Construction & Built Environment Education

Construction and the Built Environment

Standards for 14 to 19 Education – Supporting Guidance

Updated and revised 22 January 2019

Construction & the Built Environment Education Advisory Committee

This document is a companion to the updated and revised 14 to 19 education standards version 22 January 2019. The associated guidance set out in this key document supports the education standards. The standards are supported by a wide range of those having a legitimate interest in raising the level of skills across construction and the built environment.

Contents

Section A: Associated Guidance to Support the 14 to 19 Education Standards

Standard 1.1: Design of the Built Environment

Learning Outcomes and Associated Guidance

1.1.1 **Identify social, cultural, economic, environmental and infrastructure factors influencing design.** This provides learners with an introduction to the broad human and physical factors to be taken into consideration in the design process. This includes identifying how the size and composition of the community and its development over time influences the design of different buildings and structures; the role of the existing infrastructure in influencing future social needs, including transport services; examining the impact of intended use and users on design; the economic influence of materials, labour and land costs on design; and the influence of environmental and sustainability factors in design.

1.1.2 **Explain how planning of the built environment impacts on design.** This provides learners with an introduction to how planning plays a major role in the design process. This involves identifying the local and national planning legislation, including heritage consents, and its impact on design; identifying appropriate ways of presenting designs at each stage of the planning process; recognising the need for different design solutions for different functions and purposes; and understanding how planning takes account of the local environment and local public opinion.

1.1.3 **Develop an understanding of sustainability and environmental protection as it applies to the design of the built environment.** This provides learners with an introduction to the contribution good design can make to creating a sustainable and protected environment. This involves identifying how the needs of flora and fauna are encompassed i n the design process; identifying and investigating the types of traditional and modern material that can be sourced from sustainable supplies; minimising waste; exploring the use of recycled materials and the preservation of limited natural resources; and identifying how local sourcing of materials can be taken into account in the design phases to the benefit of the environment and support local communities.

1.1.4 **Describe the properties of a range of materials and their impact on the design of the built environment.** This provides learners with an introduction to how the design process takes into account the properties of different traditional and modern materials. This involves exploring the properties and compatibility of materials available for construction in terms of their aesthetic impact, strength, durability, sound and thermal insulation and fire resistance; reviewing their sustainability in relation to required function; understanding the differences in performance characteristics between traditional buildings, materials and construction methods compared to those of modern construction; considering the contribution of different materials to suitability and environmental protection; and exploring issues of cost.

1.1.5 **Explain why a range of structures are designed in the way they are.** This provides learners with an introduction to the broad range of factors which will influence the design solution. This involves exploring how the design needs to take account of topography, ground conditions and movement, weather conditions, site context, setting and character, climate change mitigation and adaptation; ways of maximising the use of structures to meet a variety of purposes to meet the needs of local communities; and to develop an understanding of how land availability and the density and nature of the population influence design solutions.

1.1.6 **Demonstrate an understanding of design principles through the design of a simple structure.** This provides learners with an introduction to processes involved in the creation of a realistic design for a specific structure, either a new build or alteration or extension of an existing building. This involves establishing the function of the structure and exploring alternative design solutions; investigating the possibilities of different materials; evaluating the 'buildability' (can it be built) of the design; and establishing the skills needed to implement the design.

1.1.7 **Explain the principles of BIM and collaborative working and its related outcomes as well as the technologies that support a BIM project.** This provides learners with an introduction to the processes involved on a BIM project and how they support collaborative working. This involves collaboration by all parties and establishing individual responsibilities and outcomes, which are critical to the success of a BIM project. Learners will also be introduced to technologies that support BIM and how these form an integral part to the work involved during design and construction.

Standard 1.2: Create the Built Environment 1

Learning Outcomes and Associated Guidance

1.2.1 **Describe how construction methods and materials have changed over time.** This provides learners with an introduction to the benefits of different construction methods and materials. This includes identifying the benefits of traditional, modern and off-site methods, identifying the types of mechanical equipment available and their uses, and how used in conjunction, these can increase productivity.

1.2.2 **Apply safe working practices to undertake basic operations within the built environment.** This provides learners with an opportunity to carry out a range of basic work activities which involve the selection of personal protective equipment (PPE) and safe methods of work.

1.2.3 **Identify and describe the major requirements for health and safety and environmental protection.** This provides learners with an introduction to the contribution good housekeeping makes to safety and protecting the environment. This includes identifying how the segregation and disposal of waste is carried out, and how good lighting, temperature control and welfare facilities contribute to maintaining good methods of working.

1.2.4 **Use a range of hand tools and equipment used in the construction crafts and building services.** This provides learners with an introduction on how to use hand tools when working different traditional and modern materials. This involves sharpening and maintaining hand tools, using hand tools and equipment for basic activities.

1.2.5 **Describe where and how sustainable materials and processes can be used during the construction of the built environment**. This provides learners with an understanding of how to make best use of materials and processes to help sustain the built environment. This involves identifying what are sustainable traditional and modern materials and how they are processed and formed for use; retaining or reusing existing materials due to their embodied energy; identifying which materials can be recycled; and reused and where they can be incorporated in the build process.

1.2.6 **Identify a range of specific job roles in the built environment.** This provides learners with an introduction to career opportunities within the construction and built environment. This involves identifying, within construction and the built environment, the occupations which make up the areas of craft, technical, supervisory and management; the scope of progressing within each and their relationship with each other including the range and role of professional institutions that exist. Learners will also be introduced to the varied BIM related job roles that have developed recently in Construction and how they will continue to evolve.

1.2.7 **Interpret a range of basic technical information.** This provides learners with an introduction to the use of written and graphical information used in the construction and the built environment industry. This involves interpreting specifications, schedules, drawings, models and manufacturers' information used at the operative and craft levels.

Standard 1.3: Value and Use of the Built Environment 1

Learning Outcomes and Associated Guidance

1.3.1 **Identify how the existing infrastructure and transport services impact on people and places around them**. This provides learners with an introduction to the visual, cultural, social, economic and environmental impact of the built environment. This involves understanding the function of different structures and what they contribute to the built environment and the community; assessing the impact and contribution of landmark structures; identifying how the infrastructure affects people's lives including transport; and recognising how individuals and communities can influence the built environment around them.

1.3.2 **Describe how the welfare of people who use the built environment can be ensured.** This provides learners with an introduction to how the built environment can add to the well-being, happiness, safety, security and welfare of people. It involves understanding the impact of existing and new buildings and structures on where we live, how we travel around and the range of activities available to us; identifying ways in which the built environment can be made safer and more secure

continued... for people; identifying ways in which the built environment can be changed to improve our health; recognising the relationship between buildings and our quality of life, sense of place and local identity; understanding the role of the built environment in providing us with economic opportunities.

1.3.3 **Identify where and how sustainable materials and processes can be used in maintaining the built environment.** This provides learners with an introduction to the ways in which we can maintain a built environment which protects the environment and minimises use of scarce natural resources. This involves understanding the impact of the built environment on the natural environment; understanding the role of repair, maintenance, reuse, adaptation and regeneration of existing buildings; identifying where renewable materials can be used which do not harm the environment and can be recycled/reused; understanding how individuals can contribute to the protection and maintenance of a protected environment.

1.3.4 **Describe the life cycle of structures in the built environment and their contribution to economic and social development.** This provides learners with an introduction to how buildings and structures are planned, built, used, maintained, adapted and removed. This involves understanding the ways in which land is used for different purposes and how these uses may change over time; identifying the stages involved in the design, planning, building, maintenance, operation and demolition of buildings and structures; understanding the commercial value and economic importance of buildings; understanding social value and exploring how changes in the built environment affect people's lives and change the nature of communities.

1.3.5 **Explain the principles of building performance in-use and the causes of the 'performance gap'.** This provides learners with an introduction into the difference between modelled energy performance, to comply with building regulations, and actual performance in use. This involves exploring what is understood to be 'the performance gap' and the various factors that contribute to a lower level of energy efficiency than predicted by modelling tools including SAP (Standard Assessment Procedure) and BREDEM (BRE Domestic Energy Model).

Standard 2.1: Design the Built Environment 2

Learning Outcomes and Associated Guidance

2.1.1 **Identify and explore the factors influencing the design process, including BIM related processes.** This provides learners with a good knowledge, understanding and application of the wider factors that need to be taken into consideration during the design process. This involves establishing the needs of community and the social and cultural impact of the proposed structure; exploring how economic factors influence design including project funding and the lifespan of the structure; identifying how the infrastructure, site context and character, setting and climate change mitigation and adaptation influences design, including transport; examining how design can minimise the impact on the environment; examining the impact of intended use and users on design; and investigating the design considerations imposed by regulation, development policies and guidance. This also includes how BIM related processes can positively influence the design of the building project and allow for better decision making.

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2.1.2 Identify planning requirements and their impact on design. This provides learners with a good knowledge, understanding and application of the processes involved in responding to planning requirements in the design process. This involves identifying and exploring different types of planning requirements, including heritage consents, for a wide range of developments of different function and scale; understanding the impact of legislation, national and local government policies and guidance on the design process; exploring a range of alternative design solutions; ensuring that designs meet the regulatory requirements; and adapting designs to meet planning requirements.

2.1.3 Examine the nature and use of utilities in the design of the built environment. This provides learners with a good knowledge; understanding and application of processes involved in accommodating the availability and location of utilities in the design process. This involves understanding how the location and accessibility of utilities are taken into account; how utilities are distributed and scaled down; identifying how maintenance requirements for utilities are considered; and examining the environmental impact of utilities provision.

2.1.4 Investigate the use and properties of materials used in construction of the built environment. This provides learners with a good knowledge, understanding and application of the processes involved in understanding the nature of traditional and modern materials used in construction of the built environment and how they influence the design process. This involves examining the structure, properties and compatibility of materials and their uses; exploring the different functions materials can perform and their influence on building styles and the character of places over time; establishing the relationship of materials to each other; examining the differences in performance characteristics between traditional buildings, materials and construction methods compared to those of modern construction; investigating the manufacture, preparation, location and securing of materials; and practicing the use of selected materials.

2.1.5 Identify how the use of sustainable materials can influence the design process. This provides learners with a good knowledge, understanding and application of the principles involved in making best use of materials which protect and sustain the built environment. This involves understanding the embodied energy in existing buildings and structures; how sustainable raw materials are processed to form materials for sustainable use; exploring which materials are eco-friendly and can be retained, reused or recycled; and investigating the structural properties of sustainable materials and their influence on the design process.

2.1.6 Identify and make use of a range of technical information available to design the built environment including BIM related technology. This provides learners with a good knowledge, understanding and application of the major categories of technical information to be considered in the design process. This involves identifying appropriate standards for material production, quality, methods of working and manufacturers' product information and their impact on design; identifying and interpreting environmental information on climatic conditions; and understanding the impact of local authority guidelines and requirements. This also includes an introduction to how technologies supporting BIM can support the technical information on building projects in positive ways

2.1.7 **Analyse a range of common structural forms and building elements used in the design process.** This provides learners with a good knowledge, understanding and application of the various alternative structures and components used in traditional and modern forms of construction and their influence on the design process. This involves exploring the benefits of different frame structures and how they impact on design; investigating the nature and use of prefabricated elements and the common structural forms and materials associated with them; and identifying traditional on site construction processes and their suitability.

2.1.8 **Analyse a range of metrics used to set performance outcomes for buildings in-use along with methodologies for measuring actual performance.** This provides learners with a good knowledge, understanding and application of the various metrics and methodologies used to define and measure the performance of buildings in-use.

2.1.9 **Apply design principles through the design and evaluation of a complex structure.** This provides learners with a good knowledge, understanding and application of the processes involved in the creation of a realistic design for a specific complex structure either in terms of multiple components or functions. This involves establishing the function of the structure and exploring alternative design solutions; investigating the possibilities of different materials; evaluating the "buildability" (can it be built) of the design; and establishing the skills needed to implement the design.

Standard 2.1: Create the Built Environment 2

Learning Outcomes and Associated Guidance

2.2.1 **Examine main job roles and their relationship to each other within the built environment and explore typical career pathways, qualifications and progression.** This provides learners with a good knowledge and understanding of the variety of the job roles, careers and qualifications which are available in traditional and modern construction. This involves identifying the main occupations within the areas of craft, technical, supervisory and managerial levels appropriate to construction and the built environment, career and qualification progression available in each and including how occupations relate to each other and the range and role of professional institutions. Learners will also be introduced to new job roles now available in building construction in relation to BIM and how these will continue to evolve.

2.2.2 **Identify and use a range of technical information used in the construction of the built environment.** This provides learners with a good knowledge, understanding and application of the information available and the ways in which it is presented. This involves identifying and exploring different formats of graphical and written information available and including accessing specifications, schedules, drawings and models from electronic databases.

2.2.3 **Investigate a range of methods and techniques used in the construction of groundworks, substructure, superstructure and external works.** This provides learners with a good knowledge, understanding and application of the work methods involved in forming the foundations of the structure and erecting the main framework. This involves understanding how structures can be built entirely in situ or be part fabricated off site, working below ground level and at height using mechanical equipment and manual work skills.

2.2.4 **Identify a range of hazards and risks commonly encountered in the construction of the built environment and show how they can be minimised.** This provides learners with a good knowledge and understanding of likely hazards and risks encountered on site and in the workshop. This involves exploring how traditional and modern materials have inherent hazards associated with their use and how methods of work should be devised to overcome risks associated with work activities in confined spaces, below ground level, at height and using equipment covered by legislation.

2.2.5 **Identify and apply good practice in safe working techniques.** This provides learners with a good knowledge, understanding and application of the principles of safe working.

2.2.6 **Select and use a range of tools, materials and personal protective equipment to perform construction activities.** This provides learners with a good knowledge, understanding and application of skills to use hand-powered tools, natural and manufactured materials and associated personal protective equipment. This involves identifying and using appropriate tools and personal protective equipment related to operate, craft and technical occupations for a limited range of basic work activities and associated materials.

2.2.7 **Explain the principles of building performance in-use and the causes of the 'performance gap'.** This provides learners with an introduction into the difference between modelled energy performance, to comply with building regulations, and actual performance in use. This involves exploring what is understood to be 'the performance gap' and the various factors that contribute to a lower level of energy efficiency than predicted by modelling tools including SAP and BREEDEM.

Standard 2.3: Value and Use of the Built Environment 2

Learning Outcomes and Associated Guidance

2.3.1 Identify and explore the social, cultural, environmental and economic components and benefits of sustainability'. This provides learners with a good knowledge, understanding and application of the principles of sustainability and its contribution to the built environment. This involves exploring how sustainable materials and processes are used and their contribution to environmental protection; exploring how the repair, maintenance, re-use, adaptation and regeneration of existing buildings contributes to sustainability; identifying how the use of local materials and services can contribute to the local community and reduce emissions and pollution; identifying how the local infrastructure and transport services influence the local environment; exploring the benefit of using materials from renewable sources and which can be reused; exploring ways of balancing the social, cultural, environmental and economic impact on the environment; identifying ways in which individuals and organisations can contribute to sustainability.

2.3.2 Identify and describe the contribution that the built environment makes to the cultural, physical, spiritual and emotional well-being and economic prosperity of individuals and communities. This provides learners with a good knowledge, understanding and application of the ways in which the built environment influences and impacts on individuals and communities. This involves exploring the contribution that each type of building makes to the quality of life in the local community, and the quality of place and local distinctiveness of the built environment; exploring how we can improve the built environment to enhance the safety and health of individuals and communities; identifying the impact of the local infrastructure including transport services on the quality of people's lives; exploring ways in which the built environment can promote or act against the well-being of individuals and communities; and investigating how the conservation, planning and development of the built environment can contribute to the creation of sustainable communities.

2.3.3 Describe the main activities and roles involved in maintenance and service support functions. This provides learners with a good knowledge, understanding and application of the processes involved in maintaining and supporting the built environment. This involves exploring the ways in which both traditional and modern built structures are operated, managed and protected to ensure effective functioning, health and safety; and investigating how a range of building maintenance and service support functions are provided.

2.3.4 Explain the contribution of facilities management and support services to the maintenance, development and economic benefit of the built environment. This provides learners with a good knowledge, understanding and application of the processes involved in preserving, maintaining and managing the built environment and how this contributes to wealth creation and quality of life. This involves investigating ways in which a wide range of building maintenance and management services are contracted and delivered; identifying the financial contribution of managed services to the economy; establishing and evaluating the contribution of maintenance and support services to enhancing the lifespan of buildings and structures and the economic, social, cultural and environmental benefits this brings.

2.3.5 Analyse a range of metrics used to set performance outcomes for buildings in-use along with methodologies for measuring actual performance. This provides learners with a good knowledge, understanding and application of the various metrics and methodologies used to define and measure the performance of buildings in-use.

2.3.6 Identify and explore the contribution of property services and housing to the development of the built environment and the wider community. This provides learners with a good knowledge, understanding and application of the processes involved in the purchase and sale of built assets as well as their use for public and social purposes. This involves identifying the role of public and private housing and its contribution to social policy and the well-being of communities; investigating the residential, industrial and commercial property market and its contribution to personal and organisational wealth; and reviewing how the private and public use of built assets makes a direct contribution to local economies and communities.

Standard 3.1: Design the Built Environment 3

Learning Outcomes and Associated Guidance

3.1.1 Explore the historical, political infrastructure including transport, economic, social, cultural and aesthetic factors influencing the design process. This provides learners with the knowledge, understanding and application of the analytical skills involved in evaluating the impact of a wide range of factors influencing the development and design of the built environment. This involves investigating how the built environment has developed and changed over time and factors influencing changing styles and approaches to design; investigating the impact of different political policies and priorities and their impact on design; identifying and evaluating the impact of different forms of private and public funding on built environment projects and evaluating the influence of the cyclical nature of economic growth and recession; exploring how the built environment responds to community needs, social integration and contributes to social engineering; identifying how infrastructure requirements influence design, including transport and exploring various architectural styles, landmark projects and the relationship between function, form and visual appearance.

3.1.2 Identify and explore the principles and methods involved in urban design and their influence on the urban environment. This provides learners with the knowledge, understanding and application of the principles and methods involved in urban design and the factors influencing the existing and future spatial structure of urban form. This includes an exploration of the design and governance of urban spaces and their contribution to social inclusion, economic growth, environmental sustainability, transport strategies and the quality of life. Learners will also be given the opportunity to develop and experiment with a range of design skills in order to manipulate space and produce alternative strategic and detailed representations of the urban environment. The interdisciplinary nature of urban design will also be explored.

3.1.3 Identify and explore the various stages of the design process. This provides learners with the knowledge, understanding and application of the principles involved in taking a design

continued... through the complete design cycle. This involves identifying ways of establishing and verifying client requirements/briefs; exploring the visual impact of the proposed design in relation to function; exploring ways of developing preliminary and refined design solutions; identifying the different relationships in the process including client/agent and design team; identifying regulatory and planning requirements in relation to designs; identifying the technical and physical processes involved in realising the design including structural engineers and contractors; and exploring the ways in which the design solution is translated into object based models, working drawings and specifications to permit its construction.

3.1.4 Examine the various stages of the planning process and evaluate the important factors that affect planning procedures and decisions. This provides learners with the knowledge, understanding and application of the processes involved in the planning cycle. This includes identifying and evaluating the primary social, cultural, political and economic factors that influence the planning process; interpreting planning requirements and developing a strategy to achieve an acceptable design solution; identifying appropriate treatments of the design solution at each stage of the planning process; identifying ways of responding to circumstances to ensure continuing compliance with planning permission; and identify the monitoring and approval requirements to ensure compliance with planning permission.

3.1.5 Examine the health, safety and environmental factors influencing the design of the built environment. This provides learners with the knowledge, understanding and application of the principles involved in ensuring that health, safety and environmental protection are fully reflected in the design process. This involves identifying ways of incorporating health, safety and environmental protection factors which ensure the safety and well-being of people using the built environment; identifying ways of responding to regulatory requirements for health, safety and environmental protection; investigating ways of conducting risk assessment and incorporating risk management in the design process; investigating ways of ensuring the security of people using the built environment; and investigating the design implications of maximising energy efficiency, sustainability and environmental protection over the whole life cycle of the building.

3.1.6 Investigate the provision of primary services utilities to the design of buildings in terms of the main features, basic operating principles and the materials used. This provides learners with the knowledge, understanding and application of processes to ensure the external supply of utilities and the functioning of building services are accommodated within the design process for new and existing buildings. This involves identifying how the provision, location, accessibility and maintenance of utilities influence the design process; understanding how utilities are scaled down to provide effective supply; investigating the implications for design of how utilities are distributed; investigating ways of ensuring that environmental and energy efficiency are taken into account during design; and investigating ways of building in factors which will enhance the management of the built environment.

3.1.7 **Identify the impact of projected climate change on the design of the built environment and on ways of minimising energy demand and reducing emissions to air, land and water of new and existing buildings .** This provides learners with the knowledge, understanding and application of principles which ensure that the design process takes full account of environmental and climatic changes and future predictions. This involves understanding and evaluating the influence of global warming on the built environment; identifying ways of designing in protection of the built environment against changes in the water table and drought; identifying ways of designing for climate change adaptation and mitigation; identifying ways of designing for flood resilience; investigating how design processes can minimise emissions to the air and contribute to energy efficiency; understanding how waste disposal can affect land pollution and how the design process can minimise this; and investigating ways of designing in the most effective form of heat exhaust. Learners will also gain an understanding of the role of energy use, sourcing, management and renewal and their contribution to the built environment. This will involve gaining an understanding of the principles of renewable energy and their impact on technical, economic and social factors in the design process. Different sources of energy will also be explored as well as ways in which energy performance can be enhanced as a contribution to the responsible design of the built environment.

Standard 3.2: Create the Built Environment 3

Learning Outcomes and Associated Guidance

3.2.1 **Examine main job roles and their relationship to each other within the built environment and explore career pathways, qualifications and progression.** This provides learners with the knowledge and understanding to explore relationships between varying occupational job roles their career progression and relevant qualifications. This involves investigating the occupational structure of the construction and the built environment industry in relation to craft, technical, supervisory and management job roles and identifying and linking pathways for career progression and the appropriate qualification routes relating to each and including the range and role of professional institutions.

3.2.2 **Identify ways of protecting and maintaining the environment during construction of the built environment.** This provides learners with the knowledge, understanding and application of the principles involved in safe guarding structures and their surrounding areas during construction. This involves identifying regulatory requirements and planning conditions governing the construction process and how companies and employees implement procedure to comply with given laid down requirements and conditions.

3.2.3 **Identify and evaluate the construction processes required to construct the sub- and superstructures of a range of buildings, including finishes and services.** This provides learners with the knowledge, understanding and application of processes needed to develop a working knowledge of the building technology required to bring a typical construction project to a successful conclusion.

3.2.4 Identify and evaluate a range of project management tools and techniques. This provides learners with the knowledge, understanding and application of processes involved in the management of projects. This includes identifying and evaluating personal skills required for dealing with individuals and groups of employees and the recognition of the skills required to manage strengths, weaknesses, opportunities and threats associated with construction and built environment projects.

3.2.5 Identify and evaluate a range of quality assurance and project monitoring processes. This provides learners with the knowledge, understanding and application of the procedures needed to ensure the quality of work meets the given specification and how the project is monitored throughout the build process. This involves identifying and evaluating ways to 'snag' the work during and on completion of the work programme, and monitoring and evaluating materials and labour costs, work in progress, plant hire costs and production costs as part of the project processes.

3.2.6 Identify and evaluate the health, safety and environmental factors influencing the creation of the built environment. This provides learners with the knowledge and understanding to monitor the magnitude of health and safety and environmental issues created by the build process. This involves identifying current legislation and information on non-fatal injuries and fatalities, evaluating their influence on the build process in terms of the cost of safety and evaluating cost implications associated with the supply chain and sustainability of resources. This outcome should also evaluate the influence that BIM may have on the health and safety of a project and how utilising modern methods of construction can aid in this process.

3.2.7 Compare existing and developing processes used in the creation of the built environment and evaluate their impact. This provides learners with the knowledge and understanding of some key methods used in the creation of the built environment. This involves evaluation of traditional, craft and on site techniques in comparison with modern and off site methods, for example BIM, considering the impact on cost, duration of project time, health, safety and environmental risks and how they impact on the needs of society. Evaluate ways to reduce errors and to increase productivity.

3.2.8 Explore the barriers to delivering an assured performance building and examine how these barriers might be overcome. This provides learners with the knowledge, understanding and application of principles which ensure that buildings perform as intended, providing healthy and comfortable environments that are efficient to operate and maintain. This should include an understanding of the importance of whole system design, building performance, thermal bridges, airtightness, detailing & workmanship, offsite v traditional construction, post construction processes including commissioning, testing & monitoring, soft landings, user training.

3.2.9 Identify and evaluate the principles of renewable energy and its technical and social implications. This provides learners with the knowledge, understanding and application of energy production, energy conservation and energy audit with regard to renewable energy sources.

3.2.10 **Identify and evaluate ways of conserving natural resources and recycling waste in the creation of the built environment.** This provides learners with a good knowledge, understanding and application of the principles involved in making best use of materials to sustain resources for the built environment. This involves understanding how sustainable raw materials are processed to form resources for sustainable use; exploring which materials are eco-friendly and can be recycled; and investigating the uses of sustainable materials and how they influence the construction of the built environment.

Standard 3.3: Value and Use of the Built Environment 3

Learning Outcomes and Associated Guidance

3.3.1 **Describe and evaluate ways of engaging stakeholders and communities in the development and use of the built environment and the local infrastructure including transport.** This provides learners with the opportunity to analyse evaluate and explore principles and practices in relation to engagement of the whole community in the creation and use of the built environment. This involves evaluating the role and contribution of the primary stakeholders in the built environment and their different perspectives and interests; investigating ways of balancing the needs of different stakeholders and communities; and evaluating alternative ways in which individuals and communities can contribute to and influence decisions about the development of the built environment.

3.3.2 **Identify ways of protecting and maintaining the environment during use of the built environment.** This provides learners with the opportunity to analyse evaluate and explore principles and practices in relation to ensuring the use of buildings and structures protect the environment. This involves identifying ways of minimising energy demand and reducing emissions to air, land and water; identifying sustainable processes which optimise social, cultural, economic and environmental benefits; Identifying the contribution of the local infrastructure including transport services to the maintenance of the built environment; evaluating technologies and materials which can contribute directly to sustainability; exploring ways of engaging stakeholders and communities in protecting the built environment; evaluating methods of ensuring that buildings and structures are protected from damage and kept secure.

3.3.3 **Evaluate the social, economic and commercial contribution of the built environment to the wider community.** This provides learners with the opportunity to analyse, evaluate and explore principles and practices in relation to the contribution of the built environment to economic activity, prosperity and social cohesion. This involves identifying the economic and business drivers within the built environment and how this influences its development; evaluating the financial contribution of built environment activities to the broader economy; and investigating the contribution of the built environment in achieving social objectives and community development. Learners will also gain an understanding of the contribution made by planning to the well-being of individuals and communities, social cohesion and community development. Learners will understand the primary social, cultural, political and economic factors that influence the planning process and how they relate to other components of the design process.

3.3.4 **Evaluate the role of asset management in the economic and social development of the built environment.** This provides learners with the opportunity to analyse, evaluate and explore principles and practice in relation to the management of built assets to achieve economic and social benefits. This involves identifying the full range of asset management activities for both private and public provision; evaluating the financial value of asset management services and their contribution to the national and local economy; evaluating the impact of asset management services on the lifespan, financial viability and social utility of built assets; and identifying and evaluating the impact of well-managed assets on the safety, comfort and well-being of individuals and communities.

3.3.5 **Identify and evaluate ways of protecting the physical structure of the built environment.** This provides learners with the opportunity to analyse evaluate and explore principles and practices in relation to how the physical fabric of the built environment is kept secure through regular inspection, maintenance and repair. This involves identifying and evaluating techniques for repairing and maintaining the integrity of the structure from damage from the elements and people; identifying ways of protecting the built environment in order to extend its period of usefulness and maintain economic value; identifying and evaluating the contribution of protecting the built environment to sustainability, social and community objectives.

3.3.6 **Examine the basic principles of soft landings and how post occupancy evaluation and review can ensure this approach was considered and reviewed.** This provides learners with the opportunity to analyse evaluate and explore principles and practices in relation to what constitutes soft landings. It also allows learners to appreciate the relevance of how BIM processes can ensure all information is utilised during design, construction and into operation.

Section B: BIM Supplement

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1. Introduction

Building Information Modelling (BIM) is a collaborative way of working, underpinned by digital technologies which unlock more efficient ways of designing, creating and maintaining our built assets. As a result the importance of BIM and education remains critical for the successful future of the Construction industry in the UK. The inclusion of BIM in relation to the Regulated Qualification Framework (RQF) for Levels 1 to 3 is an important inclusion for establishing the future skills needed for our industry. The requirement to understand how BIM fits into the wider construction landscape and relating it to current processes and technologies is therefore a matter of urgency in regard to education for 14-19 year olds. This BIM Supplement will therefore provide an overview and detailed explanation in order for education to embed key themes from this document into further learning.

BIM is transforming the process of design, construction and operation within the built environment both in the UK and abroad. The embracing of BIM by the UK government via an aggressive BIM mandate has propelled the UK, both public and private sectors, into adopting the process and technology of BIM. This adoption rate is increasing and therefore industry requires knowledge and skills in this area in the future. A BIM Maturity model has been defined for the UK identifying Level definitions in relation to BIM and for the purpose of this document are defined as BIML2 (eg. BIM Level 02).

The introductory section will provide an overview of the basic principles of BIM, and relating these to the Construction Industry. The guide will aim to provide a basic introduction to BIM and a framework of information for Levels 1-3 of the Regulated Qualification Framework. The basic principles should be used throughout all levels of education and provide for a reference to specific learning outcomes throughout the document. It is proposed that this supplement be used in conjunction with the 14-19 Education Standards.

1 A. Basic Principles of BIM

BIM allows for key product and asset data to be embedded within all stages of a project and utilises a number of three dimensional computer models that can be used for effective management of information through a project lifecycle. This can be achieved from early concept design through to operation and maintenance of a built asset and therefore can allow for a unified set of information to be delivered to the client at handover.

The aim is that BIM consists of project information which is derived from a number of sources of a building project. These include:

- Object Based Models.
- Drawings such as PDF's or DWG's which are generated from the object based models.
- Graphical and non-graphical information in the form of specifications, schedules and reports.
- Facilities management requirements such as warranties, replacement and maintenance data.

BIM essentially creates an information repository for a project with different team members and project participants inputting and outputting digital data at all times.

BIM also enables more thorough ways of working that encourage high levels of collaboration with all project

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stakeholders being able to visualise and share digital building models that can be easily understood by all members of a project team as well as share and produce information that can be used and included throughout design, construction and operation.

BIM relates to all stages of a project in the following ways.

- Design: Conceptual and detailed design of architecture, structure and mechanical electrical and plumbing in a 3D environment.
- Communication: Visualisation and analysis of 3D information within a building project.
- Simulation: This may include structural analysis, energy analysis, solar study, ventilation and light analysis and schedules from the model data.
- Documentation: This will include CAD Output or PDF, models, work schedules, costings and product information.
- Building processes such as construction, logistics and planning can be undertaken from BIM.
- Operation information including maintenance and asset management is a key area of BIM as all the information is collected and stored in a single place.
- End of life data including demolition and re-use supports BIM.

1B. The Benefits of BIM

BIM as a process can provide best value and savings on projects. The benefits of BIM have been demonstrated outside of central government and as such BIM is being adopted across the industry and globally at rapid speed.

The main benefits of BIM can be summarised as follows:

1. **Better Stakeholder understanding of projects** - Images and visualisations that can be created at early stages of projects allow key project stakeholders to understand the built project prior to any construction being undertaken. It also allows these individuals to experience the spaces of the built form and navigate them as they please.
2. **Conflict resolution and control** - During all stages of a project BIM allows conflicts to be resolved via better coordinated information between all project stakeholders. These conflicts can be resolved prior to construction and therefore savings are achieved with the omission of construction site conflicts.
3. **Construction process certainty** - Building information Models can be used to create accurate time line sequencing to ascertain project key milestones and dates with certainty. This process can be achieved prior to construction and therefore save on time and cost.
4. **Lean construction techniques** - Utilising BIM to discover material quantities and values can achieve leaner construction techniques by avoiding error in duplication of elements that may be ordered and delivered to site.
5. **More accurate cost control** - Bills of Quantities can be achieved at all key stages of projects to ensure the accurate cost estimates can be produced and shared with the client. The process of BIM allows

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more accurate cost control by calculating values that exist in the virtual prototype of the building/site or structure prior to its completion.

6. **Improved coordination and better management** - Coordination between all consultants on a project can be managed more efficiently using BIM by drawing together all information in a consolidation way to check that differing elements do not clash. This will also aid in project savings and reduced site issues and changes during construction.
7. **Effectively manage built information to achieve better facilities management** - Information delivered to the client at handover and practical completion will be in a consolidated digital package that can subsequently be linked into a variety of Computer Aided Facilities Management software. The digital data delivered at the completion of a project can also be used for renovation or rework further downstream.
8. **BIM and sustainability** - BIM can unlock efficiencies on projects by allowing accurate data regarding the physical location of a site and its associated site conditions to be analysed and used to inform design and project schemes with this accurate data in mind. This allows for accurate climate data as well as informed building shape and orientation to be established at very early stages of a project.
9. **Improved collaboration** - BIM fundamentally encompasses more collaborative ways of working by ensuring all design team members are communicating and working together to produce better buildings. The collaborative nature of BIM allows for better coordination of building elements as well as ensures all team members are working towards an end goal of creating efficient and sustainable buildings

1C. The BIM Maturity Model

HM Government released the government construction strategy in May 2011 stating that our industry required radical change in order to become more efficient. It determined that within construction in the UK our sector performs poorly and Construction projects lead to waste and inefficiency. The report concluded that the use of Building Information Modelling would be mandated on all Government funded projects by 2016 in order to:

1. Ensure alternative design proposals can be evaluated with ease by all parties involved
2. Projects are to be modelled in three dimensions to avoid errors in coordination and to allow for 3D aggregation of discipline model data
3. Design data should be fed directly into machinery tools for DFMA (Design for Manufacture and Assembly)
4. Data can be used downstream for asset management using information expelled from design and construction model data

The Government Construction Strategy stated that… *'Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016' (Paragraph 2.32 page 14, Government Construction Strategy, May 2011, Cabinet Office).*

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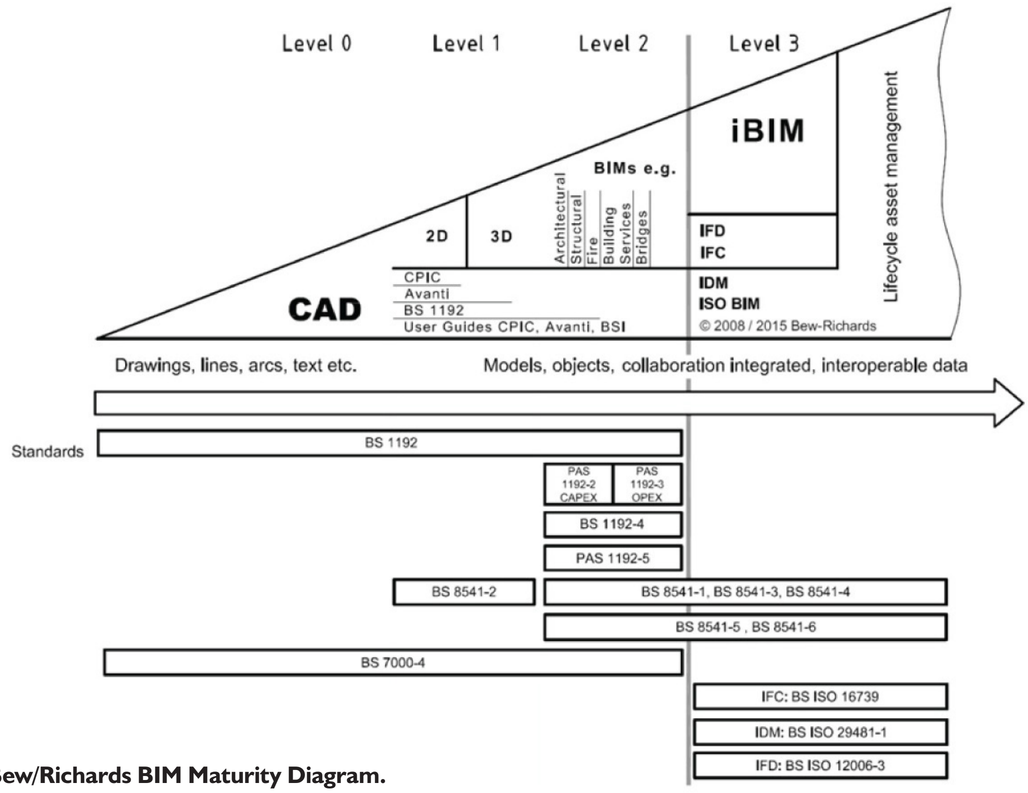
As a result of this strategy, BIM was placed as a high priority for all projects procured through HM Government. The aim was to enable a process and adoption of BIM by 2016. The BIM Task Group was formed from this incentive and driven by the government to enable this change in industry and help those involved in Building Projects to build their knowledge and capability in a BIM capacity.

The UK BIM Maturity model was devised in order to provide a clear demarcation of the varying levels of BIM implementation that could be achieved. These level definitions have helped industry understand the staged approach to development of BIM and how we have transitioned and will continue to move into a more digitally integrated process in building construction. These can be defined as levels 0 to 3 which help to categorise how projects can be defined in terms of BIM process and adoption.

The BIM Maturity diagram indicates a level definition of BIM, as outlined below:



Bew/Richards BIM Maturity Diagram.

The definitions can be defined as per the below descriptions:

BIM Level 0

Unmanaged computer aided design (CAD) including 2D Drawings, and text with paper-based or electronic exchange of information.

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BIM Level 1
Managed CAD, in a 2 or 3 dimensional format which would include such information as drawings in 2D format and information in 3D that may refer to visualisation or concept design models. Level 1 is also commonly described as 'Lonely BIM' as models are not shared between project team members

BIM Level 2
Managed 3D environment with data attached but created in separate discipline- based models. These separate models are assembled to form a federated model, but do not lose their identify or integrity. Data may include construction sequencing (4D) and cost (5D) information.

Level 2 consists of a series of domain and collaborative federated models, consisting of both 3D geometrical and non-graphical data, prepared by different parties during the project life-cycle within the context of a common data environment. The project participants provide defined, validated outputs via digital data transaction's using proprietary information exchanges between various systems in a structured and reusable form. It is of critical importance that level 02 be clearly explained to students as a national framework for building projects from 2016.

BIM Level 3
A single collaborative, online, project model with construction sequencing, cost and project lifecycle information. This is sometimes referred to as 'iBIM' (integrated BIM). Level 3 is currently underway within the core team supporting the process in the BIM Task Group and will evolve in the coming years. A report was published in February 2015 titled 'Digital Built Britain – Level 3 Building Information Modelling Strategic Plan' which outlines the government's main objectives regarding Level 3 and much of the work to develop this plan includes supporting industry post 2016 in delivering Level 2.

The advancement in construction digital technologies and associated workflows has opened communication and collaboration between the majorities of stakeholders on construction projects. The combination of these two factors has allowed the people of the construction industry to provide clear, accurate and usable data structure, removing and/or reducing many risks currently associated with a construction project.

On a BIM project you may also be required to contribute to an object based model with as-built and project information or simply provide the as-built or product data via a COBie spreadsheet.

COBie stands for Construction Operation Building Information exchange. COBie is a spreadsheet data schema and acts as a single source of information regarding all the data relating to the asset being designed, constructed and maintained on a BIM project.

The requirement of COBie and the guidance for its use is outlined within BS1192:4 2014. In simple terms, Level 3 can be summarised as follows:

1. Development of information models over the course of a project which reference, federate or exchange information with other models.

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2. Provision of an Employers Information Requirements (EIR) document with clear definition and decision points.
3. Supplier & supply chain capability assessment.
4. Provision of a BIM Execution plan (BEP) including assigned roles, standard, methods & procedures and a master information delivery matrix aligned with the project programme.
5. Provision of a Common Data Environment.
6. Compliance with the documents and standards listed below.
7. Development of information models utilising database-based software, and analysis software.
8. Data to be collated and grouped via the UK COBie 2012 framework and delivered at all key stages of a building project.

1D. BIM Standards

Information management has been refined and clarified within a series of standards developed by industry and government to aid in the adoption of BIM and support the process of both the capital/delivery phase and the operational phase of assets. Students should be aware of the standards and understand their relevance on a project lifecycle from conception to completion.

It is encouraged that these standards be included as part of Level 3 of the Regulated Qualifications Framework as an introductory guide only.

In order to ensure updates to standards are acknowledged it is recommended that the following website be used which is an industry resource for current standards in reference to BIM:
http;//bimblog.bondbryan.com/standards/

This website is updated regularly with relevant standards that relate to BIM in the UK and associated guidance documents that support delivery of BIML2.

The 1192 suite outlines both the capital/delivery as well as operational phases of assets and ensures process, information requirements and stages of delivery of information are achieved for a project delivering to BIML2. It is recommended these standards require acknowledgement at this level.

PAS1192:2 – Specification for information management for the capital/delivery phase of construction projects using building information modelling.

PAS1192 3: - Specification for information management for the operational phase of assets using building information modelling.

BS1192 – Collaborative production of architectural, engineering and construction information. Code of practice.

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BS1192:4 – Collaborative production of information. Part 4: Fulfilling employer's information exchange requirement using COBie – Code of practice.

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The future of the industry is an uncertain one but the government is doing its best to allow us to understand how technology, social impact and use of the built environment will form the basis of predicting how we'll work in Construction leading into the future. The following reports should be used as guidance for appropriate sections of the standard that mention future principles of Construction.

These include:
Industrial Strategy: Government and industry in partnership: Construction 2025
http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf

Built Environment 2050: A report on our Digital future. BIM2050 and the CIC.
http://www.bimtaskgroup.org/wp-content/uploads/2014/09/2050-report.pdf

HM Government: Digital Built Britain. Level 3 Building Information Modelling Strategic Plan.
http://www.gov.uk/government/uploads/attachment_data/file/410096/bis-15-155-digital-built-britain-level 3-strategy.pdf

2. Underpinning Principles of BIM

The following section explains and discusses the underpinning principles of BIM which include collaborative working, understanding of responsibilities and processes within a BIM environment as well as how these relate to overall project process. The section also discusses the importance of information within a BIM project.

2A. Teamwork And Collaboration

Upon commencement of any project it is absolutely critical to plan the process, ensure the team members have the capability and above all have the experience on projects in the way of teamwork. All members of a project team from client to contractor must understand what is to be achieved in totality, at key project stages and even on a weekly basis for team coordination and this should be communicated at all times.

Communication is critical and will ensure the success of a project. The concept of clear and defined communication between team members on a construction project should be clearly defined. The introduction of BIM enables this collaborative process and should be thoroughly explained and taught to students who would be pursuing careers in the Built Environment. This is critical for the future of our industry and success rate of its change.

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To coordinate the information and engage in the BIM process, effective and coordinated collaboration is essential. The BIM environment contains a large amount of information including schedules, model data and tasks and if these areas are not completely in order the project will not be successful. As we move into a more integrated way of working it is important to address the relevance of this type of collaborative work as part of all levels within education. Students should be educated not only on the technical details to achieve a successful BIM project but also the communication methods that are successful in making these projects work.

The future of the construction industry, and the value that is created, will be based around the way we interact and the ability of construction professionals to collaborate, create knowledge and contribute to positive cultural conditions within construction. This will ensure future generations of construction industry professionals work together in a way that will promote collaboration as well as enable an industry to thrive and grow as it should.

It is therefore proposed that key themes be addressed:

1. Clear identification of the roles on a construction project and how these roles relate to one another.
2. The use of communication methods should be clearly managed between all parties e.g. email, face to face and Communication through the Common Data Environment.
3. Teamwork between parties in differing areas of a project is extremely important and therefore regular interaction is encouraged (including team meetings and verbal communication).

It is proposed that through RQF Levels 1 and 2 that clear communication and interaction be reinforced. At RQF Level 3 however, the more detailed approaches of the Common Data Environment should be addressed.

2B. Information Requirements

At the very early stages of a project conception it is important for the major stakeholders managing appointment, procurement and engagement with their supply chain to ensure all information requirements are communicated on their project. This is a critical part of construction projects as it will allow all team members to understand their responsibilities as well as maintain a good relationship with the employer. The Employers Information Requirements (EIR) should exist as a key document to communicate to all project team members what information is required and when during the lifecycle of a project. This will ensure the process of BIM is achieved by creating a structured and clear set of requirements that the client will utilise at the final handover of the building.

An example EIR is located on the BIM Task Group website here:
http://www.bimtaskgroup.org/wp-content/uploads/2013/04/Employers-information-requirements-Core-Content-and-guidance.pdf

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Once these requirements outlined in the EIR are understood and communicated to the project team it is essential that each discipline create a strategy towards delivery of this information. The role of the information manager outlines that the role will involve the following in the way of checking and validating the information received by project participants and states that the Information Manager will:

- Receive information into the Information Model in compliance with agreed processes and procedures
- Validate compliance with information requirements and advise on noncompliance
- Maintain the Information Model to meet integrity and security standards in compliance with the employer's information requirements

2C. Management of Information Via a Common Data Environment

Managing the amount of information that will be transferred, translated and exchanged between all parties on a construction project is of critical importance in the BIM process. Information exchange is critical to a projects BIM success and therefore must be managed and monitored at all times on a building project. As we move into a digital space, more and more projects will require individual disciplines to appoint their own internal resource to manage this prior to any work being shared or used within the project. It is of critical importance that students are introduced to the basics of information management within a BIM Context and also understand how important the accuracy of this information is delivered.

The process as defined by the Publically Available Specification (PAS) 1192-2 states that all information be managed and shared via a common repository or a 'Common Data Environment' (CDE). A CDE will therefore act as the single source of information for a project and used to collect, manage and share all relevant project documents to all team members involved.

Individual information that is delivered and shared still remains the responsibility of the author delivering that information and the CDE will be managed by a specific project resource defined by the client. The CIC BIM Protocol proposes that an information manager, who is appointed by the client, should set up, manage and share any processes or procedures regarding the CDE with all project team members.

PAS1192-2 specifies that the information management for the project via a CDE may be used via an extranet, a project server or any file-based retrieval system. It proposes that the advantages of a CDE are as follows:

1. Ownership of information remains with the originator, although it is shared and reused; only the originator shall change it.
2. Shared information reduces the time and cost in producing coordinated information.
3. Any number of documents can be generated from different combinations of model files.

Information within a CDE can have a variety of status levels assigned to it. This is generally divided into four main areas of the CDE with a sign off process occurring for the information to then move from status to status.

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These areas include:

Work in Process. This area is used to hold information that is not yet approved for each organisation.
Shared. This is used to share information that has been checked, reviewed and approved and able to be shared with other organisations.
Published. This information will be that signed off by the client and or lead consultant (designer usually).
Archive. This area is used to record progress at critical project stages and any information that may have changed or been approved during the project.

2D. Security

Digital information is becoming more and more common within the Construction industry and it is important to understand where risks lie in terms of building projects within the UK or abroad. As a result and as part of the suite of documents that exist which support BIM Level 02 in the UK, the PAS 1192-5 Standard was created to ensure these issues are addressed. The document focuses on the threat and risk of digital information which includes but is not limited to:

1. Hostile Reconnaissance
2. Malicious Attacks
3. Loss or Disclosure of Intellectual Property
4. Loss or Disclosure of Commercially Sensitive Information
5. Release of Personally Identifiable Information
6. Aggregation of Data

Students should understand the overarching requirements of built assets when it comes to security and how roles will be assigned to those managing the asset.

Security strategies will need to be aligned to the particular project at hand and developing this information is critical to ensure there are no high level risks relating to the project. A strategy will need to be established and reviewed in line with the PAS1192-5 procedures and then measured against all new projects and threats that may become viable in the future. It is suggested that the themes relating to the protection of information and how this should be managed in construction be explained at education levels.

The BIM Task Group suggest that the PAS... *will assist organisations in identifying and implementing appropriate and proportionate measures to reduce the risk of loss or disclosure of information which could impact on the safety and security of:*

1. *Personnel and other occupants or users of the built asset and its services*
2. *The built asset itself*
3. *Asset information, and /or*
4. *The benefits the built asset exists to deliver*

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It explains the need for, and application of, trustworthiness and security controls throughout a built asset's lifecycle including:

1. Safety
2. Authenticity
3. Availability
4. Confidentiality
5. Integrity
6 Possession
7. Resilience
8. Utility

It is proposed that the area regarding security be achieved via a specialist standard as outlined in the standards via S 3.21: Security and a secure framework for managing digital information of a built asset.

2E. Soft Landings Principles

In principle it is to ensure that beyond practical completion the initial period of occupation should be analysed to ensure that the performance is satisfactory to the requirements of the users. Soft Landings goes beyond just occupation, it also includes building performance ensuring that upon use both environmental systems as well as energy can be monitored to align to further development and study.

The government construction strategy's objectives for soft landings (The Government Soft Landings Policy, September 2012, Government Property Unit, Cabinet Office) was to:

Align the interests of those who design and construct an asset with those who subsequently use it.

Students should understand that not only is the process of BIM relevant for design and construction but it is also relevant for design and construction for buildings in use.

The main benefits for the purpose of GSL (Government Soft Landings) in regard to BIM are as follows:

1. Provide a building that meets the end users need and required operational outcome.
2. Enable end user involvement at early stages and throughout the project.
3. BIM will enable early challenges involved in design that may affect ongoing maintenance and cost of operation.
4. To ensure that building performance is monitored up to 3 years post occupation and that there is a solution in place to remedy performance or use that is not achieved.
5. Use of the design and construction information and data to populate a Computer Aided Facilities Management Solution (CAFM

3. Technology Relating To BIM

The following section involves how varied technologies relating to BIM can influence the design, construction and management of built assets. The definitions, processes and technologies that support BIM are extensive and can be utilised across all stages of a project. The use of new technologies, smart materials and tagging of assets and information as buildings are used have become of critical importance within the BIM process and should be understood and communicated.

3A. Overview

There are a variety of processes involved in the delivery of a BIM project and the below explains the 'D' elements of BIM. These elements should be clearly outlined at all levels of the Regulated Qualification Framework.

2D relates to the 2-dimensional drawings generated from line-based software or from an object-based modelling software in a variety of file formats.

3D relates to the dimensional representation of a building and its components and objects. The 3D information can be used to convey design intent as well as visualisation and animation. It enables project stakeholders to be able to visualise the building very early in the design process.

4D relates to scheduling information or when an element will be built. With this information you can enable timely delivery of materials to site as well as accurately predict project construction time.

5D relates to the estimating and cost aspects of the building. Each element within the building model has a cost associated with it. This allows for detailed analysis to be undertaken regarding project budgets and Bills of Quantities. 5D BIM also allows the delivery team to create accurate predictions regarding how much need to be done at any given time in order to meet the construction targets.

6D refers to the Building Lifecycle Information and how the asset performs over the period of time during its lifecycle.

3B. BIM Uses

The use of technology is not limited to the production of a design model in 3D. It can be used on site to enhance the delivery of the asset, enhance health and safety, or used to apply logistical or programme information (4D) or cost data or quantity scheduling (5D). The holistic use of the data contained within the overall project information model will be described, reviewed, delivered, fed back and reused throughout the duration of the project allowing the completed asset to be intelligently managed during both its operational and recycle life period.

Technology is constantly evolving and as we move into the future this technology will support advanced workflow and management of data. The way we capture data and information on site and during construction will also become increasingly digital as mobile technologies are becoming more commonly used on building sites.

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The technology and processes can be divided into the following areas:

- **BIM Authoring** – The use of a particular software to create the digital 3-Dimensional models that can be used as part of the authoring process between disciplines, some examples of BIM Authoring software include Autodesk Revit, Graphisoft ArchiCAD and Trimble Tekla.
- **BIM Collaboration** – Collaboration can be achieved by the use of all authoring software discipline models and the process of 'federation' or bringing the models together in one system to check that the information does not clash or conflict between models. Some examples of collaboration software include Autodesk Navisworks, Autodesk BIM360 Glue Solibri Model Checker.
- **BIM Analysis** – Understanding how a building functions in terms of its orientation, choice of materials and overall form can be a complex task. The use of analysis tools can allow for more information to be understood in terms of the project sustainability and life. Examples of Analysis software include IES, Autodesk internal Environmental Tools.
- **BIM Data Collection** – Capturing information that includes not only 3D Geometry but information collated in spreadsheets or via Cobie can be a daunting task and there are solutions that exist that allow extraction of data from project models. These include the Autodesk Cobie toolkit, solibri model checker, and some CDE products such as 4projects that can collate and capture data and expel this data for use in Microsoft Excel or the like.
- **BIM Cost Analysis** – Extracting accurate cost data at all stages of a project has become critical in achieving accurate costings on building projects. It also allows for the Value Engineering exercise to be undertaken with greater ease due to the ability to extract data from a variety of BIM elements produced in an authoring application. Examples include, Autodesk Navisworks, QTO, BIM Measure and CostX.
- **BIM Timelining and Sequencing** – The ability to produce an accurate picture of the construction process from either detailed object based model data or early concept model data is becoming critical in the way we can now understand the build process. It also allows site management and space review prior to any work being undertaken on site. Examples include Autodesk Navisworks, Synchro.
- **BIM Visualisation** – Whilst we understand how buildings function in terms of spatial arrangements once built, it is also now possible to understand a space prior to construction via the use of visualisation tools and animation. Such tools include Autodesk 3DS Max, Navisworks and Revit, Graphisoft ArchiCAD.
- **BIM Parametric Design** – The ability to trial and test techniques within the design process via automated software is becoming more and more popular in the construction industry. By defining set rules, like floor to floor heights, structural integrity or solar gain the use of this type of software can automatically generate optimised solutions for building projects. Examples include Autodesk Dynamo, Rhionceros and Grasshopper.

3C. Smart Materials, Real Time Information And Analysis

As we move further into the future the reality of the construction industry is that it is changing at rapid speed and utilising and understanding these changes are of critical importance in construction education at all levels of the Regulated Qualifications Framework. The use of smart materials, analysis of information at real time

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and understanding these processes as part of future projects will allow us to create and build intelligently for the future. This is by no means exempt from RQF at levels 1-3 and therefore must be considered as part of future training and education needs.

Smart materials are defined as those materials that have properties that can be altered in a controlled fashion via external influences such as temperature, climate and stress. They have properties that can react and change according to their environment and therefore can potentially be changed by external conditions such as the temperature, light or condition. The process of these changes are being captured in the development of future smart materials which will likely move and reshape according to their external conditions. This includes the process of self-assembly which can be explored at length and currently part of many higher education courses. These types of materials and processes are becoming more commonly used in construction and will continue to do so as we move into the future.

Information can also be delivered via sensors, remote sources and digital devices that can report and feedback information to a building to ensure we are utilising natural processes such as natural heating and ventilation as much as possible. These types of process are now evolving at rapid speeds and the way in which this is developing will ultimately lead to our 'smart buildings' which will only require data based on the physical conditions around them.

3D. The Internet of Things and Big Data

The internet of things (IoT) and Big Data are two terms that are linked in the future of information storage, growth and the way it is utilised. The billions of internet connected things will generate massive amounts of data and this is why it is important to understand the differences and similarities between the two terms. The IoT is basically a network of things that are embedded within electronics, software and sensors to enable objects to exchange data with each other. This term was coined by a British Entrepreneur Kevin Ashton in 1999 and has grown at rapid speed since then. The IoT is expected to offer advanced connectivity of devices, systems and services that go beyond connection to each other. This connectivity will then provide data to a series of systems that will create massive amounts of information that can be used.

This area is very important in construction and asset management as we can begin to understand our built assets more intelligently, to be able to manage them and create new assets in the future that align to these needs. There are a variety of BIG Data that are aligned to BIM and these include:

1. Design Data, Models and Visualisations
2. Sensor Data
3. Logistic data including material equipment and inhabitant flow
4. Augmented reality devices that can connect to information about a BIM
5. Geospatial data, building regulations, terrain modelling and scan data

The information relating to the IoT world and BIG Data should be expressed clearly within education as it is inextricably relates to all areas of BIM and therefore all areas of construction.

4. Roles And Responsibilities

The following section discusses how the roles and responsibilities in relation to BIM will continue to evolve. BIM related job roles can be divided in to industry standard roles as well as BIML2 defined roles outlined in the standards above. Students will be introduced to the concepts of how standards are used and applied.

4A. Overview

As the landscape in construction changes, so do roles and responsibilities that will continue to evolve as we do. BIM is not exempt from this and the industry has seen a shift in the types of roles being created and continually evolving as part of the rise in BIM use and project requirements. These roles are not only aligned to best practice standards (as outlined in the Best Practice Standards area of this document) but also to the way our industry is becoming more and more specialised in skills required to achieve building and management excellence.

These roles in Construction have changed in their area of expertise and consist of standard defined roles and BIM related roles. These can be divided between all areas of a design, build and operate as listed below. Current trends that exist lead toward roles such as those defined below:

- **BIM Specialist** – An individual with specialist BIM Skills. These may include high level theoretical knowledge or technical skills. This role is typically an organisational role within a specific discipline.

- **BIM Manager**– Either a project specific or organisational role that includes strategic implementation with limited technical skill. This role can either be a client facing or organisational role.

- **BIM Consultant** – Typically an external resource to a client or a consultant that supports the BIM requirements on a project, delivers training and provides support on BIM implementation.

- **Parametric Designer** – Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response. These skills are purely technical and can be associated to a particular discipline.

- **BIM Coordinator** – Typically associated to the lead designer the BIM Coordinator reviews all discipline models and federates them to ensure there are no discrepancies and clashes between differing building elements such as Architecture vs Structure.

- **BIM Technician** – A technically capable team member who has detailed knowledge of BIM software associated to their roles. With the introduction of relevant BIM Standards as outlined in section 1 of this document, the following roles align themselves to recommended roles as part of the capital/delivery and operational phases of built assets:

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- **Project Information Manager (Pim)** – As outlined in the CIC 'Role of the Information Manager' including managing information on a project, data drops and the custodian of the Common Data Environment. This role is one appointed by the client and the role requirements are outlined in the document named above.

- **Digital Asset Manager** – Manages the digital information on the project including updating the Project Information Model with any changes to products, maintenance or information relevant to lifecycle use.

- **Task Team Information Manager (Tim)** – As Outlined PAS 1192-2:2013 this role includes that of a displine specific requirement managing information deliverables by their associated tasks, including format date and responsibilities.

- **Security Manager** – Devises a strategy towards managing security risks on a project. Develops the built Asset Security strategy and is appointed by the client as outlined in PAS 1192-5:2015

- **GSL Champion** – One who ensures that the Government soft landings process has been clearly defined at the early stages of a project and that all team members from conception to completion adhere to the user and client soft landings requirements for the built asset.

4B. BIM Learning Outcomes Overview

The BIM Level 2 training strategy recommended the development of a Learning Outcomes Framework that encouraged industry's procurement and delivery of training and education courses in order to grow a strong capacity and capability in the UK Market, underpinned by a consistent learning outcomes definition.

As the BIM Learning Outcomes Framework audience refers to higher education and sector skills as well as professional institutions the basis for this framework was used as guidance to the updating of this document at an early education level. The aim of the 2015 Learning Outcomes Framework was to upskill an industry ready for BIM level 02 but also to educate the next generation of industry professionals.

The subject areas that should be covered will be dependent on the facilitator yet, in reference to the RQF for levels 01 to 03, the framework provides a simple guidance to the education at this level. As an overview, BIM filters its way through the entire standards document and forms a basis at a very basic level. The basic principles covered in this document that refer to the BIM Learning Outcomes Framework include:

- The importance of collaboration in building construction and team management.
- How BIM supports the relationship between design, construction and asset management.
- Technologies and methods for creating and using and maintaining structured information.

5. Terms And Definitions

Building Information Modelling (BIM) The process of designing, constructing or operating a building or infrastructure asset using electronic objected orientated information.

Building Information Modelling (BIM) The process of designing, constructing or operating a building or infrastructure asset using electronic objected orientated information.

BIM Maturity Model Diagram outlining the levels of BIM maturity in regard to the ability of the construction supply chain to operate and exchange information on a building or infrastructure project.

Object Based Model 3D Based modelling focused on specific objects rather than generic entities. Object based modelling should be referenced at all times when creating 3D Model data.

Computer Aided Facilities Management (CAFM) Computer Aided Facilities management system and approach used to support the operation of a facility in a digital context.

Computer Aided Design (CAD) The use of computer aided design in the use of computer systems to aid in the creation of and modification and creation of a design.

Federated Model A series of individual discipline models that are brought together to coordinate various elements of a building project.

Non-Graphical Information not included in geometric creation of objects. Generally, data associated to object based model data.

COBie (Construction Operation Building Information Exchange) Structured information for the commissioning, operation and maintenance of a project often in a spreadsheet format used to supply data to the employer or operator to populate facilities management and asset management systems.

Client Individual or organisation responsible for the commissioning of a built project.

Common Data Environment Unique source of information for any given project used to collect, manage and disseminate all relevant approved documents in a managed process.

Employers Information Requirements Document setting out the requirements of the client that outline details toward information delivery and standards and processes to be adopted.

Hostile Reconnaissance Activity of acquiring information about a target with the view to planning to attack, compromise or destroy

Intellectual Property Ownership of a particular piece of information owned by a particular individual or organisation.

continued...

Big Data Large data sets used to analyse, store and transfer information for use in intelligent ways.

Internet of Things A network of things or physical objects embedded with software, sensors and network connectivity which enables these objects to collect and exchange data.

Built Asset A building, multiple buildings or infrastructure that is the subject of a construction project or where the asset information is held in a digital format.

Asset Information Data or information relating to the design, construction operation and maintenance of a built entity.

Project Information Model Information delivered and developed during the design and construction phase of a project.

Asset Information Model Maintained information model used to manage, maintain and operate an asset.

Model Term used to describe a 3D model.

Soft Landings Graduated handover of a built asset from the design and construction team to the operation and maintenance team.

Smart Application of autonomous or semi-autonomous technology systems to achieve greater utilization of resources.

Real Time Information Information delivered as it appears or is crated in real time to influence how a system or object functions and operates.

Information Management Policies, processes and procedures applied to inputting, processing and generating activities to ensure accuracy, authenticity and integrity of information.

Section C: Sustainable Building

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1. Introduction

This supplement explains the principles of sustainable building in terms that are useful for the development of content for standards, qualifications, apprenticeships and training courses.

The content has been adapted from the Sustainable Building Training Guide; originally created to support training providers in improving training courses and qualifications to encourage the construction industry to build sustainably, aiding the transition to an energy efficient and low carbon built environment. The Sustainable Building Training Guide was authored by the Green Construction Board working on behalf of the Construction Leadership Council and with the support of CITB

2. What is Sustainable Building

The principles of sustainable development are:

- Environmental Protection
- Economic Development
- Social Development

Sustainable (or ‘green’) building aims to embody these principles in the siting, design, building, maintenance, occupation and use of buildings.

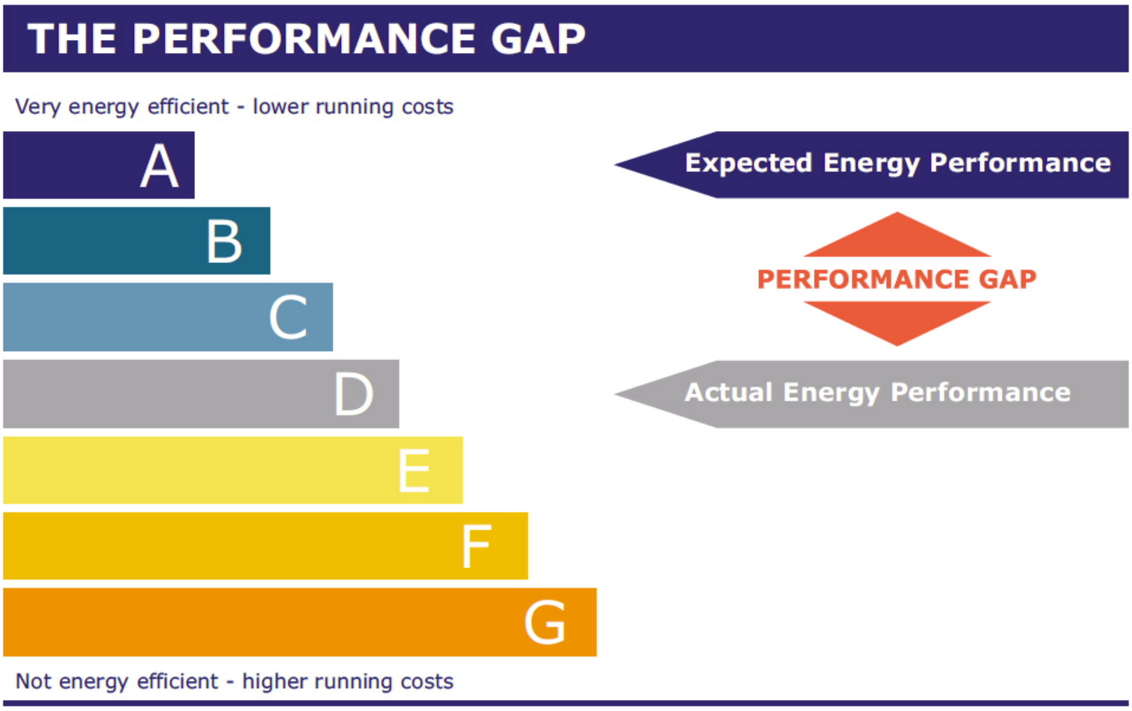
Sustainable buildings are designed and constructed to high environmental standards to minimise energy requirements, reduce water consumption, use materials which are resource efficient and of low environmental impact (e.g. low embodied energy or carbon), reduce wastage, conserve and enhance the natural environment, and safeguard human health and wellbeing.

The construction industry has a vital role to play in consistently designing, constructing and maintaining buildings that deliver these outcomes, providing healthy places for people to live and work.

3. Achieving Energy Efficiency

Buildings should work as an energy system, in which heat gains and losses are always in balance. The higher the loss from the building fabric, the more energy is needed to heat or cool it. Buildings lose heat through the external envelope in two ways: firstly, by a complex mix of conduction, convection and radiation through the materials and air spaces in the construction, and secondly via direct air leakage from inside to outside. This means that the design of the building envelope is critical.

Insulation layers and the associated detailing at junctions need to be designed and constructed with considerable care, based on a good understanding of the heat loss mechanisms involved. In addition, plant and equipment needs to be correctly sized, energy-efficient, and the whole services system designed, installed, commissioned and operated to achieve maximum overall efficiency.



4. Closing the Performance Gap

Recent research has revealed a huge gap between how much energy a building is designed or predicted to use, and its actual energy use, which is often much higher – in some cases as much as five times the designed or predicted energy consumption. Although some of this can be attributable to variations in use, which is difficult to predict, a large element is related to the technical underperformance of fabric and services due to design and construction failings. This is referred to as the 'performance gap', and one of the important contributors to the gap is a lack of understanding of energy efficiency within the built environment workforce. It is now common for building performance to be either measured during construction (e.g. airtightness tests) or after the building is complete, to identify how it performs while in use rather than just relying on a statement of the design intent.

5. Recommended Learning Outcomes for Sustainable Building

The following table comprise specific learning outcomes that can be used to embed the principles of sustainable building in standards, qualifications, apprenticeships, and training courses. They set out the key criteria for the sustainability knowledge and skills required in four different occupational areas:

- Construction trades
- Building services engineering trades
- Managers and supervisors
- Designers

Construction Trades	
Theme	**Learning outcomes**
Low energy / Low carbon building	Understand the role of your trade in achieving the required energy and carbon performance to minimise energy demand and associated costs over the life of the building. Understand the principles of airtightness and the requirements for effectively installing the air barrier (sealing at junctions and penetrations etc.) Understand the principles of effective insulation, including: • Insulation fitting and placement for different insulation types • Thermal bridging and condensation risks • Thermal bypassing Understand the impacts of your trade on the design and installation of efficient energy and ventilation services Understand the basic principles of air quality and ventilation. Understand the main causes of overheating and how to reduce it.
Sustainable products	Know and identify responsibly sourced products (FSC/PEFC and responsibly sourced materials, e.g. BES6001).
Waste, reuse and recycling	Understand the principles of materials storage, recycling and reuse opportunities, in order to minimise waste.
Water	Have a working knowledge of water efficiency on a construction site.
Whole build process	Know the sequence of works and the role of dependent trades in the build process.

Building Services Engineering Trades	
Theme	**Learning outcomes**
Low energy / Low carbon building	Understand the effect upon the building fabric of remedial or new installation work (e.g. installers should know the effects of walls and windows on heat loss, heating designers should be able to accurately calculate U-values). Understand ventilation and its effects on health, condensation, dampness etc.

Building Services Engineering Trades (continued)	
Theme	**Learning outcomes**
Low energy / Low carbon building	Understand the principles of renewable energy technologies systems installation, commissioning, handover and maintenance including heat pumps, solar thermal and PV, water harvesting/reuse and biomass systems. Understand how heating technologies, such as radiators and underfloor heating, and combustion and heat pumps can be integrated. Understand the effect that control systems (including weather compensation, thermostats, individual room control and internet-based controls) have on heating. Understand the difference between insulation types and how they are incorporated into the building fabric. Understand the main causes of overheating and how to reduce it. Understand basic life cycle costing (e.g. capital cost, energy consumption, energy costs, business case) for lighting and heating systems. Understand the principles of flexible HVAC and lighting systems in creating adaptable spaces.
Sustainable products	Know and identify responsibly sourced materials (FSC/PEFC and responsibly sourced products, e.g. BES6001).
Waste, reuse and recycling	Understand the principles of materials storage, recycling and reuse opportunities in order to minimise waste
Water	Have a working knowledge of water efficiency on a construction site. Communicate to customers appropriate resource-efficient water systems
Whole build process	Understand the role of dependent trades in the build process. Understand the main requirements and objectives of the commissioning process, as well as the various standards and how to meet them. Understand the importance of post-occupancy building performance evaluation.

Managers And Supervisors	
Theme	**Learning outcomes**
Low energy / Low carbon building	Be aware of policies, legislation, and regulation. Understand the key principles of energy performance measurement, and measurement protocols, methodologies and tools. Understand the key principles of passive and low energy design Understand the key principles of carbon and energy reduction in buildings and the application of life cycle costing to make better informed design decisions. Understand the principles of building physics in relation to energy and carbon performance. Understand the principal requirements of a range of common energy performance standards and have a working knowledge of how to achieve them. Understand the principal causes of the performance gap. Understand the key elements in the design and construction of an effective thermal fabric, including: • Insulation design and construction • Minimisation of thermal bridging and condensation risks • Minimisation of thermal bypassing • Air permeability and air barrier design and construction Understand the key principles of the design and construction of efficient energy services, including the impact of the whole system (e.g. pipework, flues and other components) on energy performance. Understand the impact of services commissioning on performance and be able to ensure they are effectively specified. Understand the key requirements for ventilation. Understand the key determinants of overheating and how it can be minimised.

Managers And Supervisors (continued)	
Theme	**Learning outcomes**
Sustainable products	Know how to procure and identify responsibly sourced materials (FSC/PEFC and responsibly sourced products e.g. BES6001) and healthy materials (e.g. low VOC products). Understand the principles of embodied carbon and other issues such as resource depletion, reuse and recycling potential waste. Understand the principles of the circular economy.
Waste, reuse and recycling	Be aware of policies, legislation, and regulation. Understand the principles of good waste management. Understand the value of resource efficiency and how to promote it. Understand the key principles of designing for waste minimisation, deconstruction, reuse, recycling and the circular economy.
Water	Understand best practice in water conservation and planning on-site water use.
Whole build process	Know the sequence of works, the role of dependent trades in the build process and their impact on the energy performance of buildings. Understand the principles of build process design to ensure effective building performance. Engage with end users and stakeholders where possible to promote the benefits of resource-efficient products and services. Work to outcomes rather than inputs – not 'how many' or 'how much' has gone into the building, but whether it will work well when it is operational. Understand post-occupancy building performance evaluation in establishing actual versus expected performance.

Designers	
Theme	**Learning outcomes**
Low energy / Low carbon building	Be aware of policies, legislation, and regulation. Understand the key principles of energy performance measurement and measurement protocols, methodologies and tools. Understand the key principles of passive and low energy design. Understand the key principles of carbon and energy reduction in buildings and the application of Life Cycle Costing to make better informed design decisions. Understand the principles of building physics in relation to energy and carbon performance. Understand the principal requirements of a range of common energy performance standards and a working knowledge of how to achieve them. Understand the principal causes of the performance gap. Understand the key elements in the design and construction of an effective thermal fabric, including: • Insulation design and construction • Minimisation of thermal bridging and condensation risks • Minimisation of thermal bypassing • Air permeability and air barrier design and construction Understand the key principles of the design and construction of efficient energy services, including the impact of the whole system (e.g. pipework, flues and other components) on energy performance. Understand the impact of services commissioning on performance and be able to ensure they are effectively specified. Understand the key requirements for ventilation. Understand the key determinants of overheating and how it can be minimised.

Designers (continued)	
Theme	**Learning outcomes**
Low energy / Low carbon building	Understand the key future maintenance requirements of the buildings assets and how these affect energy efficiency and the impact on the life-cycle costs of the building.
Sustainable products	Know how to specify responsibly sourced materials (FSC/PEFC and responsibly sourced products e.g. BES6001) and healthy materials (e.g. low VOC products). Understand the principles of embodied carbon and other issues such as resource depletion, reuse and recycling potential waste. Understand the principles of the circular economy.
Waste, reuse and recycling	Be aware of policies, legislation, and regulation. Understand the principles of good waste management. Understand the value of resource efficiency and how to promote it. Understand the key principles of designing for waste minimisation, deconstruction, reuse, recycling and the circular economy.
Water	Understand best practice in water conservation and planning water use on site.
Whole build process	Know the sequence of works, the role of dependent trades in the build process and their impact on the energy performance of buildings. Understand the principles of build process design in order to ensure effective building performance. Understand post-occupancy building performance evaluation in establishing actual versus expected performance.

6. Additional resources

www.constructionleadershipcouncil.co.uk

CIBSE Guide L: Sustainability

CIOB Education Framework

CITB Standards for 14 to 19 Education

SummitSkills' guides to sustainable energy

www.supplychainschool.co.uk

Zero Carbon Hub Builders' Book

Zero Carbon Hub Thermal Bridging Guide

Section D: Traditional and Heritage Building

1. Introduction:

A. Identify and describe the age, materials and construction methods of traditional (pre-1919) and historic buildings.

B. Understand and explain the legislation and official guidance relating to built heritage.

C. Understand and describe the heritage values and significance of traditional (pre-1919) and historic buildings and how they contribute to sustainable development

D. Explore, analyse and evaluate how the principles of conservation are applied in practice, including using traditional skills, materials and methods, minimum intervention, 'like for like' repairs and practices

E. Understand and describe the difference in performance characteristics between traditional and modern materials and construction methods, with particular reference to the energy performance of building parts and as whole buildings

F. Identify and describe the causes of common defects in traditional (pre-1919) and historic buildings, and the range of investigative and recording techniques used to understand building condition.

G. Understand the range of maintenance and repair operations, and explain the importance of these for maintaining traditional buildings.

H. Describe and evaluate the benefits, options and risks of energy-efficiency and retrofit measures, and of climate change adaptation and mitigation measures using a whole building approach.

Introduction

Working on our built heritage can involve a wide range of activities including conservation, alteration, extension, refurbishment, repair and maintenance, installation of services and energy-efficiency retrofit.

This Heritage Supplement can be used by teachers to support 14–19 learners through the standards. It explains some key terms and concepts, suggests learning activities and offers links to useful learning resources.

Built heritage incorporates both traditional and historic buildings. Traditional buildings are usually defined as those constructed before 1919 using solid wall construction methods and materials, including wood and stone. Construction changed rapidly after this time as new materials and faster methods of construction were introduced. This was prompted largely by the national programme of social house building that was introduced to tackle the acute shortage of homes after the First World War. Nevertheless, traditional buildings remain an important and much loved part of the built environment. There are few towns and villages that do not have traditional buildings at their heart, helping to create our sense of identity, quality of life and economic prosperity, through tourism for example. Many traditional buildings are also 'historic buildings' and protected through listing. Together, traditional and historic buildings are part of our historic environment, which also includes ancient monuments, historic parks and gardens, shipwrecks and battlefields.

The scale of the traditional building stock in the United Kingdom makes it a significant source of work in the construction industry. This means that it is important for learners to have the knowledge and understanding of how to care for traditional buildings.

- There are 6.5 million traditional (pre-1919) buildings in England, Scotland and Wales and a further 87, 500 in Northern Ireland.
- 20-30 per cent of buildings in the UK are traditionally constructed.
- Repair and maintenance (housing and non-housing) accounted for 35 per cent of the construction industry in the UK in 2016.

This creates numerous opportunities for heritage-trained construction workers. For more on careers in heritage construction, see the following webpages and videos:

- **GO CONTRUCT**, Construction Industry Training Board (CITB)
  https://www.goconstruct.org/construction-jobs/career-explorer/heritage-consultant/
- **Creative and Cultural Skills**
  https://ccskills.org.uk/careers/advice/job-profiles/heritage/?gclid=EAIaIQobChMIyOzf1fH62AIVr7ftCh3d8wduEAAYASAAEgIJO_D_BwE
- **Twyi Centre**
  https://www.youtube.com/watch?v=vDWKnySwwrU
- **Society for the Protection of Ancient Buildings (SPAB)**
  https://www.spab.org.uk/learning/careers-advice

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There are a number of excellent resources which can be used to help achieve the learning outcomes suggested in this annex, including:

Conservation Basics, Historic England, 2013 Conservation Basics reviews the history and evolution of building conservation in England, explaining the philosophical and legal frameworks that exist today. It covers the processes involved in caring for historic buildings, and gives advice on the practical application of current legislation and guidance. Topics covered include conservation planning, surveying and recording, assessment, and planning programmes of maintenance and repair (including specification and procurement).
https://historicengland.org.uk/images-books/publications/conservation-basics-conservation/

Conservation Principles for the Sustainable Management of the Historic Environment in Wales, Cadw, Welsh Assembly Government, 2011 Conservation Principles explains Cadw's conservation principles and how to apply them in a range of situations from routine management and maintenance to new work and alteration. It also explains how to assess the significance and heritage values of a historic building or site to inform decisions about its future
http://cadw.gov.wales/historicenvironment/conservation/conservationprinciples/?lang=en

Conservation Principles, Policies and Guidance, Historic England, 2008 The primary aim of Conservation Principles, Policies and Guidance is to support the quality of decision-making, with the ultimate objective of creating a management regime for all aspects of the historic environment that is clear and transparent in its purpose and sustainable in its application.
https://www.historicengland.org.uk/images-books/publications/conservation-principles-sustainable-management-historic-environment/

BS 7913:2013 Guide to the Conservation of Historic Buildings
This British Standard describes best practice in the management and treatment of historic buildings through all stages from initial assessment through to the completion of work.
https://shop.bsigroup.com/ProductDetail/?pid=000000000030248522

INFORM guides, Historic Environment Scotland The INFORM guides provide an excellent introduction to a range of traditional building materials and techniques.
https://www.engineshed.scot/publications/?curPage=1&publication_type=36

More detailed technical guides and case studies published by Historic Environment Scotland can be found here.
https://www.historicenvironment.scot/archives-and-research/publications/?publication_type=5&curPage=2

The SPAB Approach to the Conservation and Care of Old Buildings, Society for the Protection of Ancient Buildings (SPAB) The SPAB Approach aims to promote the value and good sense of caring for the fabric of old buildings. The SPAB takes a long-term view, urging that in our own actions we consider the legacy we will leave to future generations. https://www.spab.org.uk/campaigning/spab-approach

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Understanding Conservation, COTAC Understanding Conservation is an online educational resource for all involved in, or interested in, conservation of the historic environment. It will be particularly useful for more advanced learners. http://www.understandingconservation.org/

1 A. Recommended Learning Outcomes for Sustainable Building

Traditionally constructed buildings make up part of our built heritage and include nearly all buildings constructed before 1919. They are generally of solid wall (i.e. not cavity walls) or solid timber-frame construction.

The architectural period or style of a building (exterior and interior), its visual appearance and its form of construction are the most important ways to determine its age. But it is also important to remember that some buildings have more than one phase of construction. These phases reflect alterations to the original fabric, structure and services over a period of time. This means that a single building can include several different building styles and construction details. These changes may alter how the building performs in terms of its energy efficiency and ability to cope with moisture and extreme weather. It can also influence the type of repair and degree of maintenance that the building requires.

Examples of period architectural features (Adapted from Course Handbook 1: Energy Efficiency Retrofit of Traditional (pre-1919) Buildings, CITB, 2015)

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Medieval

Thick stone rubble or heavy timber-framed buildings with daub and wattle panels. Stone and earth floors. Thatch or stone-tiled roofs. Buildings typically of a local style and materials - vernacular.

Most houses had a simple rectangular plan. The hall or main living area was open to the roof, usually with two storeyed accommodation at either end.

© Copyright CITB

Pre-Georgian

Stone and timber-framed still the most common building materials, but some use of brickwork.

Thatch and stone-tile still common for roofs. Open halls still in use in the beginning of the period, but full upper storeys becoming common by its end. Multi-paned and casement windows. Interiors often have wood panelling, decorative plasterwork and stone hearth surrounds.
Decorative symbols of Tudor rose, thistle and fleurs de lys.
More symmetrical architecture, often around an 'E' or 'H' shaped plan.

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© Copyright Historic England

Georgian 1710s – 1830s
Stonework, including high-quality ashlar, or render where good stone not available. Brick also in widespread use.

Lower pitched roofs and use of slate becoming increasingly common. Windows vertical rather than horizontal, usually sash. Classical influence in form and detail, including elements such as classical columns in Corinthian, Ionic and Doric styles. Symmetry very important in elevations


© Crown copyright Cadw

Victorian and Edwardian 1830s – 1910s
Local stone still dominant, but brick also in widespread use. Slate the most common roofing material. Sash windows in general use.

Technological advances see the increasing use of innovative materials such as iron, glass and later concrete.

Patterned, encaustic floor tiles and stained or etched glass. Ornate marble, slate or cast-iron fireplaces, inset with patterned tiles. Gothic Revival influential with pointed arched door surrounds and windows, decorative use of contrasting materials, and irregular facades and plan forms.

The age of a building can be researched from many resources, including old maps, photographs and archives. If the building is listed, the list description is a good place to begin your research (see section B).

The building itself will hold evidence of its age in the materials used, design, methods of construction and architectural features, etc.

Materials and construction methods (Adapted from Course Handbook 1: Energy Efficiency Retrofit of Traditional (pre-1919) Buildings, CITB, 2015)


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Roofs
The design of roofs has evolved from heavy oak to thinner softwood timbers as new sources of material became available and construction techniques evolved. By the Victorian period, pre-cast iron trusses and steel had begun to be used in roof structures.

Often roof coverings in older buildings reflect the availability of local materials, including thatch, stone tiles, clay tiles and slate. They can also reflect local practices creating distinctive, but often subtle variations in detail.


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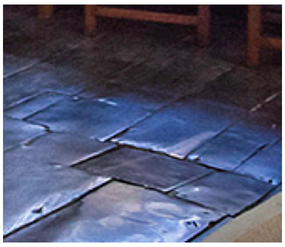
Walls

Mass masonry walls were built of brick or stone with lime or clay mortar. In some areas earth or cob were common. Up until the Victorian period it was common to cover walls with lime render or limewash for added protection.

Heavy timber-framed buildings had infill panels made of lime and mud-based daub applied onto thin wooden slats or a lattice of woven sticks, called wattle. Later, lime plaster was applied onto riven or sawn timber laths nailed to the timber framing. In some areas timber framing was clad with timber boards or clay tiles.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Floors

Solid floors were constructed from earth, concrete slab or stone slabs. In areas where gypsum was in plentiful supply, plaster was also used. Suspended timber floors usually rest on brick or stone piers and are built into the wall. Grilles in the exterior walls just below the level of a suspended floor provide ventilation and ensure that the floor remains dry and free of rot and insect attack.

Up until the Victorian period floorboards were generally irregular, hand-cut wide planks of oak or elm. They became narrower and more uniform in size as production was mechanised and softwood was introduced.


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Doors and windows

Doors and windows are critical in maintaining the character of a building and can help identify the period in which it was built. They were generally made of oak until the mid-eighteenth century after which painted softwood became popular. Casement windows were also made of cast or wrought iron, bronze or steel, sometimes with lead strips to hold the glass panes together.

Small-paned timber box sash windows were popular from the Georgian period. The panes of glass increased in size during the Victorian period as new methods of glass manufacture were developed.


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Chimneys

Chimneys can be constructed of many different types of materials and can vary from basic stone structures to very tall and ornate brick ones. They usually have projecting brick or stone courses at the top to help shed water and keep the stack dry.

Chimney pots were particularly popular from the Victorian period onwards. They were made of clay and mass produced using moulds to produce a wide variety of practical and decorative designs.

Suggested Learning Activities

Working as a group, explore the age, materials and construction of local buildings. An example of a local heritage study for younger school children gives ideas.
https://www.youtube.com/watch?v=4ejwNarbmWc

Study this timeline, which illustrates the history of domestic construction in the past 500 years. It includes key materials and architectural styles, and highlights what materials were used and when.
http://geoffrey-hunt.com/about.php

Find out more about how to research a building's history.
https://historicengland.org.uk/advice/your-home/your-homes-history/

Resources

England

The National Heritage List for England (NHLE) – is the only official, up-to-date, register of all nationally protected historic buildings and sites in England.
https://www.historicengland.org.uk/listing/the-list

Pastscape – is a quick and easy way to search over 420,000 records held in the National Record of the Historic Environment (NRHE).
http://www.pastscape.org.uk/

Heritage Gateway – allows you to cross-search over 60 resources, offering local and national information relating to England's heritage.
http://www.heritagegateway.org.uk/gateway/default.aspx

Wales

Archwilio – provides online public access to the historic environment records for each local authority area in Wales. Archwilio is maintained and supported with further information held by the Welsh archaeological trusts.
www.archwilio.org.uk

Cof Cymru – is Cadw's online record of the national historic assets of Wales, which includes listed buildings, scheduled monuments, protected wrecks, World Heritage Sites and registered historic landscapes.
http://cadw.gov.wales/historicenvironment/recordsv1/cof-cymru/?lang=en

Coflein – is the online catalogue for the National Monuments Record of Wales (NMRW), the national collection of information about the historic environment of Wales.
http://www.coflein.gov.uk/

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Scotland

Heritage Portal – allows you to search, browse and view decisions and designation records, download spatial datasets or use the map search.
https://www.historicenvironment.scot/advice-and-support/listing-scheduling-and-designations/listed-buildings/search-for-a-listed-building/

Canmore – is the online catalogue of the National Record of the Historic Environment. It holds detailed information and archive images for more than 300,000 places in Scotland.
https://www.historicenvironment.scot/archives-and-research/archives-and-collections/canmore-database/

Pastmap – allows you to find out more about the heritage in your local area.
https://www.pastmap.org.uk/

Northern Ireland

Historic Environment Map Viewer – allows you to view the location of built heritage sites.
https://www.communities-ni.gov.uk/services/historic-environment-map-viewer

Northern Ireland Sites and Monuments Record (NISMR) – this holds information on over 16,000 archaeological sites and historic monuments.
https://www.communities-ni.gov.uk/services/sites-and-monuments-record

Buildings Database – contains records of buildings in Northern Ireland that have been surveyed by the Department of Communities.
https://www.communities-ni.gov.uk/services/buildings-database

General

The Brooking National Collection of Architectural Detail – charts the evolution of Britain's buildings' constructional elements, such as windows and staircases, over the last 500 years.
http://thebrookingcollection.org/index.html

1 B. Understand and explain the legislation and official guidance relating to built heritage

'99% of people in England live within a mile of a listed building or place.' Historic England

Our built heritage is an irreplaceable resource. It is part of the wider historic environment which has been created as a result of the interaction between people and places through time. This includes all surviving physical remains of past human activity both above and below ground or under the sea, as well as deliberately planted or managed landscapes.

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When changes are proposed that will affect the historic environment, the planning system sets out a clear framework of legislation and guidance for decision-making. This helps to ensure that all aspects of the historic environment, including historic buildings, scheduled monuments, archaeology, conservation areas and designed landscapes, etc., are conserved and, where appropriate, enhanced in a manner that is consistent with its significance (see section C).

Listed Buildings

The extensive damage caused by bombing during the Second World War prompted the government to introduce a system of protection for buildings based on their architectural quality. This involved creating a list of buildings, which is why legally protected buildings are called listed buildings.

Today, a listed building is a building or structure that is considered to be of special architectural or historic interest and included on a statutory list. The term 'listed building' is wide ranging and includes not only buildings such as houses, churches or barns, but also walls, milestones, bridges, telephone boxes and many other types of structure. There is even a 5 tonne lump of coal at Tredegar amongst the 30,000 listed buildings in Wales. It is said to be the largest block of coal ever cut and is listed for its significance as a unique monument to the coal industry in south Wales and to the skill of the miners.

There are three main criteria used in deciding which buildings to list:

a. Architectural Interest: this includes all buildings which are of importance for their architectural design, decoration and craftsmanship; also important examples of particular building types and techniques (for example, buildings displaying technological innovation) and significant plan forms.
b. Historic Interest: this includes buildings that illustrate important aspects of the nation's social, economic, cultural, or military history. This might also include close historical associations with people or events of importance to the nation.
c. Group Value: especially where buildings show an architectural or historic unity or are fine examples of planning (for example, squares, terraces or model villages).

Age and rarity are also important. For example, all buildings built before 1700 which survive in anything like their original condition are listed, whereas buildings which are less than 30 years old are normally listed only if they are of exceptional quality and under threat.

Listed Building Consent

Listed building consent must be obtained from the local planning authority before starting any works to alter, extend or demolish a listed building in a way that affects its character as a building of special architectural or historic interest. Common works requiring Listed Building Consent might include replacement of windows or doors, knocking down internal walls or changing roof coverings.

Learners should be made aware that it is good practice to talk to the local planning authority's built heritage Conservation Officer at the beginning of any project. Carrying out unauthorised works to a listed building is a criminal offence and owners and their professional advisors and contractors may be prosecuted. A local planning authority can insist that all unauthorised work is reversed.

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Listed buildings are graded in slightly different ways across the UK – Grades I, II* and II in England and Wales; A, B and C in Scotland, and A, B+, B1 and B2 in Northern Ireland. However, in each case the whole building or structure is listed, both its interior and exterior. Boundary walls and other structures within the 'curtilage' or area surrounding the listed building may also be included. There is no such thing as a 'listed facade' or a 'listed interior', and even modern elements of a building added at later times are included. It should also be assumed that fixtures and fittings, such as statues or fireplaces, are protected. If in doubt, advice should be sought from the local planning authority's built heritage Conservation Officer

Other Consents

Other types of planning or heritage consent may be needed before work is undertaken; the most common are:

Planning Permission: This is needed for works that fall within the definition of development, such as the construction of new buildings and the alteration or extension of existing ones. Maintenance and repairs that would not materially affect the external appearance of a building do not normally require planning permission.

'Permitted development rights' allow certain building works, such as the construction of small-scale extensions, to be carried out without having to apply for planning permission, subject to conditions and limitations. The local planning authority will be able to provide advice.

Scheduled Monument Consent: The monuments included on the schedule are of national importance and cover a diverse range of archaeological sites from earthworks that are thousands of years old to nineteenth-century industrial buildings and Second World War military installations. Scheduled monument consent is needed for any works that would have the effect of demolishing, destroying, damaging, removing, repairing, altering, adding to, flooding, or covering up a scheduled monument. Scheduled monument consent takes precedence if the monument is listed as well as scheduled.

Applications are considered by the relevant home nation heritage body – Historic England, Cadw, Historic Environment Scotland or the Department for Communities in Northern Ireland. These organisations are also able to offer pre-application advice.

Conservation Area Consent: Conservation areas are areas of special architectural or historic interest whose character and appearance deserve to be protected. They range from historic town and village centres to stretches of canal. Conservation area consent is needed for the total or substantial demolition of an unlisted building within a conservation area, although there are some exemptions. Applications are determined by the local planning authority, which is also a good source of advice.

Conservation area consent has been merged with planning permission in England.

Ecclesiastical Exemption: Some religious groups or denominations are exempt from the need to apply for listed building consent for places of worship. These groups have their own advisory and decision-

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making bodies which provide the same standard of protection as the secular system operated by local planning authorities.

Suggested Learning Activities

Select the guidance below for your area to learn more about the listing process and what consents you might need when making changes, such as adding an extension or updating your windows:

A Guide for Owners of Listed Buildings, Historic England, 2016
https://historicengland.org.uk/images-books/publications/guide-for-owners-of-listed-buildings/

Managing Change to Listed Buildings in Wales, Cadw, 2017
http://cadw.gov.wales/docs/cadw/publications/historicenvironment/20170531Managing%20Change%20to%20Listed%20Buildings%20in%20Wales%2024303%20EN.pdf

Listed Building Consent Process, Historic Environment Scotland
https://www.historicenvironment.scot/advice-and-support/applying-for-consents/listed-building-consent-and-conservation-area-consent/listed-building-consent-process/

Buildings Advice and Guidance, Department for Communities
https://www.communities-ni.gov.uk/articles/buildings-advice-and-maintenance

Get involved by listing your local war memorial in England by using these teacher's resources:
https://historicengland.org.uk/whats-new/news/school-children-help-list-bristol-war-memorial
https://www.youtube.com/watch?v=4ejwNarbmWc

Become a contributor by Enriching the List, share your knowledge and pictures of listed places with Historic England to help record important facts, and even unlock the secrets of some places.
https://historicengland.org.uk/listing/enrich-the-list/

Resources

More information about the range of legislation and official guidance:

Historic England htps://www.historicengland.org.uk/advice/planning/consents/lbc/

Cadw http://cadw.gov.wales/historicenvironment/publications/newpublications/?lang=en

Historic Environment Scotland https://www.historicenvironment.scot/advice-and-support/listing-scheduling-and-designations/

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Department for Communities https://www.communities-ni.gov.uk/articles/buildings-advice-and-maintenance

1 C. Understand and explain the legislation and official guidance relating to built heritage

'Sustainable development is about improving the way that we can achieve our economic, social, environmental and cultural well-being.' Welsh Government

Heritage Values

The 'significance' of a traditional or historic building comes from four different heritage values. A building may possess one or more of these values and in different amounts. To help us understand what is important about the building, we have to assess its heritage values and the strength of them in comparison to other buildings. The heritage values are:

a. **Evidential Value:** This comes from those parts of a building that provide evidence about its construction and subsequent use and alteration. These elements may be easy to see or they may be hidden below ground or beneath later fabric. They reveal when and how the building was constructed and how it has changed over time. Additional evidence may be gained from archives or museum collections. Written reports or surveys of the building, old maps and photographs can be particularly helpful.
b. **Historical Value:** A building might illustrate a particular aspect of past life or be associated with a notable family, person, event or movement. It illustrates broader historical themes, such as the way society was organised, developments in agriculture and industry, or the influence of political and religious movements.
c. **Aesthetic Value:** This relates to the appearance and form of the building and its relationship with its surroundings or 'setting'. It may be the result of conscious design and style or use of local building traditions. The method of construction, materials, finish and detail, as well as the quality of craftsmanship can be important considerations. It can also include the setting and views to and from the building, which may have changed over time.
d. **Communal Value:** This comes from the meaning that a building has for people. This includes social and economic value, as well as commemorative, spiritual or symbolic value.

To identify the heritage values of a building, we must first understand its history, fabric and character.

Questions to consider might include:

- Who values the place, and why?
- How do those values (for example, usefulness, importance, serving a purpose or creating an effect) relate to the building fabric?
- What is the relative importance of these different values to the community?

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- Do associated objects, such as paintings or furniture, contribute to those values?
- What does the setting and context (for example, the garden, street or wider landscape) add to the place?
- How does the place compare with others sharing similar values?

Significance

This assessment process will help to establish the relative importance of the different values, the qualities of the building that people value and how they might be vulnerable to harm or loss. The results, particularly for buildings that are listed, scheduled or in a conservation area, should then be captured in a written statement of significance. This will help establish priorities for reconciling or balancing potentially conflicting interests and inform decisions about change.

Sustainable Development and Management

Conservation is an active process of maintenance and managing change. In the case of buildings, the risks of neglect and decay are usually best addressed by keeping the buildings in a use that is consistent with their conservation. Keeping such buildings in use and valued is likely to require sympathetic changes to be made from time to time. Understanding the heritage values and significance of traditional and historic buildings is the first step towards their sustainable management or development.

There are strong arguments for retaining traditional buildings, not least because their replacement has significant energy, carbon and financial cost implications. The durable materials used in many traditional buildings can also reduce the frequency of refurbishment, requiring less energy and carbon in the long term.

Effective conservation also delivers wider social, economic and environmental benefits. The repair, maintenance, reuse and adaptation of redundant buildings, for example, can revitalise and enhance town centres, bringing social and environmental benefits to the community, as well as economic growth and job creation through increased trade and tourism. However, change must be carefully managed to ensure that the significance of traditional and historic buildings, and their special qualities, are protected and enhanced so that they can be enjoyed and understood by present and future generations.

Suggested Learning Activities

Try the e-learning module on understanding heritage value.
http://ehhelm.articulate-online.com/p/2877919194/DocumentViewRouter.ashx?Cust=28779&DocumentID=c78b6870-1f3c-43c9-a5b1-c5c605372118&Popped=True&v=4&InitialPage=story.html

Use Cadw's best-practice guidance, Heritage Impact Assessment in Wales, to draft a statement of significance for a building of your choice such as your home, school or college. http://cadw.gov.wales/docs/cadw/publications/historicenvironment/20170531Heritage%20Impact%20Assessment%20in%20Wales%2026917%20EN.pdf

Resources

These publications explain how to assess the significance and heritage values of historic buildings and historic areas:

Conservation Principles for the Sustainable Management of the Historic Environment in Wales, Cadw, Welsh Assembly Government, 2011
http://cadw.gov.wales/historicenvironment/conservation/conservationprinciples/?lang=en

Conservation Principles, Policies and Guidance, Historic England, 2008
https://www.historicengland.org.uk/images-books/publications/conservation-principles-sustainable-management-historic-environment/

1 D. Explore, analyse and evaluate how the principles of conservation are applied in practice, including using traditional skills, materials and methods, minimum intervention, 'like for like' repairs and practices.

'Conservation is the process of managing change to any significant place in its setting, in ways that will best sustain its heritage values, whilst recognising opportunities to reveal or reinforce those values for present and future generations.' Historic England

Conservation management plans
For complex or important historic buildings it is good practice to produce a 'conservation management plan' or 'conservation plan.' This is a tool that will help those responsible for the building or site to make decisions about its future use, development and care. The objective of the plan is to:

- Identify what is important about the building and why, using the statement of significance discussed in section C
- Set out the principles of conservation and policies that will be used to conserve or manage those aspects of the building which contribute to its significance

These conservation policies might state, for example, that damage caused by the installation of new services should be kept to a minimum. One practical action to help achieve this might be to reuse existing cable routes rather than cutting new routes through structural timbers or decorative plasterwork.

The conservation management plan will be useful for the day-to-day management of the building as it can help to prioritise work and financial resources where they are most needed. It will also help to guide the development of any proposals for change, such as alterations or a change of use.

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Putting the Principles of Conservation into Practice

Before making any changes to a traditional or historic building it is important to think about the following questions:

- What are you trying to achieve and why?
- What are the heritage values and significance of the building?
- What changes or alterations are proposed or necessary?

Other factors to consider include the following:

Authenticity	Characteristics that most truthfully reflect and embody the cultural heritage values of a place.
Integrity	Wholeness, honesty.
'Like for like' repair	Repair using original, identical or matching materials.
Minimum intervention	The most appropriate works are those that entail minimum change to materials and character.
Restoration	To return a place to a known earlier state on the basis of compelling evidence, without conjecture.
Retreatablity	Using materials and techniques that do not produce permanent negative consequences that could restrict future works.
Reversibility	Capable of being undone without any significant damage or harm to the original fabric.

It is also important to think about:

- What impact will the proposals have on the evidential, historical, aesthetic and communal values of the building?
- Are there other risks, such as increased maintenance and management liabilities or compromised performance through use of incompatible materials?
- Why have you chosen this particular option rather than others? For example, could a proposed extension be repositioned to be less disruptive to the original design, or could a feature be repaired rather than being replaced?

Heritage Impact Statements

This analysis, or 'heritage impact assessment', will help you to develop your proposals and identify the approach that will bring the greatest benefit and cause the least harm to the building. For alterations requiring listed building consent, scheduled monument consent or conservation area consent, the results of this analysis should be recorded in a 'heritage impact statement' to help explain and justify the proposals.

Suggested Learning Activities

Learn more about the tools that are used in planning conservation works, including conservation management plans.
https://historicengland.org.uk/advice/technical-advice/parks-gardens-and-landscapes/maintenance-repair-and-conservation-management-plans-for-historic-parks-and-gardens/

Explore how conservation principles are applied in practice using case studies from Historic Environment Scotland.
https://www.historicenvironment.scot/archives-and-research/publications/?q=case+study%20

Using the statement of significance that you prepared in section C and the Cadw best-practice guidance Heritage Impact Assessment in Wales, draft a heritage impact statement for a proposed plan of building works to the building of your choice.
http://cadw.gov.wales/docs/cadw/publications/historicenvironment/20170531Heritage%20Impact%20Assessment%20in%20Wales%2026917%20EN.pdf

Resources

Conservation Plans: A Guide to the Preparation of Conservation Plans, Historic Environment Scotland, 2000
https://www.historicenvironment.scot/media/2786/conservation-plans.pdf

Conservation Plan Guidance, Heritage Lottery Fund, 2012
https://www.hlf.org.uk/conservation-plan-guidance

1 E. Understand and describe the difference in performance characteristics between traditional and modern materials and construction methods, with particular reference to the energy performance of building parts and as whole buildings.

> **'Traditional buildings perform differently in some respects from modern buildings, both in their existing state and when subjected to retrofit measures.'**
> Sustainable Traditional Buildings Alliance

Traditional Materials and Construction Methods
Most traditional buildings are made of permeable materials that do not incorporate barriers to external moisture. This creates a 'breathable' form of construction. As a result, the permeable fabric tends to absorb moisture which is then released by internal and external evaporation

When traditional buildings are working as they were designed to and sufficient ventilation is provided, the evaporation will keep dampness levels in the building fabric below the levels at which decay can start.

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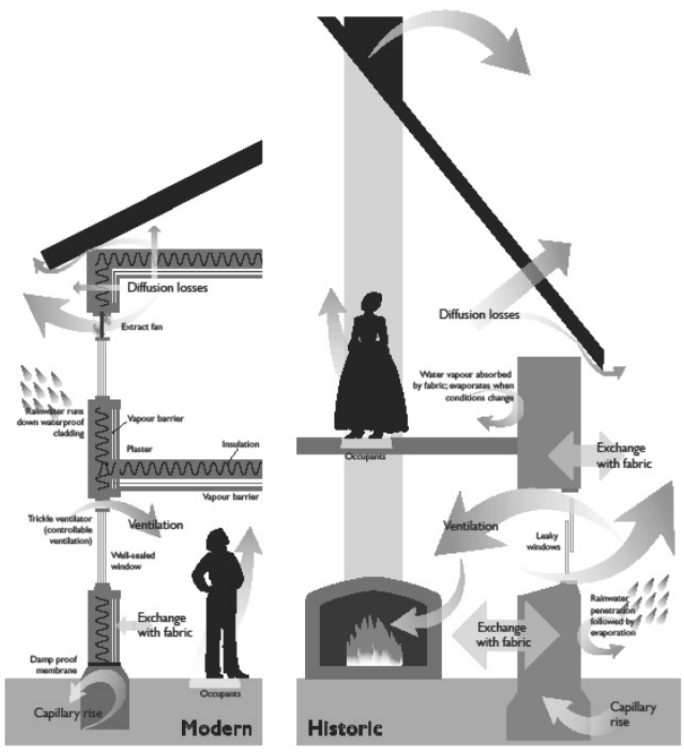
to develop. Lime and/or earth-based mortars, renders, plasters and limewash are particularly important for this as they act as buffers for environmental moisture, absorbing it from the air when humidity is high (after a shower or cooking, for example) and releasing it when the air is dry. They also have a wicking effect, drawing moisture and soluble salts away from more vulnerable building materials, including wood

The use of lime as a binder in mortars was gradually replaced by Ordinary Portland Cement (OPC) from the mid-nineteenth century. However, lime has many advantages, even in new construction:

- It is flexible and can tolerate movement well, unlike cement, which is hard and brittle. Cement is prone to forming hairline cracks which allow moisture to get in. By contrast, lime mortars are 'self-healing' and small cracks will repair themselves in time.
- Lime mortars are soft and will not wear away the edges of the stone or brick that they are binding together
- It is an easy material to use
- It produces an attractive finish, particularly limewash, with its soft appearance and subtle variations in colour
- The manufacturing process that burns natural limestone, chalk or sea shells to produce quicklime produces less carbon dioxide than cement. Carbon dioxide is also reabsorbed over time as the lime mortar carbonates.

The drawing to the right shows the differences in air and moisture movement between traditional and modern buildings.



Modern Materials and Construction Methods
Modern buildings are constructed using impermeable materials and incorporate barriers to external moisture, such as cavities, rain-screens, damp-proof courses, vapour barriers and membranes. Modern construction also often relies on mechanical extraction to remove water vapour formed by the activities of occupants.

Taking the Right Approach
As traditional buildings need to 'breathe' the use of vapour barriers and other impermeable materials commonly found in modern buildings must be avoided when undertaking repairs or making alterations. These materials can trap and hold moisture, hasten decay and reduce the temperature of walls, thereby encouraging condensation and mould growth. The use of modern, impermeable materials, if essential, needs to be based upon an informed analysis of the likely risks to the building fabric. This 'whole building approach' is described in section H below.

It is also essential that buildings are well maintained, otherwise improvements made in energy efficiency, for example, will be cancelled out by the problems associated with water ingress and/or excessive draughts.

Suggested Learning Activities

Study the INFORM guides published by Historic Environment Scotland to learn more about traditional building materials:
https://www.engineshed.scot/publications/?curPage=1&publication_type=36

Resources

SPAB Briefings, Society for the Protection of Ancient Buildings:
https://www.spab.org.uk/advice/spab-briefings

SPAB answers some commonly asked questions about building materials and construction methods here:
https://www.spab.org.uk/advice/search-our-knowledgebase?keywords=&category_type=139

1 F. Identify and describe the causes of common defects in traditional (pre-1919) and historic buildings, and the range of investigative and recording techniques used to understand building condition

> **'In order to be effective, any maintenance or repair work needs to address the underlying causes of the problem and not just treat the symptoms.'** Historic England

Moisture
Moisture and its effects are perhaps the single biggest cause of decay in traditional materials. It can lead to problems with damp, mould growth, and attack by woodworm and fungi. Nevertheless, damp issues are often wrongly diagnosed and treated.

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Moisture and its effects are perhaps the single biggest cause of decay in traditional materials. It can lead to problems with damp, mould growth, and attack by woodworm and fungi. Nevertheless, damp issues are often wrongly diagnosed and treated.

The four principal sources of moisture that can affect traditional buildings are:

a. Rain: Most traditional buildings are capable of resisting rain effectively if they are kept in good condition. But water can get into the building fabric through cracked or missing roof tiles, broken panes of glass, failed lead flashings, etc. It is important to retain traditional features, such as storm porches and projecting string courses as these help to shed water away from the building. In very exposed locations slate hanging was sometimes used to give additional protection from driving rain.
b. Rising and penetrating damp: Problems tend to occur where external ground levels are higher than the level of the internal floor structure or damp-proof course. This means that the damp-proof course, if there is one, is bridged and can no longer work effectively. Timber-suspended ground floors remain constantly damp and can begin to rot. Damaged mortar joints or render, or use of impermeable modern materials, such as concrete floors or damp-proof membranes, can also encourage rising or penetrating damp.
c. Internal moisture vapour: Activities including breathing, washing and cooking generate a lot of moisture in the air. This moisture condenses on contact with cold surfaces, such as windows and walls. If the building is well-maintained and there is enough ventilation the condensation will evaporate quickly. If not, condensation can encourage the growth of moulds.
d. Damaged drainage systems: Water from damaged or blocked drains, gullies, gutters and downpipes can create serious damp problems if not tackled early.

Structural movement

Structural movement is a potential defect. Most old buildings move to some degree during their life, but this movement may not be a problem. Cracks do not necessarily need to be a cause for concern. Most traditional buildings can tolerate a degree of movement without any serious problems. Movement can be seasonal, dictated by temperature changes. It could also be historic — that is, there is evidence of past movement, but there is no movement now. However, if the movement is ongoing or it threatens the use or safety of the building advice should be sought from a structural engineer with experience of traditional buildings.

Investigative and recording techniques

The amount and type of information captured during a survey can vary from building to building depending on the nature of the building and the reason why the survey is being undertaken. It can be as simple as a basic visual record of what is found or a comprehensive analytical record that draws on a range of resources and investigative techniques. However, the starting point of any survey involves looking closely at the building and the area around it to see what clues can be found. For example, is there staining or moss growth behind a downpipe that might suggest a leak?

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Increasingly, drones are being used to help survey and record as they are able to get close to otherwise inaccessible parts of the building, such as chimneys and roofs. Other investigative techniques are listed below.

Archaeological investigation: This intrusive method of investigation is sometimes used to reveal buried features in or around the building. Excavation of a floor, for example, may reveal the footings of earlier walls that have been removed.

Dendrochronology: Also known as 'tree ring dating', this technique involves removing a small cross-section of wood from timbers. The pattern of growth rings in the sample is then compared with those of trees of a known age to give the date at which the timber was felled.

Keyhole investigation: This is a non-destructive method that allows the condition of hidden timbers and other features to be investigated. Borescopes, for example, consist of a thin tube with an eyepiece at one end and a lens at the other. The tube is carefully pushed into crevices to examine the material beneath.

Opening up: This is a more destructive technique as it involves the removal of small areas of the building material. It can be useful where there is an underlying problem, the cause of which is not apparent from the surface.

Paint analysis: This involves microscopic examination of paint layers and other finishes. It is used to reveal past colour schemes and identify the materials used.

Monitoring: Monitoring a building over a period of time will help to establish if a problem is getting worse and, if so, how quickly. 'Tell-tales' for example can be used to measure the width of cracks over time.

Remote sensing: A variety of remote sensing techniques are available that allow you to 'look through' the surface material. Examples include ultrasound, radar and thermography. Care is needed when using moisture metres as the results can be unpredictable and difficult to interpret.

The results of these investigations should be recorded. This may include a written description and analysis of any problems found and/or measured survey drawings, sketches and photos. Building Information Models (BIM) can be a useful way of recording traditional and historic buildings.

Suggested Learning Activities

Working in a group, use the teacher's resources to undertake a condition survey.
https://historicengland.org.uk/services-skills/education/teaching-activities/doing-a-condition-survey-with-your-class-guidance-for-teachers

Resources

Maintaining your Home: Short guide 9, Historic Environment Scotland, 2014
https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=9b3ca2e8-afcc-42ba-92c3-a59100fde12b

Understanding Decay in an Older Home, Historic England
https://historicengland.org.uk/advice/your-home/looking-after-your-home/repair/decay/

There is more information on common building defects on the SPAB website.
https://www.spab.org.uk/advice/search-our-knowledgebase?keywords=&category_type=73

More information about the techniques used to investigate and record buildings, including 3D laser scanning and developing a Historic Building Information Model (HBIM) will be found here.
https://www.historicengland.org.uk/advice/technical-advice/recording-heritage/

Understanding Historic Buildings: A Guide to Good Recording Practice, Historic England, 2016
https://content.historicengland.org.uk/images-books/publications/understanding-historic-buildings/heag099-understanding-historic-buildings.pdf/

1 G. Understand the range of maintenance and repair operations, and explain the importance of these for maintaining traditional buildings

> **'Maintenance is the continuous care of a historic building and is the most common and important activity in their conservation and preservation.'**
> BS 7913:2013 Guide to the Conservation of Historic Buildings

Any maintenance or repair work needs to address the underlying causes of the problem and not just treat the symptoms. There are a range of surveys that professionals can deliver, including building surveys and structural surveys.

Maintenance

Maintenance is 'routine work necessary to keep the fabric (and services) of a place in good order'. The main objective is to limit deterioration. Inspections carried out at regular intervals, coupled with prompt action to pre-empt or remedy problems, are the basis of effective maintenance. Although it is often seen as mundane, maintenance forms a cornerstone of building conservation.

Key steps to plan effective maintenance are:

- draw up a maintenance plan and checklist to help identify any issues that will need attention
- use the checklist when carrying out inspections, which can be:
  - **Periodic / cyclical:** These take place at planned intervals — monthly, annually or even every four to five years depending on the nature of the building.

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– **Occasional / reactive:** These are carried out following severe weather or unforeseen events and need to concentrate on those parts of a building where water could get in easily, such as parapet gutters.

- **keep a log book** to record when each maintenance check is done and what was found. It can also be used to record what repairs (if any) need doing, when they were done, and by whom.

Repair
Repair can be defined as 'work beyond the scope of maintenance, to remedy defects caused by decay, damage or use. This might include minor adaptation to improve drainage, for example, but will not involve alteration or restoration.' Repair is normally carried out to sustain the significance of the building or place.

Benefits of maintenance and repair
Maintenance and repair is:

- cost-effective. Small problems can soon escalate and even risk permanently damaging a building if they are not tackled when they are first spotted. Ignoring them can prove costly at a later date and will often require more expensive repairs.
- it helps protect the value of the building
- it helps to ensure the health and safety of building users and the general public
- important for sustainability as keeping the building in use is the best way to safeguard its future
- good for energy efficiency as damp building elements are less thermally efficient than dry ones.

Maintenance and repair, where necessary, should always be carried before any energy-efficiency upgrade works are undertaken. The addition of insulation to a poorly maintained and damp building could make these problems worse and fail to improve the energy efficiency.

Suggested Learning Activities

Use the typical maintenance checklist to draw up a plan for a local building.
https://historicengland.org.uk/advice/your-home/looking-after-your-home/maintenance/maintenance-checklist/

Find out more about installing, replacing or upgrading building services, such as gas or heating pipes and electrical wiring, without causing any permanent damage to the historic fabric.
https://historicengland.org.uk/advice/your-home/making-changes-your-property/types-of-work/installing-services/

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Resources

Maintaining Your Home: Short guide 9, Historic Environment Scotland, 2014
Provides more on the range of maintenance and repair operations.
https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=9b3ca2e8-afcc-42ba-92c3-a59100fde12b

For more detail on the range of maintenance operations see the SPAB and Historic Environment Scotland websites.
https://www.spab.org.uk/advice/search-our-knowledgebase?keywords=&category_type=154
https://www.spab.org.uk/advice/rainwater-fittings
https://www.engineshed.scot/building-advice/

The Department for Communities website provides a simple maintenance checklist.
https://www.communities-ni.gov.uk/articles/buildings-advice-and-maintenance

Find out more about repairs operations such as:

Structural movement -
https://historicengland.org.uk/advice/your-home/looking-after-your-home/repair/structural-movement/

Traditional windows -
https://historicengland.org.uk/images-books/publications/traditional-windows-care-repair-upgrading/

Repointing brick and stone walls -
https://historicengland.org.uk/images-books/publications/repointing-brick-and-stone-walls/

Repairing roofs -
https://historicengland.org.uk/advice/your-home/looking-after-your-home/repair/roofs/

Another source of advice is the Ulster Architectural History Society website.
https://www.ulsterarchitecturalheritage.org.uk/maintenance/

1 H. Describe and evaluate the benefits, options and risks of energy-efficiency and retrofit measures, and of climate change adaptation and mitigation measures using a whole building approach.

> **‘Traditional buildings often perform better in terms of heat loss through fabric than as stated in standard models and assessment methods. This means that the likely paybacks from some retrofit measures, such as solid wall insulation, may be less than assumed.’**
> Sustainable Traditional Buildings Alliance

Background

For the past two centuries gas and electricity have been cheaper and more easily exploited than ever before. One of the most worrying consequences is a rapidly changing climate due to rising levels of greenhouse gases, such as carbon dioxide (CO2), in the atmosphere.

In 2010, 45 per cent of $C0_2$ emissions generated in the UK came from energy used for day-to-day building operations and powering electrical equipment in buildings. The UK Government is legally committed to an 80 per cent reduction in greenhouse gas emissions by 2050. The building stock is inevitably coming under the spotlight as it is the largest single user of energy and of many other resources.

Energy efficiency and retrofit

The three biggest influences on a building’s energy use in operation are:

a. Building fabric: Older houses are often thought to be cold and draughty, but they can vary greatly in their energy efficiency depending on how they are constructed and maintained. There is growing evidence that many perform better than assumed and some outperform modern houses. Nevertheless, action can and should be taken to reduce energy use and carbon emissions from traditional buildings where possible.
b. Building services and equipment: Of the total energy consumed by the average UK dwelling in 2010, 6 per cent was used for heating, 21 per cent for hot water, 14 per cent for electrical appliances, 3 per cent for lighting and 3 per cent for cooking. Almost 50 per cent of carbon emissions were associated with heating.
c. People: Factors to consider include how the occupants maintain their buildings; the heating and lighting levels they require; the equipment, such as computers and washing machines they use, and how they use the spaces.

All these factors are highly interdependent. Critically, the efficiency of a building will also depend on how well it is maintained.

A key benefit of upgrading the thermal efficiency of traditional buildings is that most improvements can be carried out at relatively low cost. They can significantly enhance the comfort and health of building users, creating warmer homes with improved air quality, as well as providing savings on fuel bills and helping to meet greenhouse gas emission reduction targets. Improving energy and carbon performance may also give a welcome opportunity to protect and enhance a traditional building and ensure that it remains viable into the future.

Repairing and draught-proofing windows and doors, for example, is an easy and cost-effective action that will pay for itself quickly through the reduction in fuel bills.

Useful sources of advice on upgrading the thermal performance of individual building elements, such as windows, walls and floors, are listed in the resources section below. However, there are also risks that need to be considered.

Risks

Altering the thermal performance of older buildings is not without risks. For example, use of inappropriate energy-efficiency and retrofit measures can:

- introduce thermal bridges (cold bridges)
- reduce ventilation below the level required to keep a building dry
- encourage condensation
- reduce indoor air quality
- affect the movement of moisture through the building fabric, which can encourage decay
- encourage overheating
- harm the significance of traditional buildings by damaging, removing or covering up important features.

Research has shown that these risks can result in buildings consuming considerably more energy after retrofit measures have been installed than predicted.

The most significant risk is that of creating condensation either on the surface of a building component (such as a window or wall) or between layers of the building fabric. This is referred to as 'interstitial condensation.' Condensation can give rise to health problems for occupants as it can lead to mould growth. It can also damage the building fabric through decay.

Avoiding the risk of condensation can be complex as a wide range of variables come into play. For older buildings though there is no 'one size fits all' solution; each building needs to be considered and an optimum solution devised.

Climate change adaption and mitigation

Flooding is perhaps one of the most obvious risks for traditional buildings as a result of climate change. Many older homes are in areas where there is a significant chance of river or coastal flooding. Even more are at risk from surface water, groundwater or sewer flooding.

Steps can be taken to improve the resistance and resilience of traditional buildings to withstand flooding, such as the installation of flood barriers on doors and windows. However, when flooding does occur, buildings can be damaged by unsuitable drying out methods and repair works, which can sometimes result in historic materials and fittings being thrown away needlessly.

Climate change can also bring long-term risks that are more easily overlooked, such as the gradual erosion of masonry as a result of increased rainfall and winds. It is essential to keep on top of problems as they develop through good maintenance. It is also important to retain original traditional weathering

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details, such as overhanging eaves and projecting lintels as these help to protect the building. These features should always be retained and repaired, or reinstated if they are missing.

.The introduction of micro-generation equipment, including solar panels, can harm the appearance of a traditional building or historic area, but with care in the choice, siting and design of equipment, this need not be the case. Sources of advice on this topic are included below.

Whole building approach
For historic buildings a balance needs to be achieved between improving energy efficiency and avoiding damage both to the significance of the building and its fabric. Taking a 'whole building approach' can achieve significant improvements in most cases.

Factors which should be considered are:
- existing building structure and condition
- selection of materials suited to the permeable nature of traditional buildings.
- use of correct detailing
- care in the installation of services
- heritage values and significance of the building
- technical risks
- relevant planning permission and legislation, and official guidance relating to built heritage
- national building regulations including any exemptions and special considerations for older and traditional buildings.

The whole building approach is outlined in Planning Responsible Retrofit of Traditional Buildings from the Sustainable Traditional Buildings Alliance as integrating fabric, services (such as heating and ventilation) and human behaviour with the context of the building. This follows a joined-up and balanced approach based on assessment, design, installation, user advice and on-going maintenance.

Suggested Learning Activities

Use the Guidance Wheel and Knowledge Centre on the Sustainable Traditional Buildings Alliance (STBA) website to customise and select measures for a traditional building of your choice.
http://responsible-retrofit.org/wheel/

Resources

Planning Responsible Retrofit of Traditional Buildings, Sustainable Traditional Buildings Alliance (STBA), 2015
http://stbauk.org/stba-guidance-research-papers

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Historic England has produced a series of publications offering practical advice on how to save energy in older homes.
https://historicengland.org.uk/advice/your-home/saving-energy/guidance/

Find out about installing, replacing or upgrading building services, such as gas or heating pipes and electrical wiring without causing any permanent damage to the historic fabric.
https://historicengland.org.uk/advice/your-home/making-changes-your-property/types-of-work/installing-services/

Design Guides, National Trust
https://www.nationaltrust.org.uk/features/building-design-guides

Energy Efficiency and Historic Buildings: Application of Part L of the Building Regulations to Historic and Traditionally Constructed Buildings, Historic England, 2017
https://content.historicengland.org.uk/images-books/publications/energy-efficiency-historic-buildings-ptl/heag014-energy-efficiency-partlL.pdf/

Learn more about how to implement specific energy-efficiency measures, from Historic England's technical guidance.
https://historicengland.org.uk/advice/technical-advice/energy-efficiency-and-historic-buildings/

Short Guide 1: Fabric Improvements for Energy Efficiency in Traditional Buildings, Historic Environment Scotland, 2013
https://www.engineshed.scot/publications/publication/?publicationId=179c1909-3679-4486-9583-a59100fa98c1

Short Guide 11: Climate Change Adaptation of Traditional Buildings, Historic Environment Scotland, 2017
https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationId=a0138f5b-c173-4e09-818f-a7ac00ad04fb

Flooding and Historic Buildings, Historic England, 2015
https://historicengland.org.uk/advice/your-home/flooding-and-older-homes/

enewable Energy and your Historic Building, Cadw, Welsh Assembly Government, 2010
http://cadw.gov.wales/docs/cadw/publications/Micro_gen_booklet_EN.pdf

Several publications about different types of renewable energy equipment have been produced by Historic England.
https://www.historicengland.org.uk/advice/planning/infrastructure/renewable-energy/microgeneration/

What is whole house retrofit? Sustainable Traditional Buildings Alliance (STBA), 2016
http://www.sdfoundation.org.uk/downloads/What-is-Whole-House-Retrofit-Dec2016.pdf

This teacher's guide has been written by Cadw and Historic England.