4TH EDITION

BARRY'S INTRODUCTION TO CONSTRUCTION OF BUILDINGS

STEPHEN EMMITT

WILEY Blackwell

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Contents

Preface

Robin Barry's *Construction of Buildings* first appeared in print in 1958 and eventually grew into five volumes. When I took on the task of revising and updating the Barry books, a decision was taken to condense the work into two volumes to make it more accessible to readers. This was a big task, and it required the input of a former colleague, Christopher Gorse, and the help of many individuals and companies, for which I remain extremely grateful.

Working on the books continues to be a process of addition and subtraction to keep the content topical and informative to a wide readership. Now, as a solo-authored work, it has been possible to further simplify and clarify the content while making the latest round of revisions. This has resulted in repositioning of material and new features, such as 'How to navigate this book' and the 'At a glance' fact sheets. The repositioning of material, from one volume to another, and within volumes, has helped to ensure a more logical flow of information that better reflects the process of construction. The main changes to each volume are as follows.

This volume has retained the same chapter structure, with changes made within chapters to improve readability. The introductory chapter has been rewritten to better explain the process of construction and to place greater emphasis on its environmental impact. The material on timber-framed construction has been moved to the *Advanced* volume, which has allowed for simplification, rewriting and renaming of Chapter 5 to better reflect the content on loadbearing wall construction. Scaffolding can now be found in this volume, and the material on foundations has been restructured in both volumes to remove repetition.

The *Advanced* volume has been restructured. Offsite construction has been rewritten and moved to the front of the book (Chapter 2), since most of the material in the volume is concerned with prefabricated and preassembled construction. There is a new chapter on framed timber construction (Chapter 5); thus, the three main materials for framed construction – timber, concrete and steel – are now in the same volume, making it easier for readers to draw comparisons. The material relating to existing buildings, demolition and recycling has been moved to Chapter 11, thereby completing the entire building lifecycle.

In making these revisions, the original philosophy of Robin Barry – to address the functional requirements of building elements – has been retained. Regardless of building type, the functional requirements of the main elements remain relevant. Similarly, the underpinning construction principles remain much the same, despite ever changing building codes, regulations, guidance and better awareness of the environmental impact of buildings.

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How to Navigate this Book

The Barry books are presented in two volumes, *Introduction* and *Advanced*, with the volumes designed to complement one another. The titles are used to reflect the stage at which these subjects are taught in colleges and universities in the UK. *Introduction* covers the first year, primarily dealing with loadbearing construction and domestic scale developments. It also covers the common elements found in most buildings. The *Advanced* volume includes material usually taught in the second to third year, primarily dealing with offsite techniques and framed construction for larger buildings. Combined, the two volumes take the reader through the entire life cycle of a building – from inception and construction; to the building in use; and the eventual demolition, recycling and reuse of valuable resources.

An overview of the chapters in each volume is provided in Table 1 as an aid to navigating the books.

Chapters are designed such that they can be read from front to back or they can be dipped into as the need arises. Each chapter or section introduces the primary functional requirements, and then the reader is introduced to an increasing level of detail. The illustrations and photographs are provided to enhance our understanding of the main principles. 'At a glance' sheets are used for each chapter to address the main 'what', 'why', 'how' and 'when' questions.

Table 1 Overview of the chapters

Chapter	*Introduction*	*Advanced*
1	Introduction	Introduction
2	Site Analysis, Set-Up, Drainage and Scaffolding	Offsite Construction
3	Ground Stability and Foundations	Pile Foundations, Substructures and Basements
4	Floors	Single-Storey Frames, Shells and Lightweight Coverings
5	Loadbearing Walls	Structural Timber Frames
6	Roofs	Structural Steel Frames
7	Windows	Structural Concrete Frames
8	Doors	Envelopes to Framed Buildings
9	Stairs and Ramps	Lifts and Elevators
10	Surface Finishes	Fit Out and Second Fix
11	Internal Environment and Energy Supply	Existing Buildings: Pathology, Upgrading and Demolition
12	Water Supply and Sanitation	

If readers are studying, for example, loadbearing construction, then they will need to read the *Introduction* volume and focus on specific chapters to supplement their learning in the classroom. In this situation, the reader will need to read chapters all the way through in the first instance, perhaps returning to specific issues, such as the position of damp-proof courses. Similarly, if readers are studying framed construction, the *Advanced* volume will be a valuable resource, supplemented with material on, for example, doors and windows from the *Introduction* volume. When it comes to revising for examinations in construction technology, the 'At a glance' feature will be useful in prompting one's memory, prior to revisiting key issues within the chapter.

When readers use the books to help detail their building designs, dipping into the chapters to see solutions to typical detailing problems will help with understanding. It is, however, important that we understand the principles underlying the construction of buildings – what needs to be achieved, and why. Thus, the details and photographs provided give an indication of how it could be done, and not how it should be done.

1 Introduction

The aim of this introductory chapter is to highlight some of the factors that determine how buildings are constructed and also to provide some context to the chapters that follow. Related issues are dealt with in the introduction to *Barry's Advanced Construction of Buildings*. A brief overview of the building process and the function and performance of buildings leads into a discussion about responding to climate change. This is followed by a description of the general principles of construction, concluding with some comments on legislation, sources of information and making informed choices.

1.1 The construction process

In simple terms, the process of design and construction starts with a want or need. This may relate to, for example, a new building, or extension, repair and/or alteration of an existing structure. These wants and needs are translated into a set of requirements, a written 'brief' that informs the design team. The design team will develop a conceptual design and increase the level of detail to such an extent that a constructor can interpret written and drawn instructions to realise a physical artefact. The constructor will bring together appropriate resources – people, materials and machinery – to realise the design safely and within the agreed parameters of time, cost and quality. This process, or more correctly this series of interlinked processes, involves a large number of people working towards a common goal. This requires a collaborative and integrated approach to deliver the project and the product (building) to the expectations of the client. It also requires a collective understanding of many issues, including construction technology.

The process of design and construction is extensively covered in the literature on design management, project management and construction management, and therefore it does not need to be repeated here. However, it is necessary to make the point that we rarely make decisions in isolation when designing and constructing buildings. The nature of collaboration is determined by the type of procurement route used for a project and the success of the interactions between the organisations and individuals assembled to realise the project. The process is aided by information communication technologies (ICTs) and building information models (BIMs), and conducted within a legislative framework. Digital technologies allow project contributors to communicate regardless of physical location and to work collaboratively on the design and construction via a shared virtual BIM. The legislative framework includes regulations and guidance relating to fire protection, health

Barry's Introduction to Construction of Buildings, Fourth Edition. Stephen Emmitt.

and safety, the wellbeing of workers and building users, and the protection of our environment. Our decisions are also influenced by the physical site on which the building is to be constructed, as well as the availability of materials and technologies to realise the building in an ethical manner.

Genius loci – the importance of site

Buildings exist within a local context, and they should be designed, detailed and constructed to be in harmony with nature – that is, they should respond to their *genius loci* in a positive and sustainable way. Understanding the physical characteristics of the site and its unique microclimate is fundamental to designing and constructing a building that is in balance with its environment. The importance of site characteristics becomes even more critical with some of the alternative approaches and technologies that may be more prone to damage from, for example, water. Sensitivity to the site is a crucial factor in ensuring a durable and trouble-free building. It follows that the proposed site of the building must be carefully analysed in terms of the microclimate, soil type, position of water table, etc. Then, and only then, should we start to design and make decisions about the most appropriate materials and construction techniques to realise the project within the given parameters of time, cost and quality. Site analysis is described further in Chapter 2.

1.2 The function and performance of buildings

Buildings are designed, constructed, altered, upgraded, restored or demolished for a variety of reasons. Whether the aim is simply to provide more space or to make a financial gain from speculative development, all building projects need to fulfil a function and meet set performance criteria, no matter how fundamental or sophisticated the client's requirements may be. The function of the building, be it, for example, a house, school or, hospital, will influence its design and architectural appearance. Similarly, the performance requirements will influence the type of materials and technologies used to realise the building, factors that also influence the building's architecture. Both the function of the building and the performance requirements are initially determined through discussions with the client at the briefing stage.

The briefing process aims to establish what the client wants and why. The written brief will set out the type of building required and its primary function. Performance requirements, such as the thermal performance of the building, size of rooms, etc., will also be stated, along with a financial budget, timescale for completion of the project and the required level of quality. The brief informs and guides the design team. As the design develops, attention will turn to the function of individual building elements and components and their assembly to meet the agreed performance requirements safely and efficiently. This involves interaction with specialists, manufacturers and constructors to harness knowledge and expertise to the benefit of the building's design and construction.

Function

The primary function of a building is to provide shelter from the weather, and as a container for living, working and playing in. This involves understanding how people will use the building and the equipment required to support the comfort and wellbeing of the occupants over a long time period. Thus, the daily activities that will take place within and around the building will influence the building's function. The principal functional requirements may be broken down into the following:

- ❑ Provide shelter, security and privacy
- ❑ Provide structural and fire safety
- ❑ Ensure thermal comfort and wellbeing
- ❑ Have low environmental impact
- ❑ Be easy to use and operate (functionality)
- ❑ Be easy to maintain, repair and replace/upgrade
- ❑ Be adaptable and durable
- ❑ Be able to reuse and recycle materials and components at a future date

The overall goal is to achieve these functions in an economical, safe and timely fashion using the most appropriate resources available and with minimal negative impact on the environment. These primary functional requirements are explored in the chapters that follow in relation to specific building elements – for example, walls and windows.

Performance

In construction, the word 'performance' is used to describe: (1) the performance of the design and construction team, known as 'project performance', and (2) the performance of the building, known as 'product performance'. In this book, the focus is on the performance of the building, although the manner in which the design and construction team performs – the decisions made and the actions taken – will impact upon the overall performance of the building. The design and construction of the building will influence how the users of the building are able to perform their tasks. Good design and construction will encourage positive performance and wellbeing, whereas poor design and construction will have a negative influence on performance and wellbeing.

Performance requirements will be specific to the client, the unique physical building site and the time of construction. Thus, performance requirements will vary from project to project, from site to site and over time. However, the main considerations are likely to be:

- ❑ Space, determined by the floor area and/or volume (and related to anticipated use)
- ❑ Thermal, visual and acoustic performance (quality of indoor climate)
- ❑ Design life and service life of the building and specific building components/elements
- ❑ Cost of construction, cost of use and cost of demolition/deconstruction and recycling
- ❑ Quality of the finished building (functionality, durability and usability)
- ❑ Appearance of the finished building (aesthetics)
- ❑ Environmental impact and ethical resourcing of materials and components
- ❑ Adherence to prevailing legislation and codes

Other specific performance criteria will relate to the use of the building – for example, the provision of special work surfaces for catering establishments. Legislative performance requirements are set out in building codes and regulations (see the section titled 'Building control and building regulations'). Specific performance requirements – for example, the thermal insulation of walls and fire protection of doors – must be met or bettered in the proposed construction method.

Quality

Function and performance will influence the quality of the building. The quality of the completed building, as well as the process that brings it about, will also be determined by the quality of thought behind the design process, the quality of the materials and products specified, and the quality of the work undertaken. There are a number of different quality issues:

(1) *Quality control* is a managerial tool which ensures that both work and products conform to predetermined performance specifications. This applies both to the design and the construction phases. Getting the performance specification right is an important step in achieving the required quality, be it for an individual component or the whole building.

(2) *Quality assurance* is a managerial system that ensures quality service to predetermined parameters. The ethos of total quality management aims at continual improvement and greater integration through a focus on client satisfaction. Manufacturers, contractors and professional consultants use this.

(3) *Quality of the finished artefact* will be determined by several variables that are constant for all projects – namely, the:

- ❏ Interaction and characteristics of the participants engaged in design, manufacture and assembly
- ❏ Effectiveness of the briefing process
- ❏ Effectiveness of the design decision-making process and resultant information
- ❏ Effectiveness of the assembly process
- ❏ Effectiveness of communications
- ❏ Time constraints
- ❏ Financial constraints
- ❏ Manner in which users perceive their built environment

The required quality of materials and workmanship will be set out in the written specification. Good-quality materials and good-quality work tend to carry a higher initial cost than lower-quality alternatives. However, the overall feel of the building and its long-term durability may be considerably improved – we tend to get what we pay for. When making decisions about the materials and components to be used, it is important to consider the whole-life cost of the materials, and not just their initial capital cost and the cost of labour to assemble the materials.

Economics

The building site and the structures constructed on the land are economic assets. They have a value to the owner, building users and society at large. In addition to the cost of the land, there are three interrelated costs to consider.

The first is the *initial cost* – that is, the cost of designing and erecting the building. This is usually the primary and sometimes the only concern of clients and developers. It covers professional fees and the costs associated with land acquisition and permissions, the capital cost of materials and components, and the labour costs associated with carrying out the work. Material costs are prone to wide swings in price depending on the market, and it may sometimes be necessary to adjust the design to suit the supply and price challenges. An example would be to change from a steel frame to a concrete frame because of the shortage, and hence higher-than-anticipated cost, of steel. Labour costs comprise a substantial part of the initial cost of most building projects and are related to the type of construction technologies to be used, be it site based or offsite. Ideally, we should be aiming to use local labour and locally sourced materials to reduce the carbon footprint of the building and to help stimulate the local economy.

The second cost to consider is the *cost of the building in use* – that is, the costs associated with routine maintenance and replacement, and the costs associated with heating and servicing the building over its life. These costs can be reduced by sensitive design and detailing – for example, designing a building to use zero energy and to be easy to maintain will carry significant cost benefits over the longer term (not to mention benefits to the environment). All materials and components have a specified design life and should also have a specified service life. Designers and contractors need to be aware of these factors before starting work, thus helping to reduce future maintenance requirements.

The third cost is the *cost of materials recovery* at the end of the life of the building – that is, the cost of demolition, recycling and disposal. Although it may be difficult to predict exactly when the building is likely to be substantially remodelled or dismantled, this should still be an important consideration when detailing and constructing the building.

All three areas of cost associated with a building project should be considered within a whole-life cost model, from which decisions can be made about the type of materials and components to be used and the manner in which they are to be assembled (and subsequently disassembled). This links with issues concerning maintenance, repair renovation and recycling.

1.3 Building: the (de-carbonised) product

Adopting the philosophy of 'leaving this planet in a better state than we found it' requires an understanding and appreciation of the environmental impact of construction and buildings. In many cases, this requires a change in how we think about building, how we construct buildings, how we use buildings and how we dismantle and reuse valuable materials. While the focus is often on the amount of energy used in construction (embodied energy) and the amount of energy used to service buildings once they have been constructed, we also need to reduce the amount of material waste produced during the construction process. The message is that we must do more to build in a way that has the least negative impact on our natural environment.

The environmental impact of buildings will be influenced by many factors – starting in the design phase and moving to construction to include issues such as the responsible (ethical) sourcing and manufacturing of environmentally sustainable materials and building products; the (informed) decisions taken during the construction process; the actions of owners and occupants through a long period of use, including decisions relating to maintenance, repair, alteration and reuse; through to deconstruction and the recovery of valuable materials and components at the end of the building's useful life. At this stage, materials and components can be reused in new projects, or recycled for use in new building products, helping to reduce the amount of material sent to landfills and improving the environmental impact of buildings. We should seek to minimise environmental impact through sensitive design and material selection, which requires a thorough understanding of building construction. The mantra is to:

- Reduce
- Reuse
- Recycle
- Revitalise

To decarbonise the built environment, we need to consider the amount of energy used at all stages in the life of a building. This includes the energy expended in the extraction, working and transportation of materials to the site and the total resources used during construction. This should be included in the calculation of the building's embodied energy. The choice of components and the way in which they are brought together to make a building will influence the energy consumption of the building in use and the ease or otherwise of dismantling the building at a future date with minimal energy use. The drive to decarbonise the built environment is driving innovation in building technologies and materials and helping to raise questions about how we build.

1.4 Responding to climate change

Although we cannot accurately predict the future impact of climate change, the general consensus is that, in the UK, the average temperature will rise, as will the amount of rainfall and the average wind speed. The message from the weather forecasters is wetter, warmer, windier and more 'extreme' weather. This has given rise to a number of concerns about the suitability of the existing building stock and also about the construction technologies employed for new buildings. How, for example, do these predicted changes impact on the way in which we detail the external fabric of buildings? Are existing codes, standards and building practices adequate? The general consensus is that we should adopt a cautious approach, although we should also resist over-detailing and over-specifying, which may be wasteful.

Concern has been expressed about new buildings, especially homes that are built from lightweight materials, such as timber-framed, steel-framed, modular and other lightweight construction systems. The fear is that, with the expected increase in temperatures, the internal temperature of lightweight construction may become too high during the summer, thus necessitating air conditioning (increased energy demands) and/or better shading and natural ventilation. Buildings constructed with heavy walls, with small windows and sun shading devices (e.g. shutters, verandas), are less susceptible to temperature fluctuation. However, there are plenty of places around the world that have a warmer climate than the

UK and where lightweight construction is used successfully. The answer to the problem is not so much about the type of construction used as it is about the manner in which the building is designed to respond better to its immediate environment (e.g. by building in verandas and shading devices).

Passive design includes the selection of energy-efficient building materials, so that there is very little or no need to provide heating (or cooling) of the interior space. This is referred to as a 'fabric first' approach to design and construction. An example is *Passivhaus* (German for 'passive house'), a building standard that effectively eliminates the need for space heating by using a highly insulated building fabric. Taking this concept a little further, the *Activhaus* ('active house') standard aims to design and construct a building that generates more energy than it uses. Buildings that are constructed using straw bales and rammed earth adopt the 'fabric first' philosophy to eliminate the need for space heating.

There are a variety of approaches to ecological (alternative) construction. Some have their roots in vernacular architecture and others in technological advancement, although most approaches and products combine features present in both old and new construction techniques. Strategies adopted can include, for example, the reuse of salvaged components and recycled materials from redundant buildings, designing buildings that may be disassembled with minimal damage to the components used and buildings that are designed to 'decompose' after a predetermined time frame. We urge readers to look beyond the familiar and explore more ecological approaches to the construction of buildings.

Energy efficiency and environmental performance

In attempting to reduce the amount of carbon produced by buildings during their lifetime, we need to consider many issues. As a minimum, we should be aiming to:

- Reduce the running costs of buildings (by reducing energy use)
- Enhance air quality (natural ventilation) and maximise natural daylight
- Select low-allergy and environmentally friendly materials
- Improve water efficiency and increase (greywater) recycling
- Design in the possibility of adaption and alteration (thereby reducing wastage of materials at a future date)
- Promote future-proofing (by employing easily upgradable, energy-efficient technologies)

If these (and related) factors are addressed at the conceptual and detailed design phases, then the initial cost of construction is likely to be similar to that of a less energy efficient and less environmentally friendly project. Add to this the considerable cost savings over the life of the building, and it is difficult to understand why many buildings are still being constructed with such scant regard for the whole-life performance of the constructed works.

Our existing buildings are a little more problematic, simply because it may be a challenge to make improvements to the building fabric and services to improve their environmental impact. This is particularly challenging when buildings are located within conservation areas and/or are designated as being of historic interest (e.g. those having 'Listed' status). The ability to upgrade the building fabric and retrofit appropriate technologies is addressed in *Barry's Advanced Construction of Buildings*.

1.5 General principles of construction

Regardless of the approach taken in the design and construction of buildings, there are several fundamental principles that hold true. The primary principle is that the building must resist gravity and hence remain safe throughout its design life. It also must resist the weather to provide a safe, healthy and durable structure. This is achieved by employing loadbearing or framed construction, comprising the following common elements:

- ❑ Foundations (see Chapter 3)
- ❑ Floors (see Chapter 4)
- ❑ Walls (see Chapter 5)
- ❑ Roof (see Chapter 6)
- ❑ Windows and doors (see Chapters 7 and 8)
- ❑ Stairs and ramps (see Chapter 9)
- ❑ Surface finishes (see Chapter 10)
- ❑ Services, energy supply and thermal comfort (see Chapters 11 and 12)

It is vital for the success of the building project and the performance of the constructed building that an integrated approach be adopted. It is impossible to consider the choice of, for example, a window without considering its interaction with the wall in which it is to be positioned and fixed, maintained and eventually replaced. It follows that the window should exhibit the same, or very similar, thermal and acoustic performance characteristics as the wall. The same argument holds for all building services, which should be integrated with the building structure and fabric in such a way as to make access for routine maintenance, repair and upgrading a safe and straightforward event that does not cause any damage.

Loadbearing or framed construction?

A fundamental question for many designers, engineers and constructors relates to which type of construction to use – loadbearing or framed.

Masonry loadbearing construction is well established in the British building sector, and, despite a move towards offsite construction and prefabrication, loadbearing construction tends to be the preferred option for many house builders and small commercial buildings. The two approaches are solid wall construction and, more typically, cavity wall construction. In a typical loadbearing cavity wall construction, the main loads are transferred to the foundations via the internal loadbearing wall made of blocks or bricks. The internal wall may also be constructed from timber or metal frames. In both cases, the external skin serves to provide weather protection and aesthetic quality. Primarily, 'wet' construction techniques are employed for bricklaying, plastering and so on. Quality control is highly dependent on the labour used and the quality of the supervision on site.

Framed construction has a long pedigree in the UK, starting with the framed construction of low-rise buildings from timber and followed by early experiments with iron and reinforced concrete frames. Subsequent technological developments and advances in production have resulted in three main materials being used: timber, steel and concrete (see *Barry's Advanced Construction of Buildings*). Framed construction is also suited to prefabrication and offsite manufacturing. Dry techniques are used, and quality is easier to control because the production process is repetitive and largely carried out in a carefully controlled factory environment. Site operations are concerned with the correct placement and connection of individual pre-assembled component parts in a safe and timely manner.

Design and constructability

The functional and performance requirements will inform the design process, from the initial concepts right through to the completion of the detailed designs and production of the information (drawings, schedules and specifications) from which the building will be constructed. The design of the junction between different materials, that is, the solution for how different parts are assembled, is crucial in helping to meet the performance and functional requirements of the overall building. Good design and detailing will help the contractor and subcontractors in assembling the building safely and economically. Good design and detailing, combined with good workmanship, will contribute to the durability and ease of use of the building over its life.

The manner in which materials are joined together will be determined by their material properties, shapes and sizes available, types of joints required, construction method (e.g. framed or loadbearing) and the safe sequence of assembly (and anticipated disassembly). Interfaces between materials and components can be quite complex and will be specific to particular materials and components. However, in simple terms, the following methods are used widely to join separate parts, either in isolation or in combination:

- *Gravity*. The simple placing of materials so that they stay in place due to their mass (e.g. stone on stone) or shape (e.g. interlocking roof tiles) is common, although it tends to be used in conjunction with an adhesive joint or mechanical fixing. Masonry is usually laid in mortar in loadbearing construction, and roof tiles need to be clipped in position at regular intervals.
- *Screws and bolts*. Screws and bolts perform a similar function in joining two (or more) materials together by a mechanical fixing. Screws are widely used for joining timber, with the thread of the screw drawing the timber components together through the act of screwing through one piece of the material into the other. Bolts tend to be used for joining two pieces of metal and are (usually) placed in pre-drilled holes. A nut is threaded onto the end of the bolt, and the bolt and nut are tightened to hold the materials together. The advantage of screws and bolts is that it is relatively straightforward to unscrew the screw or undo the bolt with minimum damage to the materials. Both screws and bolts can be reused. This is helpful for routine maintenance and inspection, and also for recovering materials and reusing them at a future date.
- *Nails*. Nails are driven through the first material into the second using a hammer or a nail gun, with the materials held together by friction. This is a common method of joining two materials together, although it is difficult to withdraw the nail without causing damage to the materials and the nail.
- *Adhesives, glues and welds*. A wide variety of materials are employed to stick or bond one material to another. These include lime and cement mortars, chemical adhesives, glues and welds. Unless the bond is designed to be comparatively weak in comparison with the materials being joined together (e.g. lime mortar in brickwork), it will be very difficult to disassemble the construction without damaging the materials.

- *Mastics*. Mastics are primarily used to fill joints. These 'flexible' filling materials are designed to allow movement between adjacent materials and to prevent the penetration of rain and wind through the joint. Mastic materials are usually forced into the joint, often making them difficult to remove, although this varies, depending on the material used and the shape of the joint.

Constructability (or buildability) is an approach to building design and construction that seeks to eliminate non-productive work on site, make the production process simpler and provide the opportunity for more efficient site management and safer working. Thus, designing and detailing for constructability requires an understanding of how components are manufactured off site, as well as how the building is to be assembled (the sequence of work packages) on the site. The core message of constructability is more simplicity (of joints between materials), greater standardisation (to avoid unnecessary cutting on site, and hence reduce material waste) and better communication between designer, manufacturer and builder. These three principles also relate to the eventual disassembly of the building, when materials and building products will be recovered, reused and recycled. An ethical approach should be taken to the sustainable sourcing of all building materials and products, which means that those making the decisions about which materials and products to specify and purchase must understand the supply chain and seek assurances about the provenance of each and every item. Some of the practical considerations are concerned with:

- Timescale
- Availability of labour and materials (supply chain logistics)
- Sequence of construction and tolerances (constructability)
- Reduction of waste (materials, labour, time and energy)
- Temporary protection of workers and materials from the weather
- Integration of structure, fabric and services
- Maintenance and replacement
- Disassembly and recycling strategies

Prefabrication and offsite production

In recent years, the emphasis in construction process improvement has been on prefabrication and offsite production. With the rapid uptake of BIMs and advances in digital manufacturing, the opportunities for using offsite production are more obvious than they may have been previously. While offsite production is still best suited to repeat building types and repeat components and elements of buildings, such as toilet and bathroom pods, it is sometimes also feasible to use offsite production for bespoke projects. Improvements in product quality and health and safety may be made by using prefabricated components and proprietary systems. This has tended to move the labour skills away from the building site into the controlled environment of the factory. Site operations become limited to the lifting, positioning and fixing of components into the correct position, and the emphasis is on the transportation of components from the factory to the site when required, and not before. Offsite construction is described more fully in *Barry's Advanced Construction of Buildings*.

1.6 Regulations and approvals

A number of approvals need to be in place before building work commences. The two main consents required in the UK are from the appropriate town planning authority and building control. Specific conditions relating to town planning consent and building regulation approval will be influenced by the physical characteristics of the site and its immediate surroundings.

Planning consent

Issues concerning local town planning approval are outside the scope of this book. However, it is important to understand that (with a few exceptions) planning approval must be applied for and have been granted before any construction or demolition work commences. The legislation concerning the right to develop, alter and/or demolish buildings is extensive, and professional advice should be sought before applying for the appropriate approvals. The process of obtaining approval can be very time consuming (preparing the necessary information for submission, allowing time for consultation and decisions, etc.), and conditions attached to the approval may affect the construction process (e.g. restricted times of working, conditions on materials to be used, etc.). The application may sometimes be unsuccessful, leading to an appeal or the submission of a revised proposal. Planning consent will permit development; it does not deal with how the building is to be constructed safely; this is dealt with by building control.

Building control and building regulations

In the UK, building control is governed by differing, though broadly similar, sets of legislation, for England, Wales, Northern Ireland and Scotland, respectively. Building regulations aim to ensure the health and safety of people in and around buildings by setting functional requirements for the design and construction of buildings. The regulations also aim to promote wider concerns, such as low environmental impact and the wellbeing of building occupants.

In England and Wales, the Building Act 1984 and Building Regulations 2010 set out minimum functional requirements for buildings and the health and safety requirements that may be met through the practical guidance given in the Approved Documents. These in turn refer to British and European Standards and Codes of Practice. In Northern Ireland, construction is covered by the Building Regulations (Northern Ireland) 2012 with Approved Documents, similar to those for England and Wales. In 2014, the Welsh Government brought in a series of changes that now differ from the regulations in England, with the changes binding from April 2017.

In Scotland, the Building (Scotland) Act 2003, which came into force in 2005, has replaced the old prescriptive standards with performance standards. The Act is a response to European harmonisation of standards and their use in Scotland as required under the Construction Products Directive (CPD). The Act has two objectives: to allow greater flexibility for designers in meeting minimum performance standards, and to ensure greater consistency across the country. There are separate Guidance Documents for domestic and non-domestic buildings, both of which are divided into six subject areas that match the essential requirements of the CPD – namely, structure, fire, environment, safety, noise and energy.

The Approved/Guidance Documents give practical guidance to meeting the requirements, but there is no obligation to adopt any particular solution in the documents if the stated functional requirements can be met in some other way. The stated aim of the current regulations is to allow freedom in the choice of building form and construction, so long as the stated (minimum) performance requirements are satisfied. In practice, the likelihood is that the majority of designers will accept the guidance given in the Approved/Guidance Documents as if the guidance were prescriptive. This is the easier and quicker approach to construction, rather than proposing some other form of construction that would involve calculation and reference to a bewildering array of British Standards, Codes and Agrément Certificates.

Although the guidance in this book is intended to be as broad as possible, both for consistency and to avoid confusion, reference is made only to the Approved Documents for England. However, the principles for readers in the UK are broadly similar, with differences in detailing buildings arising from a combination of legislation, response to local climate and building tradition. Full details of the Acts as well as the current versions of the Approved Documents and Guidance Documents are available online (http://www.planningportal.gov.uk; http://www.planningportal.co.uk/wales; http://www.beta.gov.scot; http://www.buildingcontrol-ni.com).

Health and safety legislation

In addition to the legislation set down in the Building Regulations, other legislations affect the way in which buildings are designed and constructed. For example, health and safety and fire safety legislation are covered in a number of documents that sit alongside the Approved/Guidance Documents. The European Union is particularly active in promoting consistent standards across the Union through a series of directives. For example, the European Union Council Directive 89/106/EEC (1988), the CPD, requires all construction products to satisfy the Essential Requirements, which deal with health and safety issues – namely, mechanical resistance and stability; safety in case of fire; hygiene, health and environment; safety in use; protection against noise; and energy economy and heat retention. Over 600 CEN standards have been mandated under the CPD. In addition to this, there exists a large body of Codes and guidance documents.

Health and safety, along with the wellbeing of workers, is covered under a variety of statutes and guidance. In the UK, the Construction (Design and Management) Regulations 2015 came into force on 6 April 2015. The regulations set out what people need to do to protect themselves and others from harm when engaged in construction work. Full details and associated advice can be found on the Health and Safety Executive homepage (www.hse.gov.uk/construction). Good health and safety starts early in the design phase and continues into the detailing of a building, so that it can be assembled, maintained and dismantled in a safe manner. Constructors need to plan the work to manage the risks involved, and also engage with the workforce about the risks and how they are being managed.

1.7 Making choices and sources of information

The design and construction activities of buildings are concerned with making informed choices. Decisions have to be made about the design of the building and its details, which necessitates the selection of materials and components to realise the design intention and aspirations of the client. At the construction stage, decisions have to be made about what mechanical plant to use, how best to sequence the work so that operations are conducted safely and efficiently, and what to do when an unexpected problem occurs. During the life of the building, decisions will need to be made about how best to replace damaged or worn components and how to upgrade buildings to improve their functionality and performance. Then, at the end of the building's useful life, decisions will need to be taken about how to deconstruct the building safely and economically while also maximising the reuse of materials, products and components. The contents of this book and *Barry's Advanced Construction of Buildings* are designed to assist with that decision-making exercise.

Sources of information

Construction is essentially a process of assembly where products are chosen from manufacturers' catalogues and/or from the builders' merchants and are put together using a raft of different fixing techniques. Each new project brings with it a new set of challenges and a fresh search for information to answer specific problems. Some of the main sources of information for readers working in the UK are:

- ❑ Building Regulations and Codes
- ❑ British (BS), European (EN) and International (ISO) standards
- ❑ British Board of Agrément (BBA) certificates
- ❑ Building Research Establishment (BRE) publications
- ❑ Trade association publications
- ❑ Manufacturers' technical literature
- ❑ Compendia of technical literature
- ❑ Technical articles and guides in professional journals
- ❑ Building information centres
- ❑ Organisational knowledge (codified in 'standard' details and specifications)

Readers should make use of the information and details provided by manufacturers, but should avoid making a choice based on information from any one source. Explore at least three different suppliers to compare functional and performance requirements, including costs and availability – and then compare this with current legislation and standards – thus making an informed decision based on achieving the best value within given parameters.

A note of caution

Before proceeding any further, it is necessary to make an important observation about the contents of this book and *Barry's Advanced Construction of Buildings*. The principles and details illustrated here are intended as a guide to the construction of buildings. Details should not be copied without thinking about what is really going on. This also applies to details given in guidance documents. Readers should be asking questions such as: How is the building to be assembled, maintained and disassembled safely and efficiently? Is the detail in question entirely suitable for the task at hand? We make this point because approaches to detailing and construction vary from region to region (e.g. a building located in a wet and sheltered area of the UK may benefit from a pitched roof with a large overhang, but a similar building in a dry and exposed part of the country may benefit from a pitched roof with clipped eaves or even a flat roof). Building practices and regulations also differ from country to country (e.g. differences between the regulations relating to England and Wales), and so it is impossible to cover every eventuality for every reader. Instead, we would urge readers to engage in some critical thinking, analyse the details and seek out alternative (more sustainable) approaches and products. At a practical level, we need to work closely with consultants, manufacturers and suppliers with the aim of applying specialist knowledge to the benefit of the construction process, thinking critically and making informed decisions.

Site Analysis, Set-Up, Drainage and Scaffolding: Chapter 2 AT A GLANCE

What? The main purpose of *site analysis* is to identify the physical features of the site, its micro-climate and legal constraints relating to the proposed development. This influences design decisions and also helps to reduce the risks associated with the proposed development. Site set-up is required to make the site safe prior to construction and/or demolition, and includes the provision of welfare facilities for workers and visitors. Early site activities include ground preparation, site drainage and the construction of foul drainage. Scaffolding will be required to allow safe working at heights above ground level.

Why? Without a thorough site analysis, it is not possible to make informed decisions about the positioning, design, material selection and construction of the building. Site set up will be specific to each site, with the location of site access, site welfare cabins and temporary storage areas determined by the physical characteristics of the site. Site drainage and foul drainage is usually undertaken before, or alongside, the construction of the building foundations. The amount and type of scaffolding required for the safe construction of the building will be influenced by the building design and the amount of offsite prefabrication to be used.

When? The site analysis should, ideally, be conducted prior to the client acquiring the site, but must be done before design commences. Data collected will inform the building design and the manner in which the building is to be constructed. Site set-up will commence once the client has legal possession of the site and is ready to proceed with the development (i.e. relevant permissions are in place). Site accommodation and scaffolding will be required for the duration of the work. Site drainage and foul drainage will be scheduled to suit specific site conditions and to suit the foundations design.

How? A number of techniques may be used to collect appropriate information. This ranges from desktop studies to walk over inspections of the site and detailed physical surveys. Site set-up will consist of secure fencing and the creation of controlled access points for personnel, delivery vehicles and plant. Welfare facilities and areas for temporary storage of materials will be located to suit the physical characteristics of the site and the planned flow of work. Site drainage and associated groundwork will help to make the site ready for the construction of the building's foundations. For new build projects, it is common to erect the scaffolding as the work proceeds. For work to existing buildings, it is usual to erect the scaffolding to allow safe access to all relevant levels and areas prior to the commencement of work.