Hmm
Reference product - Green Furniture Concept Nova C Bench

3.5 Doors, Shutters & Gates

3.5.1 Doors, Shutters, and Gates

Safety and Security Requirements
Prioritising the safety and security of passengers and staff is fundamental. Doors in stations are designed to be robust, equipped with secure locking mechanisms and, where required, capable of withstanding forced entry. Door should also be equiped with the appropriate panic hardware for emergency egress as required by the station fire strategy, Approved Document Part B of the Building Regulations and BS 9999.

Consideration should be given to Security in Design of Stations (SIDOS) requirements and the station Threat, Vulnerability And Risk Assessment (TVRA) when specifying doors.

Accessibility and Inclusivity
External doors should adhere to the Equality Act 2010 and the requirements of Approved Document Part M of the Building Regulations, promoting accessibility for all users, including those with disabilities. This includes incorporating features such as automated opening systems, powered doors, low threshold sills, and sufficient width to accommodate wheelchairs. Clear signage and tactile paving to entrances can also assist visually impaired passengers. Part M specifically outlines the necessary standards for accessibility, including provisions for easy access and manoeuvrability.

Durability and Weather Resistance
Given the high footfall and exposure to the elements, external doors in railway stations should be constructed from durable materials that can withstand frequent use and adverse weather conditions Materials such as stainless steel, aluminium, and high-performance composites can be used. Weatherproof seals and finishes are specified to prevent water ingress and corrosion.

Aesthetic and Architectural Integration
External doors are designed to complement the architectural style of the station. This involves selecting designs, finishes, and colours that are in harmony with the station's aesthetic while also considering the historical context of the location. Customisation options, such as glazing manifestations or integrated branding elements, can be utilised.

Fire Resistance and Compliance
External doors should comply with fire safety standards as outlined in Approved Document Part B of the Building Regulations, BS 9992, and BS 9999. Fire-rated doors should be specified according to the required fire resistance duration, with appropriate testing and certification provided for door products. The installation of doors should be carried out in accordance with the manufacturer's guidelines and relevant standards.

Automatic Glazed Swing Doors

Application:
Internal and external doors

Specification:
Colour - None
Finish - Glazed
Size - As specified
Reference example - KONE; Automatic swing doors

Automatic Glazed Sliding Doors

Application:
Internal and external doors

Specification:
Colour - None
Finish - Glazed
Size As specified
Reference example - KONE; Automatic sliding doors

3.5 Doors, Shutters & Gates

Pr_30_59_24_86

Partially Glazed Swing Doors

Application:
Internal and external doors, back of house

Specification:
Colour - As specified
Finish - Glazed, powder coated
Size - As specified
Reference example - Maximum Doors

Pr_30_59_24_86

Fully Glazed Swing Doors

Application:
Internal and external doors

Specification:
Colour - As specified
Finish - Glazed
Size - As specified
Reference example - Assa Abloy

Pr_30_59_24_85

Emergency Fire Doors

Application:
Internal and external fire doors

Specification:
Colour - As specified
Finish - Steel
Size - As specified
Reference example - Rhino Doors; Hinged fire rated door

Pr_30_59_24_14

Bostwick Gate - Collapsible

Application:
Internal station thresholds

Specification:
Colour - As specified
Finish - Natural, Powder coated
Size - As specified
Reference example - Boston Gate

Pr_30_59_24_37

Secure Doors

Application:
Internal and external staff-only locations

Specification:
Colour - As specified
Finish - As specified
Size - As specified
Reference example - Sunray; security rated doors

Pr_30_59_24_14

Vertical Bar Gate - Sliding

Application:
Internal retail thresholds

Specification:
Colour - As specified
Finish - Natural, Powder coated
Size - As specified
Reference example - Roche Security; Steel security shutters

3.6 Barriers

3.6.1 Barriers

Barriers and balustrades should adhere to Parts M and K of the Building Regulations. They should be designed to withstand appropriate barrier and crowd loading especially in scenarios with high pedestrian traffic. The materials and construction methods should be robust and durable, suitable for the intended usage and environment.

Metal Balustrades:
When specifying metal balustrades, special attention should be given to the size of any perforations. These perforations should be carefully designed to prevent finger traps. The strength of the metal and the integrity of its construction should be sufficient to meet the required load-bearing standards, while also providing a long-lasting solution that resists wear and corrosion.

Timber:
Timber balustrades, such as those recently used at Brent Cross West, offer a warm and aesthetically pleasing option. When specifying timber balustrades, it is crucial to select durable, weather-resistant wood that can withstand the elements and heavy usage. The timber should be treated to resist rot, insects, and moisture. Additionally, the design should establish that the wood remains smooth and splinter-free, providing a safe and comfortable touchpoint for passengers. Regular maintenance and inspections are necessary to preserve the structural integrity and appearance of timber balustrades over time.

Timber

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Natural Timber
Finish - To be treated appropriately for applicable environment
Size - In accordance with Approved Document K
Reference example - Brent Cross West

Metal

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - RAL colour as specified
Finish - PPC
Size - In accordance with Approved Document K

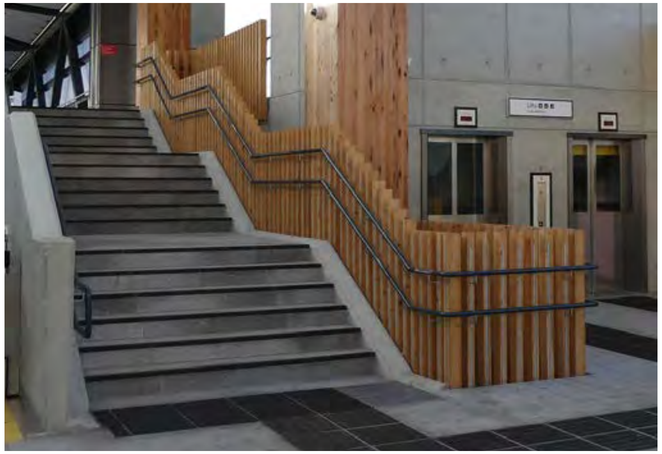


Image 3.1 Timber balustrade at Brent Cross West station

Standards Reference

Department for Transport
Design Standards for Accessible Railway Stations: A Code of Practice

National Standard

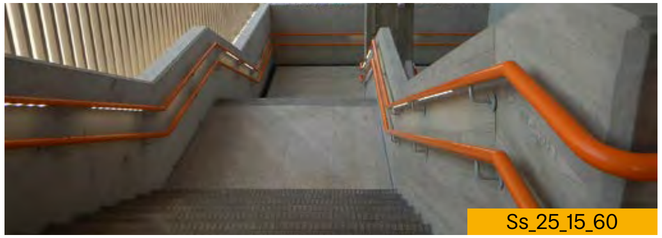
Building Regulations
Access to and Use of Buildings: Approved Document Part M

Protection from Falling, Collision and Impact: Approved Document Part K

3.6 Barriers

Glass:
Glass balustrades in transport environments should meet the crowd / barrier loading and security requirements outlined in the Security in Design of Stations (SIDOS) and Network Rail Security at Stations guidelines. The glass should be toughened or laminated to resist impact and provide a high level of safety. Consideration should also be given to the height and thickness of the glass panels to prevent accidents and provide robust crowd control. Proper detailing at the edges and joints is necessary to avoid injury and enhance the durability of the glass balustrade.

Concrete:
Concrete barriers and balustrades can be highly durable and secure, but they require careful detailing to avoid a harsh appearance. Without proper texturing and finishing, concrete can appear cold and uninviting. Stations like Hackney Wick demonstrate how thoughtful detailing can soften concrete's appearance, creating a more human-scale aesthetic that enhances the passenger experience. Techniques such as adding texture, incorporating colour, or using form liners can help achieve a visually appealing and tactilely pleasant surface.



Concrete

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Concrete / Grey
Finish - Visual concrete
Size - In accordance with Approved Document Part K
Reference example - Hackney Wick

Glazed

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Transparent
Finish - Transparent
Size - In accordance with Approved Document Part K
Reference example - Paddington

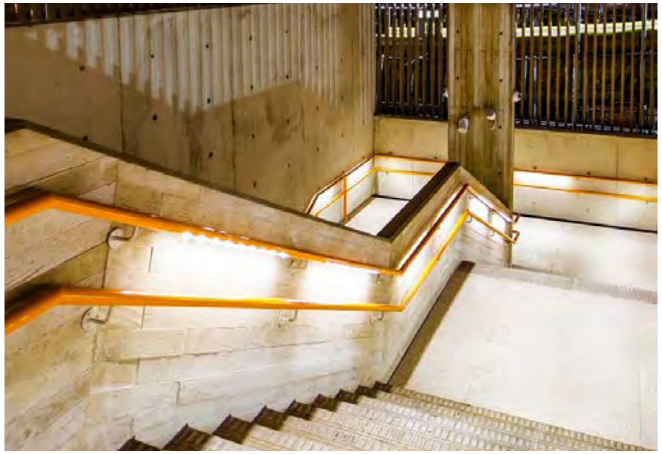


Image 3.2 Cast concrete balustrade at Hackney Wick station

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

National Standard

Department for Transport
Security in the Design of Stations (SIDOS)

3.7 Handrails

3.7.1 Handrails

Handrails should be designed in accordance with Approved Documents Part M and K and be warm to touch. They should be designed in accordance with the DfT Design Standards for Accessible Railway Stations: A Code of Practice including opportunities to integrate Braille and LED lighting.

Nylon Coated:
Nylon-coated handrails provide a warm-to-touch, non-slip surface that is comfortable to grip and highly resistant to wear and vandalism. They can also include brief information in Braille or prismatic letters at the specified height for accessibility.

Polyester Powder Coated (PPC):
PPC handrails offer durability and a wide range of colour options. The coating provides excellent resistance to weathering, UV radiation, and corrosion, making it suitable for both indoor and outdoor environments. The smooth finish also facilitates easy cleaning and maintenance.

Timber:
Timber handrails add a warm, natural aesthetic to transport environments. When specifying timber, it's important to choose hardwoods that are treated for durability and resistance to moisture, pests, and splintering. Regular maintenance is required to preserve their appearance and structural integrity.

Steel (and other Low Thermal Conductivity Metals)

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless steel
Finish - Brushed Stainless steel
Size - As defined by Approved Documents Part M and K

Timber

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour -Natural timber
Finish - Natural timber finish
Size - As defined by Approved Documents Part M and K

Polyester Powder Coated (PPC)

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - RAL colour as specified
Finish - PPC
Size - As defined by Approved Documents Part M and K

Nylon Coated

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Multiple colours available dependent on supplier
Finish - Nylon Coated
Size - As defined by Approved Documents Part M and K

3.8 Fencing

3.8.1 Fencing

Standard fencing in railway stations typically uses durable materials like galvanized steel or welded mesh, providing robust security and requiring minimal maintenance. These fences are designed to withstand weather conditions and frequent use, providing longevity and safety but can often appear harsh in sensitive or public areas of stations.

Heritage:
Fencing can often form part of the heritage context of a station. Materials like wrought iron or timber are preferred, often featuring ornate designs that complement the station's architectural style. These fences not only provide security but also enhance the historical ambiance.

National Standard

Building Regulations
Access to and Use of Buildings: Approved Document Part M

Protection from Falling, Collision and Impact: Approved Document Part K

Standards Reference

Network Rail: Boundary Measure Management Manual
NR/L2/OTK/5100

Image 3.3 Community consultation resulted in a contextually appropriate fencing to secure the railway at Sydney Gardens in Bath

3.8 Fencing

Sensitive:
Fencing in sensitive areas, such as near residential neighbourhoods, should balance security with aesthetics. Materials like powder-coated metal or timber can provide a visually pleasing barrier that minimises the visual impact while maintaining safety and privacy.

High Security:
High-security fencing is important in vulnerable areas requiring enhanced protection, such as perimeters or restricted zones. Materials like steel palisade or anti-climb mesh are used, often with additional features like barbed wire or electronic monitoring systems, to prevent unauthorized access and provide maximum security. The use of these in public facing areas should be avoided unless deemed necessary, as they can create a harsh unwelcoming environment.

Steel

Application:
External - secured areas

Specification:
Colour - Steel
Finish - Galvanised Steel
Size - As required

Bespoke - Feature Wall

Application:
External - public facing areas

Specification:
Colour - As specified
Finish - Glazed Brick
Size - As required
Reference example - West Hampstead Thameslink

Timber

Application:
External - public facing areas

Specification:
Colour - Natural timber
Finish - To be appropriately treated for external environments
Size - As required

High Security

Application:
External - secured areas

Specification:
Colour - RAL colour as specified
Finish - PPC
Size - As required

3.9 Cycle facilities

3.9.1 Cycle facilities

Cycle storage facilities at stations should be tailored to individual station requirements. Typical options include Sheffield stands, two-tier racks, or cycle hubs for stations with greater demand. Provision should accommodate adapted cycles, and charging points for electric bikes.

Lockers for folding bikes are efficient but may pose security risks, requiring consultation with security experts. Cycle Hire facilities should be located alongside cycle parking and maintenance areas with good surveillance.

Pr_40_30_21_35

Standard Sheffield Rack

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless Steel or Polyester Powder Coated
Finish - Stainless Steel or Polyester Powder Coated
Size - 750x750 (Generally)
Reference example - Cyclehoop

Pr_40_30_21

Two-Tier Bike Rack

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless Steel or Polyester Powder Coated
Finish - Stainless Steel or Polyester Powder Coated
Size - Bespoke
Reference example - Cyclehoop

Pr_40_30_21

Cycle Hire Lockers

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless Steel or Polyester Powder Coated
Finish - Stainless Steel or Polyester Powder Coated
Size - Bespoke
Reference example - Cora Bike Rack

Pr_40_30_21

Small Hub

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless Steel or Polyester Powder Coated
Finish - Stainless Steel or Polyester Powder Coated - potential for green/brown roof.
Size - Bespoke
Reference example - Cyclehoop

Pr_40_30_21

Large Hub

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Stainless Steel or Polyester Powder Coated
Finish - Stainless Steel or Polyester Powder Coated
Potential for green/brown roof.
Size - Bespoke
Reference example - Urbanspec

3.10 Help and Information points

3.10 Help and Information Points

Information desks are available in various forms from pop-up counters to permanent offices. They should allow interaction from both sitting and standing positions for accessibility, with permanent desks prominently signposted in visible areas.

Mobile desks with digital capabilities offer flexibility and can be powered through wall or floor outlets. Placement should maximise usefulness without obstructing pedestrian flows or key areas like gatelines. Specified products should be lockable overnight for security purposes and feature simple desks and high-level signage.

Help Points should be clearly visible, accessible, and coordinated with CCTV to enhance safety. Specified products should be simple, robust, user-friendly, and equipped with accessibility features, such as tactile instructions, visual indicator lamps and induction loops. Mounting to surfaces should be undertaken according to the manufacturer's specification.

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

Inclusive Design
NR/GN/CIV/300/04

Station Facilities & Amenities
NR/GN/CIV/200/03

Pr_40_50_21_21

Mobile Information Desk

Application:
Concourses and ticket halls

Specification:
Colour - As specified
Finish - Timber and laminate
Reference example - Ideas Ltd

Pr_75_75_04_70

Help Points

Application:
Platforms and waiting rooms

Specification:
Colour - White with graphics
Finish - Polyester Powder Coated
Reference example - TDM

Pr_40_50_21_21

Information Desks

Application:
Concourses and ticket halls

Specification:
Colour - Bespoke
Finish - Bespoke
Size - Bespoke
Reference Example: Leeds Station

Pr_40_50_21_21

Freestanding Inclusive Ticket & Information Counters

Application:
Concourses, ticket halls,

Specification:
Colour - Bespoke
Finish - Bespoke
Size - Bespoke
Reference Example: Paddington Station

3.11 Water Fountains

3.11.1 Water Fountains

Mains fed water fountains reduce single-use plastic consumption and may be free standing or wall mounted as required.

Dispensing options typically include automatic sensor driven or mechanical with further options such as UV sterilisation.

Their location should be strategically determined and should ideally be located in high traffic areas to allow for greater surveillance. Accessibility, along with the integration of signage and wayfinding should be considered.

Water fountains should be installed to the manufacturer's specification and guidance and be accessible to all. Compliance with BS 6700 and BS EN 806 is necessary for water supply system design.

Bottle Filling Station - In Wall Pr_40_70_15_24

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Grey / As Supplied
Finish - Self-Finished
Size - Typical: 1000 (H) 500 (W) 80 (D)mm
Reference example - Halsey Taylor

Bottle Filling Station - On Wall Pr_40_70_15_24

Application:
Managed stations - concourses, ticket halls, waiting rooms

Specification:
Colour - Grey / As Supplied
Finish - Self-Finished
Size - Typical 650 (H) 450 (W) 229 (D)mm
Reference example - Halsey Taylor

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

Inclusive Design
NR/GN/CIV/300/04

Station Facilities & Amenities
NR/GN/CIV/200/03

National Standard

Specifications for installations inside buildings conveying water for human consumption
BS EN 806

Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages Specification
BS 6700

Design of an accessible and inclusive built environment - Buildings. Code of practice
BS 8300

3.12 Bins

3.12.1 Bins

There are generally three types of bins in transport environments:

- 'Plastic Sacks' - supported by a metal or plastic hoop
- Conventional Bins
- Blast-Enhanced Bins

The design and installation of litter bins in stations should be guided by a risk assessment undertaken by the Station Facilities Operator and recorded with the Station Security Plan.

All bins should consist of a clear plastic sack, a metal hoop sack holder, and an internal bungee strap to secure the sack. Bins are required to comply with security and blast standards. See NR/GN/CIV/300/02 'Security at Stations' and Home Office standards for further information. Bins should be installed and mounted according to the manufacturer's specification.

Note that only 'Plastic Sack' type bins are permissible in Network Rail stations.

Image 3.4 Post mounted Plastic Sack type bins installed at a Network Rail managed station

Pr_40_50_07_47

Plastic Sack Holder - Typical or Transport Security Unit (TSU)

Application:
To be determined by TVRA

Specification:
Colour - Varies
Finish - As supplied
Performance - 3 Star Home Office test 23/13 2013 rating
Reference example - Glasdon

NR Guidance Suite Reference

Security at Stations
NR/GN/CIV/300/02

Standards Reference

Standard 23/14 version 2 – Test method for the determination of the explosion resistance of litter and recycling bins
Home Office

3.13.1 Services and Containment

Attention should be given at the earliest project stages to the appearance of service runs and their containment. Unplanned and ad-hoc runs of services can be particularly detrimental to the appearance of stations.

As far as is practicable, all service routes should be concealed from public view. Where this is not possible, containment should be deployed sympathetically and for the shortest spans possible.

An Architect or architectural advisor should be consulted when planning services routes and their containment and not left to the installation contractor.

Where new equipment is being added to existing sites, the opportunity to improve and minimise existing runs should be pursued. When installing new equipment or further runs of services redundant runs should be removed and the surroundings made good.

When service runs are added, additional capacity should be provided for any future expansion / additions that may be required.

Image 3.5 Example of ad-hoc and poorly managed / coordinated containment.

Image 3.6 London Bridge Underground - Integrated containment

Image 3.7 Good example at Paddington station of cable containment without negative impact to architecture

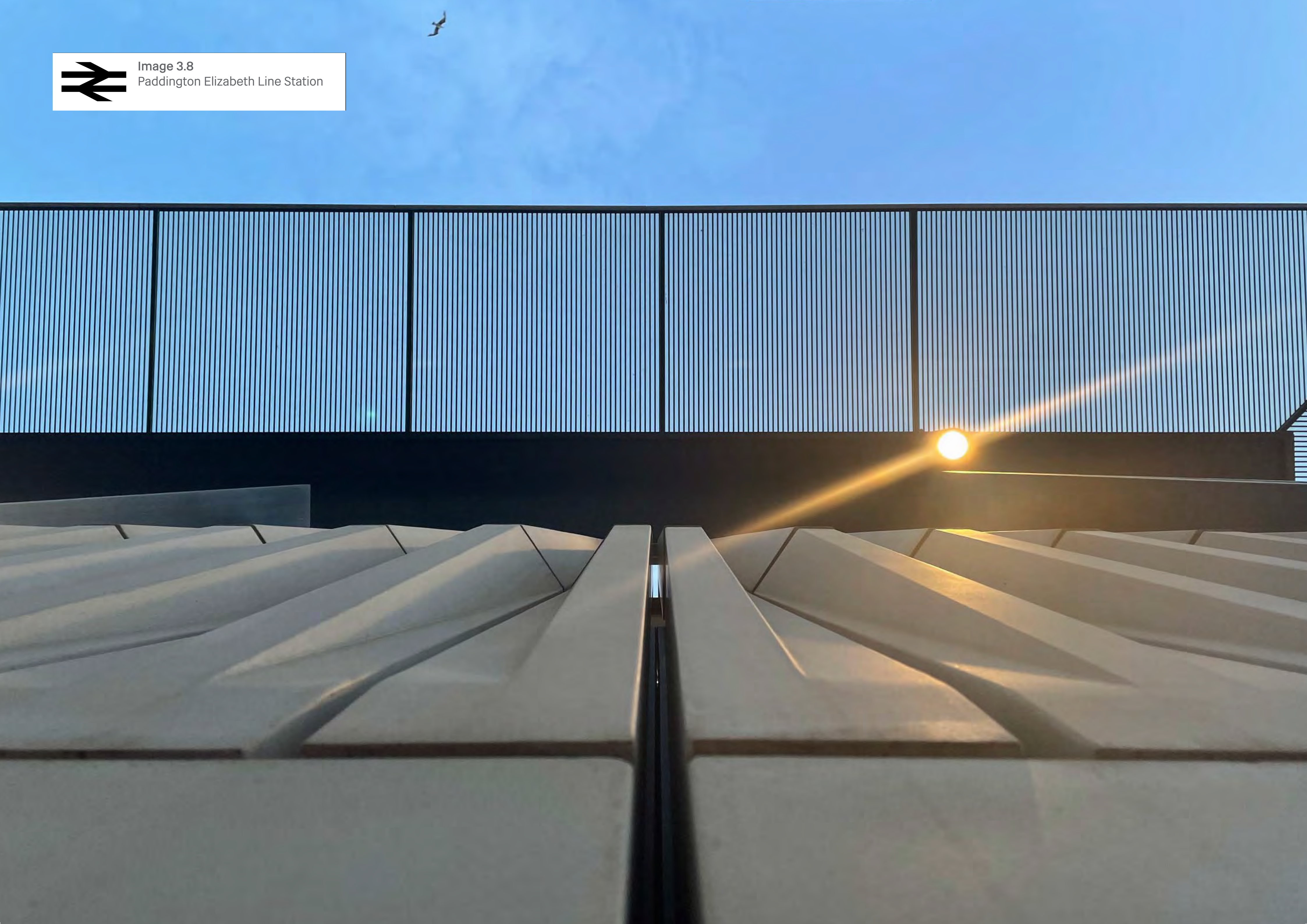


Image 3.8
Paddington Elizabeth Line Station

Materials & Components

Section 4: Maintenance

4

4.1 Surveys, Preparation and Setting Out

4.1.1 Appropriate survey information

Site information should be obtained from as built records or surveys to allow designs to be progressed and executed in line with their intent. Inaccurate information can lead to designs not meeting their spatial requirements, and materials and components that cannot be installed as intended.

For all material and component installations, the designer should stipulate that dimensions are to be confirmed on site. This enables accuracy and precision beyond what is required to progress the design intent.

4.1.2 Preparation / Understanding of conditions

Understanding site conditions and spatial zones for materials and finishes to be applied is key to assuring the designs are suitable for the spaces where they are implemented.

4.1.3 Setting Out of Materials

Materials setting out intent should:

- → Avoid small cuts and slithers
- → Maximise use of standard module sizes
- → Maximise large format materials and module sizes, to reduce the number of joints
- → Account for tolerances, movement joints, and additive 'creeping' of successive joints in a surface
- → Consider centring setting out or aligning with specific elements, so as to give the most balanced appearance.

Communication of intent should:

- → Provide clear instruction and direction
- → Demonstrate priorities, where certain elements of setting out are more important than others
- → Be capable of being implemented. On refurbishment projects this can mean providing setting out reference to physical objects, rather than distance grid references.

Image 4.1 Precise survey information helps to maintain the safety and integrity of railway infrastructure

4.2 Workmanship

4.2.1 Designing to assist Workmanship

Small material cut and unequal angles are challenging and labour intensive. Good designs should seek to reduce or minimise the amount of cutting and the level of irregular cuts, to reduce the intensity of labour required, and to avoid creating opportunities for poor or irregular workmanship.

4.2.2 Maximise prefabrication / offsite work

Assembling and fabricating offsite generally allows more control and quality over the outcome. It can:

→ Allow work to be carried out by specialists that are familiar with a task/ material, which may not be achievable in a specific on-site location.

→ Avoid site based challenges including confined spaces, controlled access and weather and temperature

→ Reduce the quantity and length of time spent on site, as site become the location of installation or assembly only, not the location of all construction.

NR Guidance Suite Reference

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

National Standard

Building Regulations
Approved Document 7 - Materials and Workmanship

4.2.3 Following Manufacturer Requirements, Guidance and Recommendations

Designers and those installing works should follow manufacturer's requirements, guidance and recommendations. It is important that these are considered by designers, as they may impact setting out, floor dimension zones, or identify early on where a material or component is not suitable as it cannot be installed to meet manufacturers requirements.

4.2.4 Referring to the associated British Standards (BS)

British Standards cover a wide range of materials and performance areas. Relevant British Standards should be consulted and followed.

4.2.5 British Board of Agrément (BBA)

British Board of Agrement certification provides assurance that products are suitable for their intended purpose and use.

4.2.6 Building Regulations

Approved Document 7 of the Building Regulations 2010 sets out the legislative requirement for materials and workmanship as part of building work.

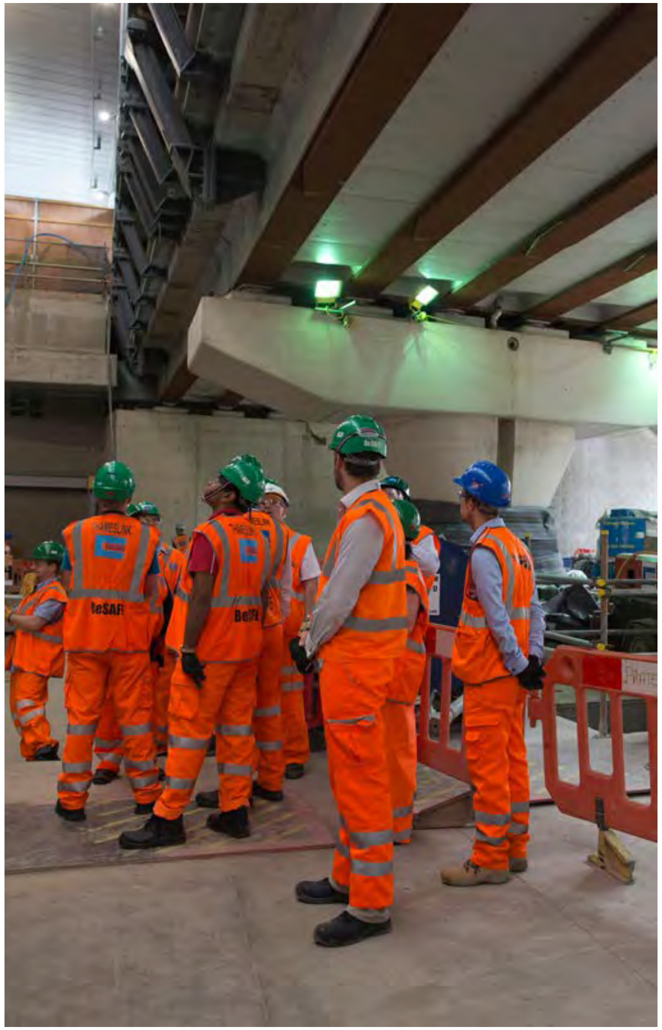


Image 4.2 London Bridge station refurbishment during construction

4.3 Renewal and Replacement

4.3.1 Renewal and Replacement

When developing proposals, the designer should demonstrate how elements can be accessed, inspected and replaced.

Additional focus should be given to items that have lower design lives and require more frequent replacement, or that can experience damage or failure, such as glazing.

Designers should consider:

→ How elements can be easily replaced without complex sequences of removing/dismantling other elements

→ Using elements that can be easily sourced for replacement, without long lead times or poor batch consistency

→ Designing for elements to be replaced without the requirement for highly specialist or proprietary expertise

→ Minimising or avoiding specialist equipment to replace elements

→ Keeping the weight of items that require replacement within safe lifting limits

→ Avoiding the use of materials that require replacement of elements above/adjacent to rail infrastructure

4.3.2 Cleaning and Maintenance

Designers should identify specific cleaning and maintenance requirements, and a preferred method for carrying out maintenance. Where practicable reference should be made to any manufacturers recommendations.

Any risks and hazards associated with cleaning and maintenance should be identified and catalogued within project risk registers and the project Health and Safety File as required by the Construction (Design and Management) Regulations 2015.

Designs should seek to minimise creating finishes that require cleaning and access from above / adjacent to rail infrastructure.

Material specification should consider the ease of cleaning materials and the methods of cleaning required. For example less heavily trafficked areas are likely easier to clean whereas higher traffic areas are more susceptible to dirt and may be harder to clean and maintain requiring specific methodologies.

Image 4.3 Elizabeth Line - GRFC panel graffiti

Image 4.4 Hackney Wick station underpass graffiti wall

4.4 Design Life

4.4 Design Life

The following table lists the expected design life of common non-load bearing materials in stations. Where materials are specified for structural and/or load-bearing purposes reference should be made to NR/L2/CIV/003/F1990, BS EN 1990 and Eurocode EN 1990 for appropriate design life requirements rather than the design lifes in the tables herein.

The following tables are formulated for Major stations. For non-major stations the design life can be adjusted according to existing circumstances - for example so that finishes need not have a longer life than the structures they are supported on. Design life should be agreed with the asset team before specification.

Establishing the expected design life of materials improves decision making when specifying materials and is important for optimising maintenance, budgeting for replacements, improving sustainable building practices, and maintaining overall performance.

Material	Design Life
External Walls	
In-Situ Concrete Coping	80 Years
Melanine Faced Cladding	30 Years
Metal Cladding	30 Years
Natural Stone	80 Years
Patent Glazing	30 Years
Precast Concrete Copings	25 Years
Reconstituted Stone	80 Years
Rendered Block Wall	100 Years
Rendered Plywood	40 Years
Solid Block Wall	80 Years
Solid Brick Wall	80 Years
Timber Cladding`	30 Years
UPVC Cladding	40 Years

Image 4.5 Design life for materials and corresponding station uses

Roof Covering	
Artificial Slating	70 Years
Asphalt - Pitched	35 Years
Asphalt - Flat	35 Years
Built-Up Felt Roof - Double	20 Years
Built-Up Felt Roof - Triple	25 Years
Clay Tiles	70 Years
Concrete Tiles	70 Years
Copper	60 Years
Fibre Cement	25 Years
Galvanised Corrugated Steel	35 Years
GRP Cladding	30 Years
Lead Flashings / Soakers / Aprons	35 Years
Lead Sheet Covering	35 Years
Natural Slating	70 Years
Patent Glazing	30 Years
Plastic Fascia / Soffit	20 Years
Profiled Stainless	35 Years
Profiled Metal - Lead	35 Years

Standards Reference

Network Rail - Technical Design Requirements for BS EN 1990
NR/L2/CIV/003/F1990

National Standard

Eurocode. Basis of Structural Design
BS EN 1990

European Standard

Eurocode - Basis of Structural Design
EN 1990

4.4 Design Life

Profiled Metal - Zinc	30 Years
Profiled Metal - Copper	35 Years
Profiled Plastic	20 Years
Supalux Soffit Lining	25 Years
Timber Boarding	30 Years
Timber Fascia	20 Years
Timber Fascia / Soffit	20 Years
Zinc	60 Years
Roof Structure	
Concrete	80 Years
Metal	40 Years
Plastic	20 Years
Profiled Metal	100 Years
Steel	100 Years
Timber	40 Years
Woodwool Slats	50 Years
Superstructure - External Walls	
Brick	80 Years
Brick Bund	80 Years
Brick Coping	80 Years
Brick Faced / Concrete Core	80 Years
Brick / Block Cavity	80 Years
Ceramic Tiles	30 Years
Concrete	80 Years
Concrete Coping	80 Years
Concrete Sill	80 Years
Curtain Walling	30 Years
Dense Block	80 Years
Fibre Cement Cladding	30 Years
Glass Block	50 Years
GRP Cladding	30 Years
In-Situ Concrete	80 Years
In-Situ Concrete Coping	25 Years
Melamine Faced Cladding	30 Years
Metal Cladding	30 Years
Natural Stone	80 Years
Patent Glazing	30 Years
Precast Concrete Copings	25 Years
Reconstituted Stone	100 Years
Rendered Solid Block Wall	140 Years
Rendered Plywood	40 Years
Solid Block Wall	80 Years
Solid Brick Wall	80 Years
Timber Cladding	30 Years
UPVC Cladding	40 Years
Ceilings Internal Ceiling Finishes	
Dampa Metal Plank	40 Years
Formica Panelling	25 Years
Metal Cladding	40 Years
Metal Tile Suspended	20 Years
Mineral Tile Suspended	30 Years
Paint (Plaster Board)	35 Years
Paint (Plaster)	25 Years
Varnished Timber Boarding	60 Years
Canopies & Canopy Drainage	
Cast Iron Frame	100 Years
In-Situ Concrete Frame	80 Years
Steel Frame	100 Years
Steel Truss	25 Years
Timber Frame	60 Years
Canopy Roof Covering	
Artificial Slating	70 Years
Asphalt - Pitched	35 Years
Asphalt - Flat	35 Years
Built-Up Felt Roof - Double	20 Years

Image 4.5 Design life for materials and corresponding station uses

4.4 Design Life

Built-Up Felt Roof - Triple	25 Years
Clay Tiles	70 Years
Concrete Tiles	70 Years
Copper	60 Years
Fibre Cement	25 Years
Galvanised Corrugated Steel	35 Years
GRP Cladding	30 Years
Canopy Roof Structure	
Steel Roof Structure	100 Years
Timber Roof Structure	40 Years
Woodwool Slats	50 Years
Platform - Structures	
Brick	80 Years
Natural Stone	80 Years
Steel Frame	50 Years
Timber	40 Years
Brick	80 Years
Concrete	80 Years
Concrete Frame	80 Years

Car Parks, Roads, and External Works	
Armco Barrier	30 Years
Bollards - Concrete	40 Years
Bollards - Steel	40 Years
Bollards - Timber	40 Years
Landscaping	
Brick	40 Years
Brick Kerbs	60 Years
Brick Paving	35 Years
Brick Setts	35 Years
Blockwork	40 Years
Cobbles	40 Years
Concrete	80 Years
Concrete Edgings	40 Years
Concrete Kerbs	40 Years
Concrete Paving	35 Years
Concrete Sleepers	45 Years
Double Yellow & White Lining	10 Years
Granite Kerbs	60 Years

Granite Setts	80 Years
Granite Sett Channel	80 Years
Gravel	5 Years
Hardcore	20 Years
Low Level Railings	40 Years
Maximum Headroom Frame	50 Years
Natural Stone	80 Years
Natural Stone Kerbs	60 Years
Rubber Speed Ramps	20 Years
Speed Hump	20 Years
Stone Wall	80 Years
Stone / Shale	15 Years
Tarmacadam	20 Years
Timber Edging	30 Years
White Lining	10 Years
Tactile Paving	40 Years
Terrazzo	30 Years
Timber Sleepers	25 Years
Brick Planters	80 Years
Ground Cover	50 Years

Image 4.5 Design life for materials and corresponding station uses

Image 4.6
London Bridge station concourse

Materials & Components

Section 5: Sustainability

5

5.1 Sustainability Strategy

Our vision is to serve the nation with the cleanest, greenest mass transport. We want to put passengers first, help passengers and freight users to make green choices, support local communities and be a good neighbour.

Our commitment to wider sustainable development goals, including social value, are also very important to us. There are social benefits to everything we do, and we are committed to supporting our local communities.

Detailed social value plans are addressed separately. Some wider environmental topics such as noise, vibration and water pollution are not the focus of this strategy but do form part of our wider environmental sustainability plans.

To deliver our vision we have four core priorities:

- 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

Successful delivery of this strategy relies on integrating environmental sustainability into everything we do. Delivering our commitments against the six key enablers below can help make our strategy a success

- People: How we communicate with our employees, increase their capabilities and create the culture we require to enable change.
- Funding and Planning: How we integrate environmental sustainability into the planning and funding process, which is vital for the delivery of our ambitions.
- Systems and Processes: What changes to company-wide processes and systems should be made to support change (including procurement and partnerships with our supply chain).
- Engagement: Communications, partnerships with external organisations, working with our neighbours and engaging with our stakeholders to support change.
- Technology: How we approach research and innovation to support the delivery and acceleration of our programmes.
- Measurement: What information, data and measures should be in place to monitor and demonstrate change.

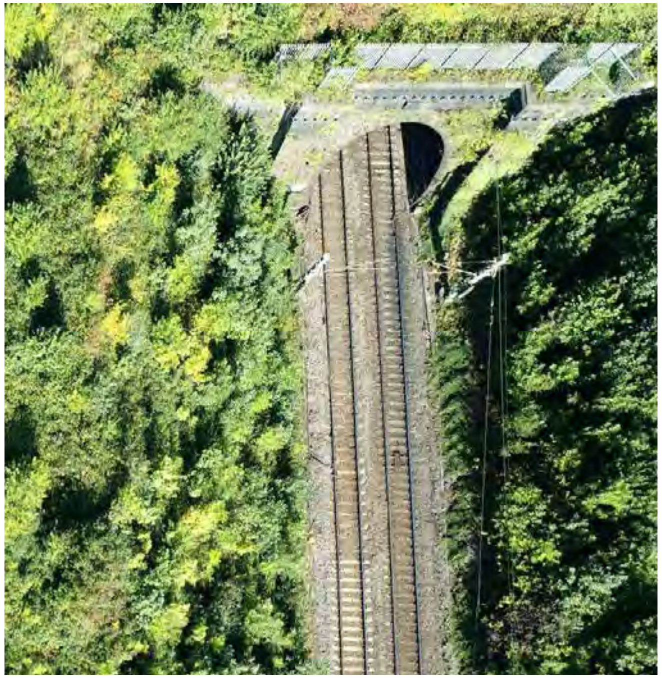


Image 5.1 Aerial view of rail tunnel surrounded by vegetation

NR Guidance Suite Reference

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

Standards Reference

Network Rail Environmental Sustainability Strategy
NR/L2/ENV/015

5.2 Circularity

5.2.1 Circular Economy

A Circular Economy can be defined by two distinct, closed, materials loops: the ‘Biological’ and the ‘Technological’. Biological materials are part of a cycle of absorbing CO2 which is then sequestered until it is released by decomposition back into the biological cycle. The ‘Technological’ materials are derived from raw materials, through mining and refining and other human activities – these materials do not decompose, and therefore should be recycled and reused.

The key principles of moving toward a circular economy in the construction industry;

- → Conserve Resources, e.g., by avoiding demolition and reusing assets and materials so as to avoid new construction where possible. Upgrade and intensify building use where possible, where it is necessary to use virgin material sources do so efficiently and design out construction waste,
- → Design to eliminate future waste; design for longevity, ease of repair and maintenance, flexibility adaptability or deconstruction and re-usability
- → Manage existing material resources so they retain their quality and value and don’t become waste e.g. by specifying recycled products, reducing wastage

5.2.2 Circular Economy Key Points:

- → Organise workshops as early as possible with the client, their maintenance/ asset management team, and the design team to discuss a circular economy strategy
- → Recommend that a pre-demolition audit/material inventory is carried out as early as possible to identify opportunities for on-site material reuse or re-purposing. Discuss storage space for reclaimed materials at an early stage and clarify intended reclamation, storage and reuse of materials.
- → Recommend that testing and sampling of reclaimed materials is carried out at an early stage to build confidence in technical/aesthetic properties and process; reclaimed materials often require additional testing and validation.
- → Discuss the end-of-life expectations of different layers of the building (from structure and cladding to internal finishes and fitout) with the client and the project team: the brief should establish the approach to longevity, future changes of use, and deconstruction/disassembly.
- → Specify materials and components that can be reused at the end of a building’s life: opt for reversible connections and design for disassembly. Be mindful of, or avoid if possible, specifying composite products with inseparable materials

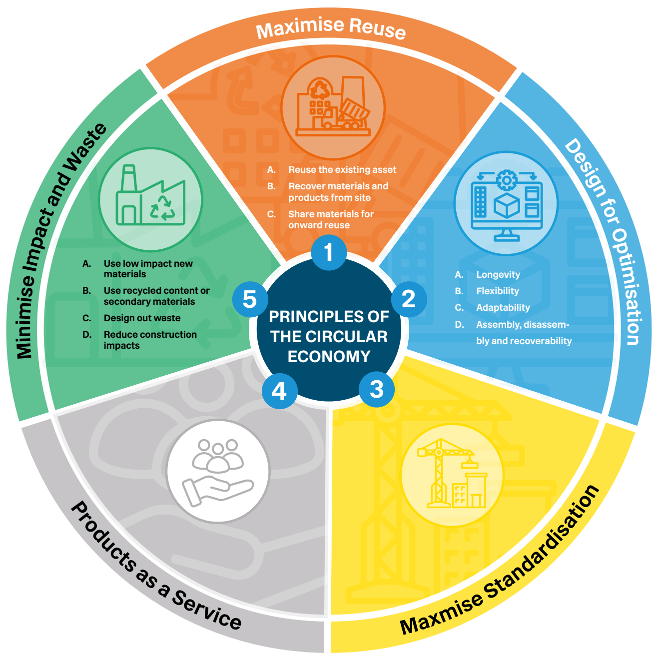


Image 5.2 Principles of the Circular Economy

- Consider elements and products that could be procured through leasing agreements with suppliers that can take back end-of-life components for reuse and recycling.
- Evaluate opportunities to source secondary materials from local reclamation yards, materials exchange platforms
- Work with contractors to adhere to WRAP recommendations (https://wrap.org. uk/ resources/guide/recycling-guidelines) and achieve >90% landfill diversion where materials cannot be reused on- or off-site.
- Think of the current buildings you are working on as material Banks for future buildings
- Operational waste: enable minimum waste in operation through recycling provision, food/ bio compost provision (in-line with Government target of 0% biodegradable waste to landfill by 2025). Explore opportunities for surplus goods 'banks' on site and in the local community;
- Be aware of issues linked with waste disposal: e.g. toxins leaching from landfills, financial loss of wasting resources, carbon cost.

5.2.3 Biobased Materials

Biobased materials, such as Flaxboard, Hemp, and Myco Foam, offer significant advantages for smaller rail infrastructure buildings, like those developed by ProRail in the Netherlands. These materials are derived from natural sources, making them inherently sustainable and environmentally friendly. One of the primary benefits is their circularity; Myco Foam can be decomposed and returned to the ecosystem, thus reducing waste and supporting a circular economy. Furthermore, these materials are highly reusable and adaptable, allowing for easy modifications and re-purposing as required.

In practical applications, Myco Foam serves a dual purpose. It is effective as an insulating material, enhancing energy efficiency by maintaining optimal indoor temperatures and reducing heating and cooling costs. Additionally, it functions as exterior cladding, providing protection against the elements while contributing to the aesthetic appeal of the structure. Overall, the use of biobased materials like Myco Foam aligns with sustainable development goals and promotes environmentally responsible construction practices.

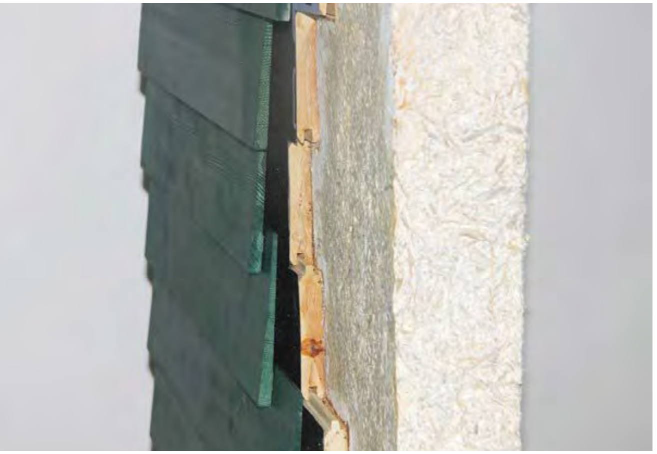


Image 5.3 'Myco Foam' insulation

Image 5.4 'Myco Foam' - mycelium based material developed by Ecovative

5.3 Carbon

5.3.1 Embodied Carbon

Embodied Carbon emissions are the total greenhouse gas (GHG) emissions and removals associated with materials and construction processes throughout the whole life cycle of a building (Modules A1-A5, B1-B5, C1-C4 of the Life Cycle stages defined by BS EN 15978 — Whole Life Carbon Network definition.

Embodied carbon includes emissions caused by extraction of raw materials, transport to factory, manufacture/processing, transportation to site, and the assembly of every product and element within the building. It also includes emissions generated through the maintenance, replacement of materials and building systems during the building's lifetime; as well as the deconstruction and recycling or disposal of the materials and systems at the end of the building's life.

The carbon emitted in producing the building materials of a building or development can represent upwards of two-thirds of the total carbon emissions of that project over its lifetime, and this proportion might increase further given the decarbonisation of the grid. Over time a cleaner grid should lead to improved operational efficiency of buildings. A good design solution considers both embodied carbon and the carbon emissions related to operational energy to optimise whole life carbon reductions.

The metrics used to assess embodied carbon emissions are kgCO2e/m2. CO2e is the abbreviation for carbon dioxide equivalent, 'a metric measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.'

5.3.2 Embodied Carbon Key Points:

- → Establish a project programme that allows time within the design work for embodied carbon analysis and iterations to be made before key project gateway decisions.
- → Establish a project strategy with upfront and total embodied carbon targets in collaboration with the client and all consultants: Assess or request an assessment of any existing buildings to determine whether they can be retained
- → Measure embodied carbon in new and existing buildings. Focus initially on structure and façade.
- → Avoid high carbon materials such as concrete, aluminium and steel wherever possible as we transition to low carbon versions or alternatives.
- → Investigate low carbon and bio based materials wherever possible (e.g. timber and stone but also hempcrete, straw, mycelium, rammed earth).
- → Undertake a full Life Cycle Assessment (e.g., GLA London Plan Policy S12) and test real design options you are considering.
- → Be aware of embodied carbon emissions related to the operational use of a building—emissions generated through the maintenance, replacement of materials and building systems during the building's lifetime.

NR Guidance Suite Reference

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

Standards Reference

Network Rail Environmental Sustainability Strategy
NR/L2/ENV/015

5.3.3 Operational Carbon

The operational energy used by buildings over their lifetime is a key contributor to carbon emissions in the atmosphere, so minimising this through good design can achieve significant carbon savings.

A good design considers both operational energy related carbon emissions and embodied carbon to minimise whole life carbon emissions.

The operational energy use includes regulated use (for lights, heating, hot water, cooling, ventilation, and pumps), and unregulated use (any plug-in small power equipment e.g. kettles, TV, computers, and catering, lift operation, or specialist end-uses).

Energy use intensity (EUI) is used to quantify the operational energy use, in kWh/m2, that is kWh of total energy (electricity, gas, etc) used per m2 (GIA) of building area. The energy use can be estimated (modelled) at design stage by building service engineers or architects, and recent benchmarks can be used at very early stages to guide design choices. The energy use can be translated into greenhouse gas emissions using the conversion factors published by the UK Government (www.gov.uk/government/publications/ greenhouse-gas-reporting-conversion-factors-2021).

Operational energy is influenced by:

- → Passive design measures (e.g. massing, orientation, glazing, shading, etc),
- → Fabric performance (e.g. insulation, airtightness, glazing specification, minimal thermal bridges)
- → Low energy services with adequate controls, commissioning and performance

Operational Carbon refers to the greenhouse gas (GHG) emissions arising from all energy consumed by an asset in-use, and water supply and wastewater treatment for an asset in-use, over its life cycle. (Modules B6 operational energy and B7 operational water of the Life cycle stages defined by BS EN 15978 — Whole Life Carbon Network definition.)

5.3.4 Operational Carbon Key Points:

- Set ambitious targets with the client and the design team to aim for as little energy use as possible
- Create an energy strategy with the design team early in the design process and have an open discussion with the client also at the outset about setting clear energy targets
- Consider design for performance certification, e.g. NABERS
- Start with passive measures: orientation, form, massing, controlled glazing ratios, optimised floor to ceiling heights, shading to prevent overheating and a fabric first approach.
- Build tight, ventilate right! Airtight buildings require adequate ventilation (see resources below). Use passive ventilation where appropriate, but mechanical ventilation with heat recovery is likely to be required to save energy and meet energy efficiency targets, alongside openable windows.
- Develop an appropriate, dynamic energy model to estimate both the regulated energy use and unregulated (small power)
- RIBA Sustainable Outcomes guide recommends TM54 or PHPP as suitable energy modelling options
- Avoid fossil fuel-based sources for heating and hot water—avoid gas and boilers for heating, or stoves which cannot be made zero carbon.
- Use heat pumps for heating and hot water and heat recovery mechanical ventilation. Ground source heat pumps (GSHP) can be much more efficient than air source heat pumps (ASHP), but currently more expensive, and require extensive ground work.
- Consider seasonal optimisation and easy to use and to configure operational controls
- Design to minimise and eliminate the performance gap. Predictions can help guide the design, but high build quality, diligent commissioning and educating the end-users can help achieve the targeted building performance, so monitor the key building aspects all the way to occupation and in-use.
- Incorporate energy performance targets (energy budgets) in the building contract if possible and how the targets are intended to be achieved (clearly defining responsibilities and project brief requirements, e.g. expected operational hours, occupancy levels, etc).
- Assign responsibilities for updating the performance targets at key project stages and reconciling with achieved performance in use.
- If working with an existing building, start by using existing DEC (Display Energy Certificate) data or existing bills as a benchmarking tool to indicate areas to make improvements.

The UKGBC net zero carbon buildings framework defines net zero carbon operational as the instance “when the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/ or off-site renewable energy sources, with any remaining carbon balance offset.”

5.4 Assessment and Measures

Various schemes for the certification and assessment of sustainability in construction exist to promote, monitor, and assure the sustainability credentials of projects.

The most widely-used include Leadership in Energy and Environmental Design (LEED), and the Building Research Establishment Environmental Assessment Method (BREEAM).

LEED emphasises sustainability, resource efficiency, and human well-being in building design, construction, operation, and maintenance. It is used globally though is typically more common in the United States where it was developed by the U.S Green Building Council. Buildings are certified as Sliver, Gold, or Platinum based on the total points achieved in the assessment.

BREEAM maintains a strong presence in the UK and Europe and focusses on the comprehensive assessment of a building's environmental, social, and economic sustainability performance. BREEAM covers various aspects, including energy and water use, materials, pollution, waste, health, and well-being. Buildings are rated on a scale from Pass to Outstanding encouraging continuous improvement.

There are various types of BREEAM assessment available depending on the project being assessed. These include:

→ New Construction

→ Refurbishment and Fit-Out

→ In-Use

→ Communities - for Masterplanning and Regeneration projects

→ Infrastructure - formerly CEEQUAL

BREEAMs flexibility makes it particularly suitable for the assessment of projects undertaken for Network Rail, this could include the use of BREEAM Infrastructure for large heritage train sheds, Refurbishment and Fit-Out for the renewal of habitable buildings which form part of the estate such as offices, or Communities where a significant project such as a new station is planned as part of wider development.

Image 5.5
Woolwich Elizabeth Line Station

Materials & Components

Appendix A: Standards and References

A

The following table provides a summary of current Network Rail Guidance Notes on various topics relating to composite materials and components.

Guidance Note	Revision	Purpose
GN200.01 (G11)	V1	To provide an overview of composite materials including: 1. Description of materials constituents, 2. Description of manufacturing processes likely to be used in railway applications of composites
GN200.02 (G12)	V1	To provide an overview of the main standards applicable to the selection, characterisation, and testing of composite materials.
GN200.03 (G13)	V1	When specifying a composite material for a component (individual part within a product) a list of requirements is captured which can drive the selection of the materials and manufacturing process.
GN200.04 (G21)	V1	To provide guidance on installation and assembly of composite structures, this includes: 1. Examples of mechanical fasteners in non-structural composite installations. 2. Use of mechanical equipment and cutting tools in the assembly of fibre reinforced products. 3. Use of hand tools in the assembly of fibre reinforced products. 4. Product damage and its significance.
GN200.05 (G23)	V1	To give guidance on the typical defects found in FRP composite structures, their significance, and possible causes, to provide the knowledge required to be able to specify, use and maintain FRP structures.
GN200.06 (G24)	V1	To give guidance on the methods of detection of defects to provide Network Rail with the knowledge required to be able to specify, use and maintain FRP structures.
GN200.07 (G15)	V1	To give guidance on the interpretation of composite material supplier specifications. To define the typical information recorded on a specification and how they can be used in material selection.
GN200.08 (G16)	V1	To give guidance on fire, smoke and toxicity (FST) issues associated with fibre-reinforced polymer (FRP) composites, to inform on the hazards for different types of commonly used fibre and resin materials.
GN200.09 (G22)	V1	To provide guidance on manufacturing induced defect types and to provide the knowledge necessary to specify inspection requirements for manufactured FRP structures.
GN200.10 (G32)	V1	This guidance sheet outlines general principles and good practice for the main composite repair techniques. Composite structures get their strength and stiffness from fibres aligned in the principal stress directions, which are optimised dependent on the application. This means that composite repairs should also be optimised, taking thickness and laminate stacking sequence into consideration.
GN200.11 (G41)	V1	To provide an overview to the design process of composite structures using standard section profiles. To enable designers to understand and use suppliers design guides to design composite structures.

Image A.1 Summary of Composite material Guidance Notes

Design Guidance Notes for Composites

Guidance Note	Revision	Purpose
GN200.12 (G42)	V1	To provide an overview of composite properties relevant to construction, and the test methods used to determine them. The objective is to provide the designer with knowledge of what the properties provided by suppliers mean and how to interpret them or specify requirements for further tests where necessary.
GN200.13 (G43)	V1	To describe the standards and test methods for materials to pass fire, smoke, and toxicity (FST), with an emphasis on standards for trains and buildings. References are made to specific fibre-reinforced polymer (FRP) materials in the context of the tests (i.e. which types of fibres and resin combinations are more likely to pass).
GN200.14 (G14)	V1	To give guidance on how to procure composite components and structures. This covers the procuring process to give knowledge in the following: Specifications for purchasing a composite component/structure, Supplier quality assurance procedures, Understanding supplier capability, Supplier quality control measures, Procurement differences between composite material components and traditional material components.
GN200.15 (G31)	V1	To give an overview of when a factory repair is required the main considerations to make when evaluating the repair and how to ascertain the quality of the repair.
GN200.16 (G33)	V1	To give guidance on through life repairs of composite structures, what is repairable and how best to deal with damage.
GN200.17 (G34)	V1	To provide an overview for maintenance requirements and best practices of composite products. Types of inspection required, maintenance schedules, cleaning dos and don’ts, damage identification and potential repair routes.
GN200.18 (G44)	V1	To provide an overview of how component and system testing is used to assure that composite parts are fit for purpose and to provide a high-level introduction to structural health monitoring systems for composites.
GN200.19 (G45)	V1	To provide an overview of sustainability for composites in terms of the three pillars of sustainability, Life Cycle Thinking and Circular Economy. To give an understanding of current and future end-of-life routes for fibre reinforced composite materials and components with reference to the Waste Hierarchy.
GN200.20 (G46)	V1	To provide an overview of how composite structures are designed when NOT using standard section profiles and the benefits of using such bespoke composite structures and components.

Image A.1 Summary of Composite material Guidance Notes

Glossary

BREEAM

Building Research Establishment Environmental Assessment Method

CABE

Commission for Architecture and the Built Environment

CCTV

Closed Circuit Television

CEEQUAL

Civil Engineering Environmental Quality Assessment and Award Scheme

DEC

Display Energy Certificate

DfT

Department for Transport

DPTAC

Disabled Persons Transport Advisory Committee

GIA

Gross Internal Area

HSE

Health and Safety Executive

LCA

Life Cycle Assessment

LEED

Leadership in Energy and Environmental Design

NABERS

‘National Australian Built Environment Rating System’ - Rating system assessing the actual performance of a building over a 12-month period

NTSN

National Technical Specification Notices

PACE

Project Acceleration in a Controlled Environment

PHPP

Passive House Planning Package

RIBA

Royal Institute of British Architects

RUS

Route Utilisation Strategy

SIDOS

Security in the Design of Stations - Department for Transport Standard

TS

Transport Scotland

TVRA

Threat and Vulnerability Risk Assessment

UKGBC

UK Green Building Council

Reference Documents

A wide range of Network Rail and industry-wide documents and guidance notes were used in compiling this guide.

Below is a list of the most relevant standards and guidance documents referenced within this guide. The list is not intended to be exhaustive but provide the user of this guide with a sound basis upon which to base material and specification decisions.

Relevant Network Rail Standards and Guidance documents:

- NR/GN/CIV/100/02 Station Design
- NR/GN/CIV/100/03 Station Capacity Planning
- NR/GN/CIV/100/04 Climate Action Design
- NR/GN/CIV/100/05 Heritage: Care & Development
- NR/GN/CIV/200/02 Design for Medium to Small Stations
- NR/GN/CIV/200/03 Station Facilities & Amenities
- NR/GN/CIV/200/10 Public Realm at Stations
- NR/GN/CIV/300/02 Security at Stations
- NR/GN/CIV/300/03 Fire Safety at Stations
- NR/GN/CIV/300/04 Inclusive Design
- NR/GN/CIV/300/06 Tactile Wayfinding
- NR/L2/ENV/015 Environmental Sustainability Strategy
- NR/L2/OTK/5100 Boundary Measure Management Manual
- NR/L3/CIV/030 Platform Components & Prefabricated Construction Systems
- NR_L2_CIV_140_1700C Specification for Concrete

Other useful documents:

- ARUP - Buildings & Infrastructure Priority Actions for Sustainability - Embodied Carbon - Concrete (2023)
- Building Research Establishment (BRE) Digest 416 - Specifying structural timber (1996)
- Building Research Establishment (BRE) Digest 445 - Advances in timber grading (2000) CABE Delivering Quality Places
- Department for Transport (DfT) Design Standards for Accessible Railway Stations - A Code of Practice (ACoP)
- Department for Transport (DfT) Security in the Design of Stations (SIDOS)
- Disabled Persons Transport Advisory Committee (DPTAC) – Disabled Persons Protection Policies
- English Heritage Managing Heritage Assets
- Health and Safety Executive - Construction (Design and Management) Regulations (CDM) 2015
- Health and Safety Executive - Control of Lead at Work Regulations
- Home Office - Standard 23/14 version 2 – Test method for the determination of the explosion resistance of litter and recycling bins
- Materials for Architects and Builders - Arthur Lyons (2020)
- National Technical Specification Notice: Persons with Reduced Mobility (NTSN PRM)
- Railway Safety and Standards Board – A Guide to RSSB.
- Railway Safety Principles and Guidance
- RIS-7016-INS - Interface between Station Platforms, Track, Trains and Buffer Stops
- The Building Regulations - Approved Documents
- The Building Safety Act 2022
- The Equality Act 2010
- The Green Guide to Specification
- The Town and Country Planning Act – Permitted Development Rights.

British Standards:

- BS 1217 - Cast Stone Specification
- BS 476–3 - Fire tests on building materials and structures - Classification and method of test for external fire exposure to roofs
- BS 4978 - Visual strength grading of softwood
- BS 5385 - Wall and Floor Tiling
- BS 5534 - Slating and tiling for pitched roofs and vertical cladding. Code of practice
- BS 5756 - Visual strength grading of temperate hardwood
- BS 6206 - Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings
- BS 6206 - Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings
- BS 6700 - Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages Specification
- BS 6925 - Specification for mastic asphalt for building and civil engineering (limestone aggregate)
- BS 7619 - Extruded cellular unplasticised white PVC (PVC-UE) profiles. Specification
- BS 8217 - Reinforced bitumen membranes for roofing. Code of practice
- BS 8221–1 - Code of Practice for Cleaning and Surface Repair of Buildings - Cleaning of Natural Stone, Brick, Terracotta, and Concrete
- BS 8298–3 - Stone-faced Precast Concrete Cladding Systems
- BS 8298–4 - Stone Cladding on Rainscreen Support Systems
- BS 8300 - Design of an accessible and inclusive built environment - Buildings. Code of practice
- BS 8747 - Reinforced bitumen membranes (RBMs) for roofing. Guide to selection and specification
- BS 952–2 - Glass for glazing - Terminology for work on glass
- BS 9992 - Fire safety in the design, management and use of rail infrastructure. Code of practice
- BS 9999 - Fire safety in the design, management and use of buildings. Code of practice
- BS EN 10088–4 - Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
- BS EN 10088–5 - Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes
- BS EN 10169 - Continuously organic coated (coil coated) steel flat products. Technical delivery conditions
- BS EN 10210–1 - Hot finished structural hollow sections of non-alloy and fine grain steels - Technical Delivery Requirements
- BS EN 10219–1 - Cold formed welded structural hollow sections of non-alloy and fine grain steels - Technical Delivery Requirements
- BS EN 10340 - Steel Castings for Structural Uses
- BS EN 10346 - Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions
- BS EN 1172 - Copper and copper alloys. Sheet and strip for building purposes
- BS EN 12150–1 - Glass in building. Thermally toughened soda lime silicate safety glass - Definition and description
- BS EN 12588 - Lead and lead alloys. Rolled lead sheet for building purposes
- BS EN 12600 - Glass in building. Pendulum test. Impact test method and classification for flat glass
- BS EN 12600 - Glass in building. Pendulum test. Impact test method and classification for flat glass

Reference Documents

- BS EN 12944–5 - Paints and varnishes. Corrosion protection of steel structures by protective paint systems - Protective paint systems
- BS EN 13022–2 - Glass in building. Structural sealant glazing - Assembly rules
- BS EN 13168 - Thermal insulation products for buildings. Factory made wood wool (WW) products. Specification
- BS EN 13501–1 - Fire classification of construction products and building elements - Classification using data from reaction to fire tests
- BS EN 1365 - Fire resistance tests for loadbearing elements
- BS EN 13707 - Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics
- BS EN 13748 - Terrazzo Tiles - Terrazzo Tiles for Internal Use
- BS EN 13956 - Flexible sheets for waterproofing. Plastic and rubber sheets for roof waterproofing. Definitions and characteristics
- BS EN 14081–1 - Timber structures. Strength graded structural timber with rectangular cross section - General requirements
- BS EN 14411 - Ceramic tiles. Definitions, classification, characteristics, evaluation of conformity and marking
- BS EN 14618 - Agglomerated Stone. Terminology and Classification
- BS EN 14782 - Self-supporting metal sheet for roofing, external cladding and internal lining
- BS EN 14783 - Fully supported metal sheet and strip for roofing, external cladding and internal lining
- BS EN 14783 - Fully supported metal sheet and strip for roofing, external cladding and internal lining
- BS EN 15197 - Wood-based panels. Flaxboards. Specifications
- BS EN 15373 - Furniture. Strength, durability and safety. Requirements for non-domestic seating.
- BS EN 15434 - Glass in building. Product standard for structural and/or ultra-violet resistant sealant
- BS EN 15743 - Supersulfated Cement - Composition, Specification and Conformity Criteria
- BS EN 1611–1 - Sawn timber. Appearance grading of softwoods - European spruces, firs, pines and Douglas fir
- BS EN 16165 - Determination of slip resistance of pedestrian surfaces. Methods of evaluation
- BS EN 16165 - Determination of slip resistance of pedestrian surfaces. Methods of evaluation
- BS EN 197–1 - Cement - Composition, Specification and Conformity Criteria for Common Cements
- BS EN 300 - Oriented strand boards (OSB). Definitions, classification and specifications
- BS EN 316 - Wood fibre boards. Definition, classification and symbols
- BS EN 338 - Structural timber. Strength classes
- BS EN 350 - Durability of wood and wood-based products. Testing and classification of the durability to biological agents of wood and wood-based materials
- BS EN 459–1-Building Lime - Definitions, Specification and Conformity Criteria
- BS EN 501 - Roofing products from metal sheet. Specifications for fully supported roofing products of zinc sheet
- BS EN 505 - Roofing products from metal sheet. Specification for fully supported roofing products of steel sheet
- BS EN 506 - Roofing products of metal sheet. Specification for self-supporting products of copper or zinc sheet
- BS EN 508–2 - Roofing and cladding products from metal sheet. Specification for self-supporting products of steel, aluminium or stainless steel sheet – Aluminium

Reference Documents

- BS EN 508–3 - Roofing and Cladding products from Metal Sheet. Specification for self-supporting products of steel, aluminium or stainless steel sheet - Stainless Steel
- BS EN 572–5 - Glass in building. Basic soda lime silicate glass products - Patterned glass
- BS EN 572–6 - Glass in building. Basic soda lime silicate glass products - Wired patterned glass
- BS EN 572–7 - Glass in building. Basic soda lime silicate glass products - Wired or unwired channel shaped glass
- BS EN 622–2 - Fibreboards. Specifications - Requirements for hardboards
- BS EN 622–3 - Fibreboards. Specifications - Requirements for mediumboards
- BS EN 622–4 - Fibreboards. Specifications - Requirements for softboards
- BS EN 622–5 - Fibreboards. Specifications - Requirements for dry process boards (MDF)
- BS EN 633 - Cement-bonded particleboards. Definition and classification
- BS EN 634–2 - Cement-bonded particleboards. Specifications - Requirements for OPC bonded particleboards for use in dry, humid and external conditions
- BS EN 636 - Plywood Specifications
- BS EN 771 - Clay Masonry Units
- BS EN 806- Specifications for installations inside buildings conveying water for human consumption
- BS EN 975–1 - Sawn timber. Appearance grading of hardwoods - Oak and beech
- BS EN 975–2 - Sawn timber. Appearance grading of hardwoods – Poplars
- BS EN 988 - Zinc and zinc alloys. Specification for rolled flat products for building
- BS EN ISO 20568–1 - Plastics. Fluoropolymer dispersions and moulding and extrusion materials - Designation system and basis for specifications
- BS EN ISO 21305–1 - Plastics. Polycarbonate (PC) moulding and extrusion materials - Designation system and basis for specifications
- BS ISO 11485–1 - Glass in building. Curved glass - Terminology and definitions
- DD CEN/TS 15679 - Thermal modified timber. Definitions and characteristics
- PAS 6463 - Design for the mind. Neurodiversity and the built environment. Guide
- PD CEN/TS 13388 - Copper and copper alloys. Compendium of compositions and products

Materials & Components

Appendix B: Material selection toolkit

B

Material Toolkit Definitions

The table on the following pages forms the Material Toolkit. It condenses key information from throughout this guidance document to present a snapshot for ease of reference. This includes the material's NBS Uniclass reference number, and it's embodied carbon figures per the ICE Embodied Carbon database.

The toolkit is divided into four sections; Walls, Floors, Ceilings, and Roofs. The materials discussed throughout Section 2 of the guidance are listed within the Toolkit and graded against a variety of criteria, the definitions for which are provided here.

The toolkit should be seen as guidance only as the appropriateness of a material should be reviewed against project specific requirements.

Location

Location refers to where the building element i.e., a wall, or floor, is within the station environment, these include:

- → External
- → External Covered
- → Internal
- → Underground

Please note this is general guidance only and each material should be considered specifically within the site it is proposed particularly in relation to fire and security requirements.

Station Category

Refers to the Station Categories defined by the Department for Transport and Network Rail where A is the highest (i.e., busiest) and F is the lowest.

Maintainability

Maintainability is qualitatively assessed via RAG scoring, as many aspects of maintenance are determined by project specific design and specification decisions i.e., cleaning requirements, and ease of replacement or inspection are more directly impacted by spatial arrangement than a materials inherent qualities.

To that end the Toolkit considers a materials maintainability from the perspective of a materials inherent:

- → Durability
- → Resistance to Vandalism

Design Life

Per **Section 4.4** Design Life tables. The Material Toolkit lists the expected design life of common non-load bearing materials in stations by location. Where materials are specified for structural and / or load-bearing purposes reference should be made to NR/L2/CIV/003/F1990, BS EN 1990 and Eurocode EN 1990 for appropriate design life requirements.

Sustainability

Sustainability is divided into two sub-sections which include:

Renewable or Recyclable: representing a materials ability to reused or recycled i.e., demolished bricks may easily be crushed and processed to become aggregates , whereas glass is much less widely incorporated back into other materials.

Embodied Carbon: Defined by Circular Ecology's Inventory of Carbon and energy (ICE) Database which aggregates various sources information to arrive at a materials average embodied carbon measured in 'Kilograms of Carbon Dioxide equivalent per Kilogram' (KgCO2e/Kg).

Note: While per kilogram, concrete has a relatively low embodied carbon, due to the vast quantities of concrete often used this can have a large impact on a project's overall embodied carbon.

RAG Key

Acceptable	(green)
Possible - Use Caution	(yellow)
Seek alternative if practicable	(red)
Not Applicable	(grey)

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Masonry														
Brick - Common	**Ma_20_16**								Varies - As Specified			80 Years		00.21
Brick - Facing	**Ma_20_16**								Varies - As Specified			80 Years		00.21
Brick - Engineering	**Ma_20_16**								Varies - As Specified			80 Years		00.21
Brick - Reclaimed	**Ma_20_16**								Varies - As Specified			80 Years		00.21
Stone														
Granite	**Ma_40_84_41_24**								Varies - As Specified			80 Years		00.70
Basalt	**Ma_40_84_41_06**								Varies - As Specified			80 Years		N/A
Sandstone	**Ma_40_84_79_76**								Varies - As Specified			80 Years		00.06
Limestone	**Ma_40_84_79_48**								Varies - As Specified			80 Years		00.09
Slate	**Ma_40_84_51_80**								Varies - As Specified			80 Years		00.06
Reconstituted Marble	N/A								Varies - As Specified			100 Years		00.21
Quartzite	**Ma_40_84_51_69**								Varies - As Specified			80 Years		N/A
Agglomerated Stone	**Ma_40_84_51_80**								Varies - As Specified			100 Years		N.A
Terrazzo	N/A								Varies - As Specified			100 Years		00.12

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Stone Clad Rainscreen	N/A								Varies - As Specified			N/A		N/A
Gabions	Ma_20_03_19_56								Varies - As Specified			80 Years		00.01
Concrete														
Ultra High Performace Concrete (UHPC)	Ma_40_19_37_92								As Specified			80 Years		00.11
Visual Concrete	Ma_40_19_41								As Specified			80 Years		00.11
Precast Concrete	Ma_40_19_66								As Specified			80 Years		00.15
Lime Rendered Concrete	N/A								As Specified			80 Years		N/A
Hempcrete	N/A								As Specified			N/A		N/A
Carbicrete	N/A								N/A			N/A		N/A
Metals														
Aluminium	Ma_40_52_03								As Specified			30 Years		08.71
Steel	Ma_40_52_83								As Specified			30 Years		02.36
Stainless Steel	Ma_40_52_83_82								As Specified			30 Years		04.40
Weathering Steel	Ma_40_52_83_96								As Specified			30 Years		N/A

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Iron (Cast and Wrought)	**Ma_40_52_42**								As Specified			100 Years		02.03
Copper	**Ma_40_52_18**								As Specified			30 Years		02.71
Zinc	**Ma_40_52_99**								As Specified			30 Years		03.09
Brass	**Ma_40_52_08**								As Specified			30 Years		02.64
Titanium	**Ma_40_52_89**								As Specified			30 Years		14.70
Timber														
Hardwood - Ash	**Ma_60_97_04**								As Specified			30 Years		- 01.28
Hardwood - Oak	**Ma_60_97_58**								As Specified			30 Years		- 01.28
Hardwood - Beech	**Ma_60_97_07**								As Specified			30 Years		- 01.28
Hardwood - Maple	**Ma_60_97_51**								As Specified			30 Years		- 01.28
Hardwood - Walnut	**Ma_60_97_97**								As Specified			30 Years		- 01.28
Cross-Laminated Timber (CLT)	N/A								As Specified			60 Years		- 01.20
Soft Wood - Douglas Fir	**Ma_60_97_30_24**								As Specified			30 Years		- 01.29
Soft Wood - Larch	**Ma_60_97_46**								As Specified			30 Years		- 01.29
Timber Shingles	N/A								As Specified			30 Years		N/A

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Pine - External Grade	**Ma_60_97_63**								As Specified			30 Years		- 01.29
Charred Timber	N/A								As Specified			30 Years		N/A
Plywood	N/A								As Specified			30 Years		- 00.98
Parallel Strand Lumber (PSL)	N/A								As Specified			60 Years		N/A
Dowel Laminated Timber (DLT)	N/A								As Specified			60 Years		N/A
Glue Laminated Timber (Glulam)	N/A								As Specified			60 Years		- 00.89
Laminated Veneer Lumber (LVL)	N/A								As Specified			60 Years		- 01.34
Structural Insulated Panels (SIPs)	N/A								N/A			60 Years		N/A
Glass *(Note: All glass types should be specified in accordance with SIDOS and TVRA recommendations)*														
Transparent Glass	**Ma_40_35**								As Specified			30 Years		01.44
Opaque Glass	**Ma_40_35_04_82**								As Specified			30 Years		N/A
Sandblasted Glass	N/A								As Specified			30 Years		N/A
Self-Cleaning Glass	N/A								As Specified			30 Years		N/A
Glass Blocks	N/A								As Specified			50 Years		N/A
Toughened Glass	N/A								As Specified			30 Years		01.67

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Wired Glass	**Ma_40_35_75_97**								As Specified			30 Years		N/A
Safety Glass - Multi Layer	**Ma_40_35_75**								As Specified			30 Years		02.08
Ceramics														
Porcelain	**Ma_20_13_65**								As Specified			30 Years		N/A
Fireclay	**Ma_20_16_30**								As Specified			30 Years		N/A
Ceramic Rainscreen Cladding	N/A								As Specified			30 Years		00.78
Terracotta	**Ma_20_13_88**								As Specified			30 Years		00.24
Stoneware	**Ma_20_13**								As Specified			30 Years		N/A
Specialist / Heritage Decorative Tile	N/A								As Specified			30 Years		N/A
Mosaic	N/A								As Specified			30 Years		N/A
Faience	**Ma_20_13_88**								As Specified			30 Years		00.24
Ceramic Granite	**Ma_20_13**								As Specified			30 Years		N/A
Earthenware Tile	**Ma_20_13_26**								As Specified			30 Years		00.24

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Walls

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Composites														
Glass Fibre Reinforced Plastics (GFRP)	N/A								As Specified			30 Years		08.10
Glass Fibre Reinforced Concrete (GFRC)	**Ma_40_19_71_34**								As Specified			80 Years		00.12
Polycarbonate	**Ma_60_65_12**								As Specified			N/A		07.62
Ethylene Tetrafluoroethylene (ETFE)	N/A								As Specified			N/A		N/A
PTFE Coated Glass Fabric	N/A								As Specified			N/A		N/A
Glass Fibre Reinforced Gypsum (GFRG)	N/A								As Specified			N/A		N/A
Miscellaneous														
Bitumen	**Ma_60_08_56_08**								As Specified			N/A		00.19
Mastic Asphalt	**Ma_60_08_56_04**								As Specified			35 Years		00.09
Green Roof - Extensive	N/A								As Specified			N/A		N/A
Green Roof - Intensive	N/A								As Specified			N/A		N/A
Green Wall	N/A								As Specified			N/A		N/A
Anti-Graffiti Coating / Film	N/A								N/A			N/A		N/A

Image B.1 Material Selection Toolkit - Walls

Materials Selection Toolkit - Floors

Material		Location				Station Category			Finish	Maintainability		Foot Traffic			Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance	High	Medium	Low		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Masonry																	
Brick - Common	Ma_20_16								Varies - As Specified						80 Years		00.21
Brick - Facing	Ma_20_16								Varies - As Specified						80 Years		00.21
Brick - Engineering	Ma_20_16								Varies - As Specified						80 Years		00.21
Brick - Reclaimed	Ma_20_16								Varies - As Specified						80 Years		00.21
Stone																	
Granite	Ma_40_84_41_24								Varies - As Specified						80 Years		00.70
Basalt	Ma_40_84_41_06								Varies - As Specified						80 Years		N/A
Sandstone	Ma_40_84_79_76								Varies - As Specified						80 Years		00.06
Limestone	Ma_40_84_79_48								Varies - As Specified						80 Years		00.09
Slate	Ma_40_84_51_80								Varies - As Specified						80 Years		00.06
Reconstituted Marble	N/A								Varies - As Specified						100 Years		00.21
Quartzite	Ma_40_84_51_69								Varies - As Specified						80 Years		N/A
Agglomerated Stone	Ma_40_84_51_80								Varies - As Specified						100 Years		N.A
Terrazzo	N/A								Varies - As Specified						100 Years		00.12

Image B.2 Material Selection Toolkit - Floors

Materials Selection Toolkit - Floors

Material		Location				Station Category			Finish	Maintainability		Foot Traffic			Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance	High	Medium	Low		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Concrete																	
Visual Concrete	Ma_40_19_41								As Specified						80 Years		00.11
Precast Concrete	Ma_40_19_66								As Specified						80 Years		00.15
Metals																	
Aluminium *	Ma_40_52_03								As Specified						30 Years		08.71
Steel *	Ma_40_52_83								As Specified						30 Years		02.36
Timber																	
Hardwood - Ash	Ma_60_97_04								As Specified						30 Years		- 01.28
Hardwood - Oak	Ma_60_97_58								As Specified						30 Years		- 01.28
Hardwood - Beech	Ma_60_97_07								As Specified						30 Years		- 01.28
Hardwood - Maple	Ma_60_97_51								As Specified						30 Years		- 01.28
Hardwood - Walnut	Ma_60_97_97								As Specified						30 Years		- 01.28

** Anti Slip Treads Only*

Image B.2 Material Selection Toolkit - Floors

Materials Selection Toolkit - Floors

Material		Location				Station Category				Maintainability		Foot Traffic				Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F	Finish	Durability	Vandalism Resistance	High	Medium	Low	Design Life	Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Ceramics																	
Porcelain	**Ma_20_13_65**								As Specified						30 Years		N/A
Fireclay	**Ma_20_16_30**								As Specified						30 Years		N/A
Terracotta	**Ma_20_13_88**								As Specified						30 Years		00.24
Stoneware	**Ma_20_13**								As Specified						30 Years		N/A
Specialist / Heritage Decorative Tile	N/A								As Specified						30 Years		N/A
Mosaic	N/A								As Specified						30 Years		N/A
Miscellaneous																	
Bitumen	**Ma_60_08_56_08**								As Specified						N/A		00.19
Mastic Asphalt	**Ma_60_08_56_04**								As Specified						35 Years		00.09

Image B.2 Material Selection Toolkit - Floors

Materials Selection Toolkit - Ceilings

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Masonry														
Brick - Facing	Ma_20_16								Varies - As Specified			80 Years		00.21
Concrete														
Visual Concrete	Ma_40_19_41								As Specified			80 Years		00.11
Precast Concrete	Ma_40_19_66								As Specified			80 Years		00.15
Metals														
Aluminium	Ma_40_52_03								As Specified			30 Years		08.71
Steel	Ma_40_52_83								As Specified			30 Years		02.36
Stainless Steel	Ma_40_52_83_82								As Specified			30 Years		04.40
Copper	Ma_40_52_18								As Specified			30 Years		02.71
Zinc	Ma_40_52_99								As Specified			30 Years		03.09
Brass	Ma_40_52_08								As Specified			30 Years		02.64
Titanium	Ma_40_52_89								As Specified			30 Years		14.70
Timber														
Hardwood - Ash	Ma_60_97_04								As Specified			30 Years		- 01.28

Image B.3 Material Selection Toolkit - Ceilings

Materials Selection Toolkit - Ceilings

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Hardwood - Oak	**Ma_60_97_58**								As Specified			30 Years		- 01.28
Hardwood - Beech	**Ma_60_97_07**								As Specified			30 Years		- 01.28
Hardwood - Maple	**Ma_60_97_51**								As Specified			30 Years		- 01.28
Hardwood - Walnut	**Ma_60_97_97**								As Specified			30 Years		- 01.28
Cross-Laminated Timber (CLT)	N/A								As Specified			60 Years		- 01.20
Soft Wood - Douglas Fir	**Ma_60_97_30_24**								As Specified			30 Years		- 01.29
Soft Wood - Larch	**Ma_60_97_46**								As Specified			30 Years		- 01.29
Timber Shingles	N/A								As Specified			30 Years		N/A
Pine - External Grade	**Ma_60_97_63**								As Specified			30 Years		- 01.29
Charred Timber	N/A								As Specified			30 Years		N/A
Plywood	N/A								As Specified			30 Years		- 00.98
Parallel Strand Lumber (PSL)	N/A								As Specified			60 Years		N/A
Dowel Laminated Timber (DLT)	N/A								As Specified			60 Years		N/A
Glue Laminated Timber (Glulam)	N/A								As Specified			60 Years		- 00.89

Image B.3 Material Selection Toolkit - Ceilings

Materials Selection Toolkit - Ceilings

Material		Location				Station Category				Maintainability			Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F	Finish	Durability	Vandalism Resistance	Design Life	Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Laminated Veneer Lumber (LVL)	N/A								As Specified			60 Years		- 01.34
Glass *(Note: All glass types should be specified in accordance with SIDOS and TVRA recommendations)*														
Transparent Glass	**Ma_40_35**								As Specified			30 Years		01.44
Opaque Glass	**Ma_40_35_04_82**								As Specified			30 Years		N/A
Sandblasted Glass	N/A								As Specified			30 Years		N/A
Self-Cleaning Glass	N/A								As Specified			30 Years		N/A
Toughened Glass	N/A								As Specified			30 Years		01.67
Safety Glass - Multi Layer	**Ma_40_35_75**								As Specified			30 Years		02.08
Ceramics														
Ceramic Rainscreen Cladding	N/A								As Specified			30 Years		00.78
Terracotta	**Ma_20_13_88**								As Specified			30 Years		00.24
Specialist / Heritage Decorative Tile	N/A								As Specified			30 Years		N/A
Mosaic	N/A								As Specified			30 Years		N/A
Faience	**Ma_20_13_88**								As Specified			30 Years		00.24
Ceramic Granite	**Ma_20_13**								As Specified			30 Years		N/A

Image B.3 Material Selection Toolkit - Ceilings

Materials Selection Toolkit - Ceilings

Material		Location				Station Category				Maintainability			Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F	Finish	Durability	Vandalism Resistance	Design Life	Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Earthenware Tile	**Ma_20_13_26**								As Specified			30 Years		00.24
Composites														
Glass Fibre Reinforced Plastics (GFRP)	N/A								As Specified			30 Years		08.10
Glass Fibre Reinforced Concrete (GFRC)	**Ma_40_19_71_34**								As Specified			80 Years		00.12
Polycarbonate	**Ma_60_65_12**								As Specified			N/A		07.62
Ethylene Tetrafluoroethylene (ETFE)	N/A								As Specified			N/A		N/A
PTFE Coated Glass Fabric	N/A								As Specified			N/A		N/A
Glass Fibre Reinforced Gypsum (GFRG)	N/A								As Specified			N/A		N/A
Miscellaneous														
Anti-Graffiti Coating / Film	N/A								N/A			N/A		N/A

Image B.3 Material Selection Toolkit - Ceilings

Materials Selection Toolkit - Roofs

Material		Location				Station Category				Maintainability			Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F	Finish	Durability	Vandalism Resistance	Design Life	Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Stone														
Slate	**Ma_40_84_51_80**								Varies - As Specified			80 Years		00.06
Stone Clad Rainscreen	N/A								Varies - As Specified			N/A		N/A
Concrete														
Metals														
Aluminium	**Ma_40_52_03**								As Specified			30 Years		08.71
Steel	**Ma_40_52_83**								As Specified			30 Years		02.36
Stainless Steel	**Ma_40_52_83_82**								As Specified			30 Years		04.40
Weathering Steel	**Ma_40_52_83_96**								As Specified			30 Years		N/A
Iron (Cast and Wrought)	**Ma_40_52_42**								As Specified			100 Years		02.03
Copper	**Ma_40_52_18**								As Specified			30 Years		02.71
Zinc	**Ma_40_52_99**								As Specified			30 Years		03.09
Lead	**Ma_40_52_47**								As Specified			30 Years		01.67
Titanium	**Ma_40_52_89**								As Specified			30 Years		14.70

Image B.4 Material Selection Toolkit - Roofs

Materials Selection Toolkit - Roofs

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Timber														
Timber Shingles	N/A								As Specified			30 Years		N/A
Glass *(Note: All glass types should be specified in accordance with SIDOS and TVRA recommendations)*														
Transparent Glass	**Ma_40_35**								As Specified			30 Years		01.44
Opaque Glass	**Ma_40_35_04_82**								As Specified			30 Years		N/A
Sandblasted Glass	N/A								As Specified			30 Years		N/A
Self-Cleaning Glass	N/A								As Specified			30 Years		N/A
Glass Blocks	N/A								As Specified			50 Years		N/A
Toughened Glass	N/A								As Specified			30 Years		01.67
Wired Glass	**Ma_40_35_75_97**								As Specified			30 Years		N/A
Safety Glass - Multi Layer	**Ma_40_35_75**								As Specified			30 Years		02.08
Ceramics														
Porcelain	**Ma_20_13_65**								As Specified			30 Years		N/A
Fireclay	**Ma_20_16_30**								As Specified			30 Years		N/A

Image B.4 Material Selection Toolkit - Roofs

Materials Selection Toolkit - Roofs

Material		Location				Station Category			Finish	Maintainability		Design Life	Sustainability	
Name	ID	Underground	Internal	External covered	External	A	B - D	E - F		Durability	Vandalism Resistance		Renewable or Recyclable	Embodied Carbon kgCO2e/kg
Ceramic Rainscreen Cladding	N/A								As Specified			30 Years		00.78
Terracotta	**Ma_20_13_88**								As Specified			30 Years		00.24
Stoneware	**Ma_20_13**								As Specified			30 Years		N/A
Ceramic Granite	**Ma_20_13**								As Specified			30 Years		N/A
Composites														
Glass Fibre Reinforced Concrete (GFRC)	**Ma_40_19_71_34**								As Specified			80 Years		00.12
Polycarbonate	**Ma_60_65_12**								As Specified			N/A		07.62
Ethylene Tetrafluoroethylene (ETFE)	N/A								As Specified			N/A		N/A
Miscellaneous														
Bitumen	**Ma_60_08_56_08**								As Specified			N/A		00.19
Mastic Asphalt	**Ma_60_08_56_04**								As Specified			35 Years		00.09
Green Roof - Extensive	N/A								As Specified			N/A		N/A
Green Roof - Intensive	N/A								As Specified			N/A		N/A

Image B.4 Material Selection Toolkit - Roofs

Materials & Components

Appendix C: Case studies

C

Case Studies Introduction

The following three case study stations; Waterloo, Paddington Elizabeth Line, and Hackney Wick, have been chosen to illustrate the practical applications and benefits of innovative materials and construction techniques in modern rail infrastructure projects.

The projects have been selected to showcase diverse approaches to material selection and implementation, highlighting how thoughtful choices can enhance structural performance, sustainability, and passenger experience.

The chosen case studies aim to provide an understanding of how advanced materials and methods can be effectively utilised in contemporary construction, ensuring both the preservation of historical elements and the integration of modern efficiencies.

Image C.1 Case study stations from left to right: Waterloo, Paddington, and Hackney Wick

Waterloo

As part of Waterloo Station's £47 million renovation the century-old roof which was rebuilt just after the First World War in 1922 is being extensively repaired and upgraded.

The renovation, initiated by Network Rail, involves installing approximately 10,000 new glazed panels across the concourse and porte-cochere roofs. The renovation covers an area of approximately 8,000 cubic meters, including 25 glazed 'lantern' structures with partially curved profiles, and the porte-cochere roofs which provide sheltered access for passengers, buses, and taxis.

As part of the project, several different roofing material options were considered, including ETFE, polycarbonate, and laminated glass. Glass was discounted because the loading required of new SIDOS-compliant glass would be too heavy for the historic train-shed structure. ETFE was then considered instead due to its lighter weight and lower frangibility. However, acoustic tests showed that during rainfall, the noise of rain on the ETFE roof structure would be loud enough to potentially drown out public safety announcements. A series of tests were conducted on the polycarbonate panels to confirm compliance with SIDOS guidance.

Following this, and due to its better acoustic and weight performance, polycarbonate was chosen as the preferred transparent roofing material.

Image C.2 Waterloo Station roof viewed from the concourse

Paddington

Modern Methods of Construction (MMC) played a pivotal role in the design and construction of the new Paddington Elizabeth Line station. MMC encompasses a range of innovative building techniques to enhance efficiency, quality, and sustainability. At Paddington station, these methods included prefabrication, modular construction, and the use of advanced materials.

Prefabrication was extensively employed, particularly in the creation of large format brick panels which were manufactured off-site in controlled environments, allowing for precise craftsmanship and consistent quality. They were then transported to the site and assembled, significantly reducing on-site construction time and minimising material waste through greater precision.

The use of prefabrication and modular construction also allowed for extensive integration of acoustic treatment and sound absorption which features throughout the stations prefabricated elements to create a balanced auditory environment that enhances passenger experience. Mitigating the noise associated with a busy transit hub.

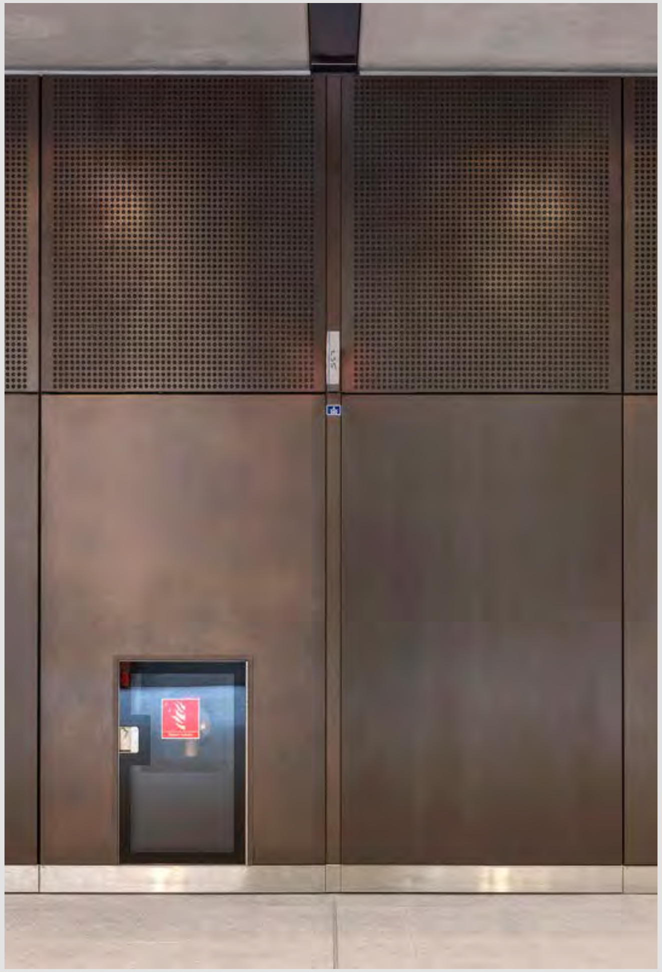


Image C.3 Prefabricated bronze cladding units line the ticket hall with integrated acoustic treatment behind their perforations

Image C.4 Prefabricated brick panels lining the ticket hall also contain acoustic treatment

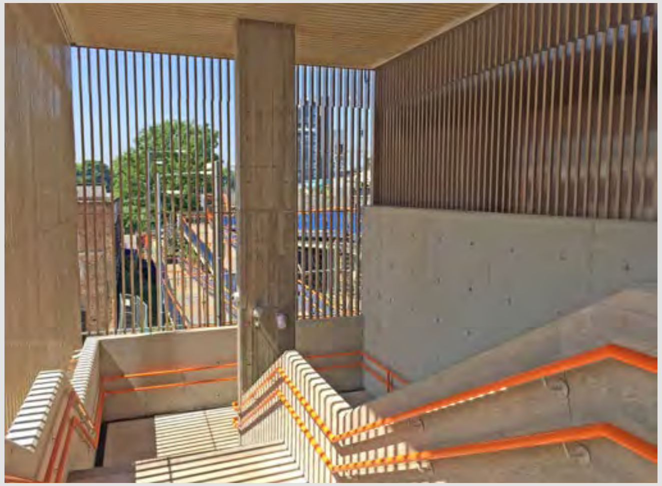
Hackney Wick

Hackney Wick station was completely rebuilt in 2018 as part of Network Rail's Railway Upgrade Plan on behalf of the London Legacy Development Corporation (LLDC) who were the principal funders of the project, along with Tower Hamlets and Hackney Council who provided additional funding. The redesigned station is fully accessible and features architectural elements that significantly elevate the passenger experience. Among these elements are the cast concrete staircases which stand out as both functional structures and striking visual features.

The design for the staircases was inspired by the natural environment and nearby trees informing the use of shuttered concrete which retains the imprint of Douglas fir planks from the casting process, creating a deeply textured finish. The juxtaposition of rough and smooth surfaces captures attention, adds interest to the architectural form, and provides a natural feel.

Lighting plays an important role in highlighting and accentuating the materials. The integration of sensitive lighting into the staircases helps them to be well-illuminated and feel safe, while also enhancing their sculptural quality. Integrated downlights, positioned under the flights of stairs and along the handrails, provide both functional illumination and dramatic highlights, emphasising form and texture. Ambient lighting at the top of the stairs, filtered through suspended fins, diffuses light to create a sheltered, canopy-like effect, softening the space and providing a welcoming environment for passengers.

Hackney Wick station demonstrates the profound impact of considering texture and light when specifying materials. The textured shuttered concrete staircases and the thoughtfully integrated lighting not only fulfil functional requirements but in combination with careful arrangement and detailing transform the more often utilitarian aspects of a station into an aesthetically pleasing space.



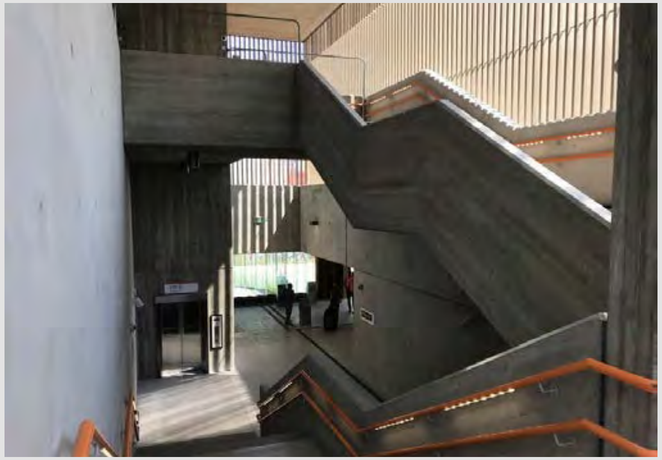


Image C.5 Hackney Wick station cast concrete stairs viewed from top and intermediate landings

Materials & Components

Appendix D: Acknowledgements

D

Acknowledgements

Photo credits

Inside Cover © Weston Williamson + Partners

0.1 © Weston Williamson + Partners
© Benedict Luxmoore

1.1 © Weston Williamson + Partners
1.2 © Weston Williamson + Partners
© Morley von Sternberg
1.3 © Network Rail
1.4 © Adam Parker
1.5 © Landolt + Brown
1.6 © Weston Williamson + Partners
1.7 © Weston Williamson + Partners
1.8 © Weston Williamson + Partners
1.9 © Weston Williamson + Partners
1.10 © Weston Williamson + Partners
1.11 © Vandkunsten Architects, CINARK, Boligfonden Kuben and Realdania.
1.12 © Vandkunsten Architects, CINARK, Boligfonden Kuben and Realdania.
1.13 © Marco Bernadini - Wikimedia Commons
1.14 © Luna Wagner - Wikimedia Commons
1.15 © Weston Williamson + Partners
1.16 © Weston Williamson + Partners, Unsplash, Clem Rutter, and Robin Stott - Wikimedia Commons
1.17 © Weston Williamson + Partners
1.18 © Weston Williamson + Partners
1.19 © Weston Williamson + Partners
1.20 © Adam Parker
1.21 © Weston Williamson + Partners
1.22 © Health and Safety Executive
1.23 © Network Rail
1.24 © Weston Williamson + Partners
© Benedict Luxmoore
1.25 © Network Rail
1.26 © Weston Williamson + Partners
© David Yeow
1.27 © Weston Williamson + Partners
1.28 © Daniel Wright
1.29 © Network Rail
1.30 © Mima Group Ltd.
1.31 © Weston Williamson + Partners
1.32 © Landolt + Brown
1.33 © Weston Williamson + Partners, Landolt + Brown, Unsplash
1.34 © Weston Williamson + Partners
1.35 © Daniel Wright
1.36 © Carmody Groarke, Cinzia Romanin, Tomas Noceto
1.37 © National Institute of Standards and Technology - Wikimedia Commons
1.38 © Daniel Wright
1.39 © Weston Williamson + Partners
1.40 © Weston Williamson + Partners
© Morley von Sternberg
1.41 © Weston Williamson + Partners
1.42 © Crossrail Learning Legacy
1.43 © Weston Williamson + Partners
1.44 © Network Rail
1.45 © Weston Williamson + Partners
1.46 © Weston Williamson + Partners
1.47 © Weston Williamson + Partners
1.48 © Alamy
1.49 © Sunil060902 - Wikimedia Commons
1.50 © Weihag
1.51 © Public Sector Build Journal
1.52 © Sunil060902 - Wikimedia Commons
1.53 © Paul Childs, Railway Heritage Trust
1.54 © Weston Williamson + Partners

2.1 © Wiehag, Ferreday Pollard
2.2 © Matt Buck - Flickr Creative Commons
2.3 © Idris2000 - Wikimedia Commons
2.4 © Network Rail
2.5 © Dezwartehond, Sebastian van Damme
2.6 © BMe3001 - Wikimedia Commons
2.7 © Wiehag, Ferreday Pollard
2.8 © Alamy
2.9 © British Standards Institute
2.10 © British Standards Institute
2.11 © Weston Williamson + Partners
2.12 © British Standards Institute
2.13 © Andrey Pertsev 1967 - Wikimedia Commons
2.14 © British Standards Institute
2.15 © British Standards Institute
2.16 © Troldtekt
2.17 © Jebulon - Wikimedia Commons
2.18 © JamesH251 - Wikimedia Commons
2.19 © Wiley-VCH Verlag GmBH & Co
2.20 © Weston Williamson + Partners
2.21 © Weston Williamson + Partners
© Morley von Sternberg
2.22 © British Standards Institute

This document was produced on behalf of Network Rail by Weston Williamson + Partners.

WW+P

Acknowledgements

2.23 © Weston Williamson + Partners
© Morley von Sternberg
2.24 © Lisa Risager - Wikimedia Commons
2.25 © EpicGenius - Wikimedia Commons
2.26 © Weston Williamson + Partners
2.27 © Weston Williamson + Partners
2.28 © Network Rail
2.29 © Billie Ward - Wikimedia Commons
2.30 © Weston Williamson + Partners
2.31 © James St. John - Flickr Creative Commons
2.32 © Weston Williamson + Partners
2.33 © Aconfora - Wikimedia Commons
2.34 © Sunil060902 - Wikimedia Commons
2.35 © USCapitol - Wikimedia Commons
2.36 © TheFrog001 - Wikimedia Commons
2.37 © Daniel Wright
2.38 © Alamy
2.39 © Weston Williamson + Partners
2.40 © Network Rail, Landolt + Brown
2.41 © Marco Bernadini - Wikimedia Commons
2.42 © Alamy
2.43 © Landolt + Brown
2.44 © Reckli
2.45 © Images Georges Rex - Wikimedia Commons
2.46 © Marcus Herrfeld, HEBAU GmbH, Sonthofen
2.47 © Marshalls Plc
2.48 © Alamy
2.49 © Weston Williamson + Partners
2.50 © Leiem - Wikimedia Commons
2.51 © Jnzl - Flickr Creative Commons
2.52 © Brett and Sue Coulstock
- Flickr Creative Commons
2.53 © Weston Williamson + Partners
2.54 © Cox Architecture
2.55 © KentWang - Wikimedia Commons
2.56 © Ozzy Delaney - Flickr Creative Commons
2.57 © Marc Teer - Flickr Creative Commons
2.58 © FlorianFuchs - Wikimedia Commons
2.59 © British Standards Institute
2.60 © British Standards Institute
2.61 © VM Zinc, photoarchitecture.com
2.62 © Christian Alexander Tietgen
- Wikimedia Commons
2.63 © Jason Bruges Studio & James Medcraft
2.64 © Matt Buck - Flickr Creative Commons
2.65 © Matt Buck - Flickr Creative Commons
2.66 © Network Rail
2.67 © Bert76 - Wikimedia Commons
2.68 © Concierge.2C - Wikimedia Commons
2.69 © Luc Mercelis - Flickr Creative Commons
2.70 © Manuelarosi - Wikimedia Commons
2.71 © Matt Buck - Flickr Creative Commons
2.72 © Weston Williamson + Partners
2.73 © Wald1siedel - Wikimedia Commons
2.74 © British Standards Institute
2.75 © NBS
2.76 © Ungry Young Man - Flickr Creative Commons
2.77 © Alamy
2.78 © Weston Williamson + Partners
2.79 © Weston Williamson + Partners

3.1 © Sunil060902 - Wikimedia Commons
3.2 © Network Rail
3.3 © Network Rail
3.4 © Weston Williamson + Partners
3.5 © Network Rail
3.6 © Weston Williamson + Partners
3.7 © Weston Williamson + Partners
3.8 © Weston Williamson + Partners

4.1 © Plowman Craven
4.2 © Alamy
4.3 © Londonrail.uk
4.4 © Network Rail
4.5 © Network Rail
4.6 © Paul Childs

5.1 © Network Rail
5.2 © Weston Williamson + Partners
5.3 © Ecovative
5.4 © Ecovative
5.5 © Weston Williamson + Partners

A.1 © Weston Williamson + Partners

B.1 © Weston Williamson + Partners
B.2 © Weston Williamson + Partners
B.3 © Weston Williamson + Partners
B.4 © Weston Williamson + Partners

C.1 © Network Rail, Weston Williamson + Partners -
© Morley von Sternberg,
© DiamondGeezer - Wikimedia Commons
C.2 © Network Rail
C.3 © SAS International
C.4 © Weston Williamson + Partners,
© Morley von Sternberg
C.5 © DiamondGeezer - Wikimedia
Commons, Network Rail

Inside Cover © Weston Williamson + Partners
© Morley von Sternberg


PADDINGTON
GENERATION REWEAR

200/

01