Understanding Housing Defects
Duncan Marshall, Derek Worthing, Roger Heath and Nigel Dann
Understanding Housing Defects provides a concise, coherent and comprehensive introduction to the causes, investigation and diagnosis of defects in domestic buildings.

For this new edition, many of the chapters have been substantially updated and new photographs have been added. There are four new chapters covering:

- how defects are defined
- an overview of building and architectural history
- external joinery and painted finishes
- environmental and health-related building problems.

Many of the 21 chapters cover a specific building element and include a brief introduction setting out construction principles and the evolution of current practice. All of the chapters consider the identification, cause and diagnosis of common (and sometimes not so common) defects. This book is a must-have for all those students and practitioners who require a broad understanding of housing defects. Building surveyors, general practice surveyors, architects, estate agents, housing officers and anyone involved in the management and maintenance of property as well as its construction will benefit hugely from this highly informative full-colour text. Written by the authors of The Construction of Houses, the book is also the natural companion to this bestselling textbook.

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“Having used the companion text, The Construction of Houses, to teach first year undergraduate Building Technology for many years I came late to Understanding Housing Defects but since discovering this excellent book I have used it extensively to teach building pathology at undergraduate and postgraduate levels. The book has been very well received by my students.”

Mike Hoxley, Professor of Building Surveying, Nottingham Trent University and former editor of Structural Survey

“Such a wealth of knowledge is rare to find in a book which makes it a ‘must own’ for students pursuing their undergraduate degree within a construction discipline. The full colour illustrations bring home what often goes wrong in the building process. The book not only proffers alternative solutions and unrivalled knowledge, but is an ideal desk copy for lecturers and professional builders and even ordinary home owners trying to upgrade the energy performance of their homes or first time developers looking to resolve some of the challenges associated with converting older properties.”

Dr Joseph Kangwa, Senior Lecturer, Leeds Metropolitan University, UK
To Duncan Marshall

Duncan Marshall, Derek Worthing and Roger Heath were the authors of the first three editions of Understanding Housing Defects. Sadly, Duncan died in 2009, not long after publication of the third edition.

Duncan is still rightfully included as one of the authors of this new edition, not only as a sign of respect and affection, but also because he was such an important part of developing the character and content of the original book and all the previous editions. While the new material in the book had to be written without Duncan, the essential aims, core and feel of the book remain those which he, Derek and Roger developed over the years.

Duncan’s memory lives on in this new edition which we would like to dedicate to him.

Derek Worthing and Roger Heath
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# Contents

Preface viii  
Acknowledgements ix  

1 Understanding defects: an introduction 1  
2 Building history 7  
3 Building movement: foundations 71  
4 Building movement: walls 103  
5 The investigation of structural defects 133  
6 External walls: brickwork and stonework 155  
7 Ground floors 191  
8 Upper floors 217  
9 Pitched roofs 237  
10 Flat roofs 275  
11 External rendering 305  
12 Plastering and plasterboard 325  
13 Internal walls and partitions 349  
14 External joinery and painted finishes 363  
15 Timber pests 379  
16 Damp: rising damp, penetrating damp and condensation 403  
17 System building 449  
18 Environmental and health-related building problems 479  
19 Water and heating 501  
20 Drainage 517  
21 Electrical installations 533  

Index 543
Understanding Housing Defects was first published in 1998 and this is its fourth edition. In this new edition, besides reviewing and extensively revising and updating the text, we have also added new chapters on:

- how defects are defined
- an overview of building and architectural history
- external joinery
- environmental and health-related building problems.

We strongly believe that the impact of the visual image enhances and clarifies the matters being discussed in the text and to that end we have added many new photographs throughout this latest edition.

As stated in previous editions, our aim in writing this textbook has not changed from our original intention – to provide an interesting, coherent and comprehensive introduction to the causes, investigation and diagnosis of housing defects. There are a number of other excellent texts on building failure, but these tend to be either highly technical or aimed at specialist practitioners. We have always felt there was a need for a more general text, aimed at those students and practitioners who require a broad understanding of housing defects as part of a wider sphere of academic or professional activity. This group includes building surveyors, general practice surveyors, architects, maintenance inspectors, facilities managers, estate agents, housing managers, environmental health officers and builders.

This latest edition, like the first, has three specific objects:

- to explain why, and how, defects occur;
- to enable the reader to recognise and identify building defects;
- to provide, where appropriate, guidance on the correct diagnosis of defects.

Additionally, we still hold the view that a broad knowledge of building principles and good building practice are prerequisites for a genuine understanding of building defects. To this end, we have, where appropriate, introduced each chapter with a brief summary setting out construction principles and describing the evolution of current practice.

The text does not include anything on the repair of defects and, once again, we make no apology for this. Many repairs are obvious, others require input from specialists. In addition, there is often a very wide range of repair methods and materials available and, as these are constantly changing and being developed, to do them all justice would require several volumes.
Acknowledgements

The authors would like to thank a number of individuals, companies and organisations who have contributed to this book.

**Individuals:**
Jeff Ayling, F. Blampied, Stephen Bond, Steve Brown, Fiona Burrows, Mike Bryant, Stuart Clarke, Ian Constantinides, Roger Cowles, A. Cox, N.J. Donnithorne, C. Edmans, Dr Amy Frost, Sally Gilbert, Azadour Guzelain, Michael Hammet, Ian Hancock, Gregg Kerry, John Lobb, Ben Locke, Susan Marshall, Johan Mattsson, David McLaughlin, John Moore, Samantha Organ, Tim Pearce, Robert Shadbolt, Peter Smith, Simon Spokes, Simon Starling, Ole Martin Stensli, Ian Stokes, Graeme Todd, Jenny Walmsley.

**Organisations:**
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Understanding defects: an introduction

This book is concerned with explaining how a housing defect is caused, how it might be identified and, to some extent, what its consequences might be. The importance of an understanding of defects can be seen by the number of legal cases related to them. It is therefore worth considering what we mean when we say something is defective.

All building materials will have a lifespan over which they degrade and/or eventually fail. Proper and timely maintenance will help to extend the function by offering protection against degradation, or preventing failure in one element affecting another element. Notwithstanding the fact that all materials will fail at some point, and require repair or replacement, early failure may occur for various reasons including:

- poor manufacture
- poor design
- poor specification
- poor construction
- poor maintenance
- inappropriate use.

These are not necessarily ‘stand-alone’ reasons for early failure – sometimes they work in combination – it is not uncommon, for instance, for the failure of flat roofs to be caused by the ‘unholy trinity’ of an initial poor design, aggravated by a poor specification and then finished off by mistakes made at the construction stage.

Perhaps the most straightforward way of defining a defect is to suggest that something is defective when it no longer performs its functional requirements. As when, for example, a wall or its individual components no longer prevent rain from reaching the interior of the house, or perhaps, more dramatically, when a support or restraint gives way and a wall collapses. However, something could also be considered defective if it is still performing its primary function but its condition threatens to cause damage to other elements of the building, or, indeed, to other buildings.

In assessing the condition of a building, one usually attempts to make an assessment of the severity of the defect, based on an analysis, or at least an assumption, of the impact of the defect on the element itself and also on the surrounding elements. An example of this latter situation might be a rising damp problem in a wall, which is in itself a defect, but if it is not dealt with, it could lead to additional defects, such as dry or wet rot in, say, an adjoining timber floor. An assessment of potential impacts might also have to take into account a situation where there could be a relatively minor defect that, if it remains uncorrected, may lead to a more serious problem – an example of this might be a small plumbing leak that is a catalyst for dry rot. In both these cases a good knowledge and understanding of the construction and materials of the house being inspected are crucial in determining the likely severity and impact of the defect. The importance of understanding how the house being inspected was built, in general and in detail,
and the materials used to do so, applies not only to older houses. For example, in a modern house the effect of damp penetration through the outer skin of an external wall will potentially have a greater significance for a timber-frame house than for a brick and block house in terms of the possibility of fungal attack and also differential movement.

It is of course possible that an element can be functioning as intended but is still considered to be defective because the requirements or expectations have changed with time – the width or steepness of stairs, for example – or that health and safety issues which were not appreciated at the time have emerged, such as the use of lead piping, lead paint, asbestos, etc. Another obvious example is that of increased environmental concerns where a lack of sufficient thermal insulation or heating controls in line with current, and indeed future, standards could be identified as a defect.

**Perspectives on defects**

However, it should be remembered that, while sometimes defects are a matter, more or less, of fact, they are also, sometimes, more of a matter of opinion, perception or interpretation. For example, the idea of character and patina of age may be relevant. Quite often, older houses are valued because they have character. To some people, the very fact that a building is old will be enough to imbue it with character. This connection between age and character is relevant to the identification of defects because it is clear that what might be regarded as an unacceptable physical condition in a new house might be seen as part of the character of an older house. Examples of this phenomenon might include sloping floors, or steep and/or narrow staircases.

To some extent, the issue of perception and context could also be affected by other factors close to, but not the same as, ideas of character. One of these could be that of expectation. For example, many people would accept the minor undulations or hairline cracks in the walls or ceilings of an older house that they would not in a newly built house, which they might expect to be in ‘perfect’ condition. Expectation also plays a part in determining the notion of something being defective in other ways. There is some evidence that the higher the purchase price of a house, the more the purchaser is likely to see minor ‘blemishes’ as significant defects, i.e. the owners of higher value houses perceive similar defects to be more serious than do owners of houses that cost less to purchase.

There is another aspect to the link between character, age and defects, and that is how something that might be considered defective in some circumstances – such as deterioration in the surface of stonework – might, in a house that is an historic building (i.e. listed because it is of cultural significance) be considered to be an important aspect of its ‘patina of age’ and therefore part of its essential character.

Obviously, in all of these cases of character there is a judgement to be made about where character ends and a defect begins. The same surface ‘damage’ in stonework that might be seen as part of its character will also make that stone more vulnerable to defects such as frost attack and damp penetration, which will in turn damage the historic value of the building through the loss of important historical fabric.

**Design flaws**

Although we do not deal explicitly in the book with defects in overall design, in the sense of, say, a house not functioning because of its juxtaposition of rooms or poor provision or use of space, design flaws can affect the functioning of an element. Examples of such flaws might be where the detailing of brickwork has been inadequate and has exposed it to excessive rain and low
temperatures, leading to defects such as frost attack or sulfate attack. Or where a staircase is too narrow or too steep, making it difficult or dangerous to navigate. Design defects may also include the inadequate provision of natural ventilation via window openings. Some of these situations are covered in the Building Regulations.

Although we have not included wider issues regarding aesthetics in the book (in the sense of what a house looks like overall), aesthetic judgements are often linked to the issue of quality of workmanship and clearly something could be considered aesthetically defective in, for example, the quality of a finished surface in perhaps joinery, plaster or paint. This can be a matter of relative judgement or relative experience or knowledge: if you have never seen a high-quality emulsion paint finish on a plastered wall, you may think that the ‘orange peel’ effect is perfectly acceptable.

**Legislation**

One might consider that there is a factual basis for deciding that something is defective if it is identified as being so under one or more of the pieces of legislation which cover the physical condition of buildings but in reality this is, like much law, quite a complex area of both fact and interpretation. There are a number of statutes, as well as common law principles, which govern matters relating to buildings that are defective or ‘in disrepair’. The statutes overlap to a certain extent, and they approach the problem from different perspectives. Take the example of rising damp which could, depending on the severity of the problems, come within the definitions below:

- **statutory nuisance, covered by the Environmental Protection Act 1990**;
- **unfit for human habitation, covered by the Housing Act 1985**;
- **landlord’s contractual repairing covenants, covered by the Landlord and Tenant Act 1984 and common law**.

Because dampness is capable of causing injury, such as allergic reactions (in the sense that damp allows moulds to grow and their spores can create the problem), it could also be covered by the Defective Premises Act 1972. If it causes structural damage, such as rotting floor joists, which makes the building unsafe, it might be covered by the Building Act 1984. If the floor joists give way while a visitor is standing on them, the owner or occupier might be liable under the Occupiers Liability Act 1984.

Action taken under these statutes could in some instances lead to the criminal prosecution of the person with ultimate control of the building (the owner, usually). Common law and other statutes give rights to the injured party to sue the person responsible and for local authorities to take action.

There are a number of Acts of Parliament and considerable case law which can apply to housing defects, and which approach the problem from a number of different angles. Some examples of these are discussed below.

**Defective Premises Act 1972**

This Act, which applies to work in relation to a new dwelling (new development or conversion), imposes a duty on those who undertake work for, or in connection with, the provision of a dwelling, to:

- **do the work in a professional or workmanlike manner**;
- **use proper materials**;
- **ensure that the dwelling is fit for human habitation when the work is completed**.
Chapter 1: Understanding defects: an introduction

**Occupiers’ Liability Act 1957 and 1984**

The duty of care imposed under this Act is to see that any visitor is reasonably safe in using the premises for the purposes for which they were allowed in. The duty of care may vary according to such factors as whether the visitor is a child, or an independent contractor employed to carry out works of repair, or in any event knows of the danger because it has been brought to their attention. Liability is imposed on the occupier, who, for the purposes of this Act, is the person in control of the premises.

**Landlord and Tenant Act 1985**

This Act places substantial legal duties on landlords to repair and maintain properties which they let to tenants. When landlords fail to keep their premises in repair, their tenants may be able to sue them for breach of contract. Tenants may be able to recover damages (compensation) for the breach for a period of up to six years, depending on when the landlord first had notice of the disrepair. The tenant can also ask the court to order that the repairs be carried out.

**Environmental Protection Act 1990**

A house in poor condition can amount to a statutory nuisance, which is a criminal offence. The law relating to statutory nuisance is set out in the Environmental Protection Act 1990 (EPA). This largely, but not entirely, replaced the Public Health Act of 1936. Statutory nuisance under the Act could include ‘any premises in such a state as to be prejudicial to health or a nuisance.’ An example of a statutory nuisance might be an ill-fitting window frame, not because it needs repair, but because it allows wind and water penetration which in turn causes dampness and mould growth which are prejudicial to health.

The term ‘prejudicial to health’ is taken to mean ‘injurious, or likely to cause injury, to health.’ Therefore, both actual and potential ill-health are covered. Premises will fall within this definition if it can be shown that the conditions of the premises would cause a well person to become ill, or the health of an ill person to deteriorate. ‘Health’ is defined broadly to include physical and mental health. Mere interference with comfort will not count but it would include stress caused by the effects of poor housing.

Dampness is a common statutory nuisance, whether it is penetrating, rising or condensation dampness. Premises which are damp are harder to heat and can aggravate conditions such as arthritis and rheumatism. Dampness can affect the furniture in the room, making beds and bed linen damp, for example. The mould growth associated with dampness, particularly condensation dampness, is a known health hazard. Many people are allergic to the mould spores, which can cause bronchitis, asthma and other complaints which cause breathing difficulties.

**Liability in tort for failure to repair**

A claim may be made in the tort of negligence where the state of repair of a building causes personal injury or damage to a person’s property, and the injury or damage can be said to arise out of the breach of a duty of care owed to that person. The categories of persons who are subject to legal liability for inadequate buildings have been expanded, both through common law and through statutes. Defects in the design, construction, or modification of a building may also give rise to a claim in negligence. This is a complex area of law and beyond the scope of this book.
The Building Act 1984

This is primary legislation under which various pieces of secondary legislation are made. The secondary legislation includes the Building Regulations, Dangerous Structures and Demolition of Buildings. The Act allows local authorities to take action in relation to premises which are in such a ‘defective state’ that they may be prejudicial to health or a nuisance. It also allows a local authority to take action where it considers that a building or structure or part of a building or structure is in a condition that renders it dangerous. This may include restrictions on the use of the building until it has been made safe.

The Act also allows the local authority to take action where a building’s ‘ruinous or dilapidated condition’ is considered to be seriously detrimental to the amenities of the neighbourhood.

The Building Regulations

The Building Regulations are not retrospective but they are a useful reference point for considering an existing building in the light of modern requirements and standards in respect of both the health and safety of occupants and energy usage.

Town and Country Planning Acts

Legislation relating to planning is perhaps a less obvious reference point for taking action concerning defects, but there are two relevant and possibly interconnected areas which may apply. The Town and Country Planning Act 1990 gives the local planning authority the power to require that land be cleaned up if its condition ‘adversely affects the amenity of the area’. Although reference in the legislation is to ‘land’, the term is used to cover land and buildings. Therefore, a building with a number of, presumably external, defects could be the focus of action under this legislation. The normal course of action is for the local authority to serve a notice on the owner setting out what must be done to remedy the situation. The local authority has the power under the Act to carry out the work themselves and recover the costs from the owner. There is encouragement from government for local authorities to use these powers proactively, i.e. not just in response to complaints by neighbours, and they are often used in respect of buildings in conservation areas and for listed buildings. Remedies for defects to listed buildings can also be sought using Urgent Works Notices and Repairs Notices (referred to below).

If the building is listed, action can be taken against the owner by the local authority if the building falls into a state of disrepair. The legislation in this case is the Planning (Listed Buildings and Conservation Areas) Act 1990. The primary purpose of the Act is to deal with defects that are serious enough to cause damage to the character of the listed building. There are two processes that the local authority might use to do this:

Urgent Works Notice. This can only be served in respect of an empty building. It is used where emergency work is required to avoid further damage and deterioration of the fabric of the listed building. The work involved can only be temporary in nature and intent, i.e. it does not involve repairs. Typically it might involve using tarpaulins to prevent rain coming in through a damaged roof, or making the building secure against vandals. The owner is given a reasonable amount of time to respond to the notice. The notion of what is a reasonable time will depend upon the condition of the building but, given that the title involves the word ‘urgent’, then clearly it implies that the owner should act before the situation worsens.
**Repairs Notice.** This involves requiring the owner of a listed building to carry out repairs which the local authority thinks are necessary for the ‘proper preservation of the building.’ The work required is set out in a specification from the local authority. If, after a set period, the work has not been carried out, the local authority may begin compulsory purchase proceedings on the building.

**Fitness Standards**

There also have been a number of government-led initiatives related to Fitness Standards which are usually based on risk assessments aimed at evaluating the risks to health and safety present in a dwelling. Such initiatives in the past have included the Housing Health and Safety Rating System and the Decent Homes Standard, which was aimed at social housing.

**The Party Wall etc Act 1996**

This Act applies where a building owner intends to carry out repair or improvement works to a party wall, a party structure (for example a floor separating flats), boundary walls, or excavations near neighbouring buildings. Under the Act the building owner must meet a number of requirements but primarily the focus is on informing the adjoining owner of the intended work.
Section 1: Introduction

The housing stock of England and Wales was constructed over several hundred years although the great majority of those houses were built since the middle of the nineteenth century. However, there are still many houses standing that pre-date this period.

During this period, many housing architectural styles were introduced, and many of these lasted for considerable periods of time and produced buildings that are still in use today. Many different forms of construction and types of materials have also been used, many of which are still in use, while others which are no longer favoured.

This chapter discusses the principles of house design and construction during the past 500 years or so and outlines a number of the more common defects that the houses can suffer. A more detailed discussion of the causes of the defects, their investigation and their impact on a building is set out in the chapters that follow.

This chapter is divided into four sections: Section 1 is the Introduction; Section 2 covers the period up to the First World War (up to 1914); Section 3 covers the inter-war period between the First World War and the Second World War (1918–1939); and Section 4 covers the period from the end of the Second World War until approximately the end of the twentieth century (1945–1990). This division makes sense as the First World War is a watershed in terms of house construction. Before then, house building was essentially based on traditional construction methods and materials that had developed over hundreds of years. Housing since the end of the First World War (i.e. since 1918) saw modern construction methods and materials applied, first slowly and then at an increasing pace through the remainder of the twentieth century and into the twenty-first century. This was due to the increasing demands for: (1) new housing as the population increased; (2) better-quality housing as living standards rose; and (3) more environmentally efficient buildings as the effects of climate change became apparent. Industrial progress, increasing knowledge of how buildings perform and the development of new materials have also greatly influenced building design and construction in the past 100 years or so.

In this chapter, vernacular buildings and Georgian and Regency housing are discussed in greater detail than housing during the Victorian and later periods. This is because the houses from the middle of the nineteenth century up to the present day make up the great majority of our current housing stock and the problems associated with their poor performance are really the main subject of this book.
PART A: VERNACULAR BUILDINGS

Throughout history, different economic, social and cultural influences have impacted on the design and construction of houses. Those with more financial resources had a far greater ability to exercise influence over the conscious design aesthetic of their houses. They also had significantly greater ability to select both the material and construction form of their houses. The associated status that this provided was, and remains, desirable and generally has filtered downward in society. In pre-industrial societies this process was slow. Given the major constraints on the transmission of design and construction ideas and, more significantly, access to non-local building materials, the houses of the vast majority of the population were subject to local tradition, local craft knowledge and local materials. They were also built to respond to local environmental and cultural needs.

In pre-industrial societies, the vast majority of dwellings were not intended to be of a permanent nature and were often seasonal or short term. There is little written on or archaeological evidence of these structures. Those houses which do survive from this period are all relatively high-status buildings, even if they do not all necessarily appear to be so from our contemporary point of view. Although most of these were not designed by a professional designer (in the modern sense), they were commonly professionally built by teams of craftsmen who were working in a long and verbally transmitted tradition with local materials and who clearly had the ability and knowledge to produce permanent structures. Such buildings are often now referred to as ‘vernacular buildings’.

Two typical vernacular buildings. Left: A local rubble stone cottage finished in a series of coats of coloured lime-wash; rubble stone was universally lime-rendered or lime-washed in the past. The upper storey is built within the roof void and the roof is covered with locally derived thatch. Small window openings reduce heat loss and probably date from a period where shutters, rather than the more recently installed windows, closed the openings. Right: A Wealden house, a commonly high-status timber-frame building from the south-east of England. Timber-frame construction was vernacular in that it made use of local resources, responded to local needs and was a verbally transmitted technique which flourished for 500 years after 1200.

As industrial development gathered pace throughout the seventeenth and eighteenth centuries, vernacular approaches to building were increasingly challenged because of a mixture of economic and cultural factors:

• increasing urban development as an increasing proportion of the population moved to the cities looking for work.
Building history

- increasingly sophisticated and widespread speculative housing development, where aesthetic fashion played an increasingly important role in marketing.
- greater wealth and, to some degree, a trickle-down of such wealth, enabling a larger proportion of the population to have greater concern with and control over aesthetics and status.
- the breakdown of verbally transmitted tradition as printing, publishing and the transmission of new cultural ideas gathered pace.
- an increasing need for new forms of housing in urban areas to house large numbers of workers required for industrial production.
- industrial production enabling more efficient production of products and services which previously had been limited in scale, or constrained by efficiency in terms of their production and their physical transportation.
- associated with this, the improvements in transport technology and systems, enabling bulk and industrially produced building materials to achieve a distribution well beyond their immediate zone of production.
- the increasing education and professionalisation of specialist designers and craftsmen.

Though there are numerous surviving pre-eighteenth-century buildings, it remains relatively rare to find houses pre-dating 1700 in England and Wales. Numerous examples from the post-1700 stock of historic buildings can be described as vernacular in some respects, i.e. responding to relatively simple local needs, designed by builders using local tradition and local materials. However, the upheaval of industrialisation through the eighteenth and nineteenth centuries saw vernacular building techniques being replaced by increasingly standardised approaches to both design and building. This was particularly acute in the cities. Although some local variations in materials, techniques and distinctiveness did remain, this lessens with time.

In more rural areas, particularly those areas remote from urban influence, with limited access to new design and construction ideas, vernacular traditions persisted longer, in some cases almost to the present day.

The vernacular tradition is, thus, not constrained to a house size or type and nor to a period nor even a specific location. It is possible that high-status buildings from as recently as the late nineteenth century could have some vernacular influences, in terms of the use of local materials. However, they are unlikely to be influenced by vernacular building techniques, whereas a modest rural cottage, long distant from transport and urban influences, could have been built in a vernacular tradition and materials well into the twentieth century.

The aesthetic qualities of vernacular buildings are now revered for their local distinctiveness, in terms of their form, the palette of materials employed and how they seem to ‘fit’ with their environment. They are also admired for the simple beauty of a fundamentally utilitarian approach to design rather than a conscious and deliberate adherence to a design theory, often emulating building designs from distant places or times.

In the past 50 years, there has been an increasing interest in and study of vernacular buildings, techniques and materials. This has led not only to a far greater understanding, appreciation and conservation of such buildings, but it has also increasingly seen attempts to revive aspects of the traditions. This has included the revival of traditional building craft, such as traditional timber framing and cob building to name two, but it has also led to a greater concern and attempt to ensure that new construction responds to the specific locality where houses are being constructed.

Occasionally, it is possible to find examples of vernacular buildings hidden behind more recent façades. It was not uncommon for façades to be replaced for fashion, as well as for technological reasons. An understanding and ability to recognise the range of vernacular materials and techniques are essential, particularly when one is concerned with defects and repairs to such buildings.
Chapter 2: Building history

The biggest influences on the vernacular tradition are the environmental conditions of England and Wales and, more importantly, the geology. The Earth’s crust provides a range of potential and frequently used building materials: soils, in particular clays and sands, stone, and timber. All these materials, in both pure and modified form, have been used for millennia in the production of buildings. Indeed, they all still continue to be used; it is the extent, frequency and geographical spread of use which have changed over time. To some extent, the increased concern about sustainability and the lack of local distinctiveness have seen an increasing focus and emphasis on the use of vernacular materials.

A relatively narrow range of local materials was used in vernacular buildings. This was necessitated by the lack of industrial production and highly constrained transportation opportunities. Other than brick and lime, which were both modified, vernacular materials all occurred naturally and, to many, they age attractively (if they are well maintained) and have become popular again in the past few decades.

The biggest influences on the vernacular tradition are the environmental conditions of England and Wales and, more importantly, the geology. The Earth’s crust provides a range of potential and frequently used building materials: soils, in particular clays and sands, stone, and timber. All these materials, in both pure and modified form, have been used for millennia in the production of buildings. Indeed, they all still continue to be used; it is the extent, frequency and geographical spread of use which have changed over time. To some extent, the increased concern about sustainability and the lack of local distinctiveness have seen an increasing focus and emphasis on the use of vernacular materials.

A range of materials, all local to the site, are employed in this extended medieval hall house. Hall houses were the preserve of the wealthy in this period. The ‘hall’ – a central double-height communal space in the centre of such buildings, generally with a central open hearth – can be identified externally by the double-height window. This plan form was commonly adopted in many parts of Britain. Its popularity waned in the sixteenth century when the desire for greater privacy among the upper classes reduced the need for communal space. More significantly, in the sixteenth century, masonry chimneys became widely used and provided for greater comfort, efficiency and convenience. The chimney also enabled the open double-height space to be floored over, adding valuable living space. This stone, brick and timber-framed building has been extended over many centuries.
Chapter 2: Building history

Soils

The most widely available of all these vernacular materials are soils. Soils have been used in buildings for millennia and have commonly been a key constituent for mortars, renders and plasters. They have also been used as a mass walling material.

Burning or firing suitable ‘brick earths’ – predominantly clay – to form bricks is, arguably, the earliest example of a manufactured building material. It has a long history of use in England and Wales and has become the most widely and visibly used material for external load-bearing wall construction.

Buildings made of brick

The technique for brickwork was known to the Romans. Their bricks tended to be thin (25mm or so), but large on plan (300mm square) and used as a bonding course in rubble walls and for arches and barrel vaults rather than for entire walls. Such techniques and technology were widely exported and used in all parts of their empire, including the British Isles. Brickwork and its associated technologies pretty much disappeared from use once the Romans left in the fifth century, though there are several examples of salvaged and recycled Roman bricks being used throughout the medieval period.

The native brick industry really started again in the late thirteenth century in the eastern counties of England that were close to and influenced by ports which imported bricks and, more significantly, the brickmakers from the Low Countries.

The popularity and increasingly widespread use of bricks really took off in the sixteenth century for the construction of effective domestic chimney stacks. This was a largely vernacular undertaking, as transporting this bulky and heavy material for great distances was difficult and expensive. It established widespread local brick production and developed and encouraged brick-laying techniques.

As a mass walling technique, the seventeenth century saw brickwork becoming increasingly more desirable following its extensive use in prestigious high-status buildings, such as Hampton Court Palace. However, the true popularity of brick did not occur until the eighteenth century. The increasingly widespread and effectively implemented regulation in favour of fireproof wall construction following the Great Fire of London and increasing demand for mass housing in industrialising cities saw brickwork become the predominant building material in urban settings. Even here, however, brick production itself remained a largely local, hand-made activity, adding a distinctiveness to the look of brick buildings and hence a vernacular feel to such buildings.

*Early brickwork was hand-made and of great variability. Brick production was a local and largely hand-crafted activity, right up until the nineteenth century.*
From the mid-nineteenth century, improvements in transport and the industrialisation of production meant that bricks, now in standardised sizes, but from different areas throughout the country, were increasingly easier to distribute. This, combined with increased education, training and the increasing professionalisation of the building industry significantly reduced the local distinctiveness of brick buildings in the latter half of the nineteenth century. Refer to Chapter 6 for a more detailed discussion of bricks and brickwork.

Buildings made of mud

Solid wall construction using unburnt local soils – the most universally available building material – has a long history of use. There are a range of techniques:

• turf (walls of stacked earth with its grass in place);
• clay lump or adobe (unfired earth bricks bonded with earth mortars);
• rammed earth (walls formed by ramming earth into in-situ formwork);
• cob (muds mixed with straw and sometimes lime as a binder) stacked up in layers and trimmed. Cob is also known as ‘clum’, ‘clob’ and ‘wichert’ in various localities.

Other than turf walls, all of these vernacular techniques are seeing a revival because of concerns about the environmental impact of more popular materials as well as the loss of local distinctiveness.

This sub-section focuses on the most commonly found technique for vernacular buildings in the UK: cob.

Cob is a simple building technique which requires a suitable earth, ideally a mixture of a clay (15–25 per cent) and sand/aggregate (75–85 per cent). Suitable soils were worked up by mixing the soil (often using animals as well as humans to ‘tread’ the mix) with chopped straw and by adding water to the mix. The straw is added to provide a matrix to reduce the impact of shrinkage. The water is necessary to produce a plastic, workable and consistent material for the construction of walls. On some occasions, and where available, lime or chalk was added as a binder to provide added strength.

Slightly eroded cob on a dry stone plinth wall – the typical lime-wash finish has long since disappeared. Mud buildings are still considered to be relatively inferior and this can militate against their conservation.
Once mixed to a workable consistency, the cob was simply piled into a layer, or ‘lift’, on top of a suitable stonework plinth. The plinth was necessary to minimise the contact between the cob and the damp earth. Once the lift (typically 150–300mm) had been placed and then trodden down to compact it, it would be allowed to initially dry so that it was firm enough to be trimmed to bring it to an appropriate thickness. Typically this varied between 300–1000mm. Once dried – anything up to four weeks per lift – the subsequent layer would be added and the process continued until the appropriate height was achieved.

Lintels for openings were built in as work proceeded, with the opening itself often being cut once the walls were dry and complete. Because there was no formwork and the mud was added in thick layers trimmed by hand, the corners of cob buildings tend to be rounded, with soft curving lines. This ‘organic’ sinuous form is characteristic of cob buildings.

To minimise the mud wall’s exposure to moisture and precipitation, they required a ‘good pair of boots and a good hat’. The plinth wall, usually 300–500mm in height, reduced the chances of rain-splashing, capillary action and rising damp eroding the base of the wall. At the wall head, wide over-hanging eaves were ideal – usually in thatch. This was detailed so as to throw precipitation away from both the head and face of the wall. The walls themselves were sometimes lime-rendered, but were frequently lime-washed (a mixture of air-drying lime, water and tints) to achieve on-going moisture resistance. The use of porous lime-based coatings also encouraged the evaporation of any moisture within the body of the wall, so-called ‘breathability’. Mud buildings generally had a low-status reputation. Indeed, they still have such a reputation – this is a significant barrier to their conservation. The surviving examples tend to be relatively low-status rural workers’ dwellings, agricultural buildings and garden walls. There are regional variations in vernacular mud building techniques using cob. In the northern Home Counties,
cob construction is known as wychert. However, it is the south-west of England, and Devon in particular, that has the largest number of cob houses. It is in Devon, too, that there are numerous examples of relatively high-status cob buildings.

The approach described earlier is the most widely used technique, but there are variations. In the east of England, notably Leicestershire and Lincolnshire, a number of ‘mud and stud’ houses remain. These consist of simple, lightweight timber frames. Riven or split laths are fixed to this frame. Then, a thick cob-type mix is daubed onto both sides of the laths and the frame, and mud is used to provide enclosure and strengthen the frame by transferring part of the load of the roof (and upper floors, if there are any). Similar techniques using full or part cruck timber frames which independently support the roof have been identified in parts of Cumbria too. In other parts of the UK, similar load-bearing frames independently support the roof and lightweight wattle walls form the core of earthen wall structure. All these techniques have the advantage of being a faster building method than the multiple lift approach to cob building adopted in the south of the country.

Although mud building in the past was undoubtedly associated with poverty, its relative cheapness gave rise to a number of short-lived revivals in the nineteenth and twentieth centuries. There has been an increasing interest in the conservation of the remaining earth buildings in the UK, and Devon is the centre of a significant revival of the use of this ancient building technology – the motivation now is environmental impact, the sculptural and distinctive qualities and the motivation to support local rural enterprise.

Buildings made of stone

In contrast to mud, stone has long been associated with durability and status. Some stones have the distinct advantage of being easily winnable from the earth, even appearing in relatively usable form at the surface. Other stones have to be worked out by quarrying or mining, which has influenced the extent to which they have been used in the vernacular tradition. The balance of durability and ease of working to enable it to be used for building purposes has had a significant influence on the extent to which particular stones have, or have not, been used in the past.
By the late sixteenth century, stone quarrying and mining had become more widespread and stone became more widely used in vernacular building. There is some evidence for the idea of a Great Rebuilding occurring across England between 1550 and 1640. Many timber-framed buildings were refaced in masonry, i.e. in brick, where it was being produced, and stone where it was easily available. Many new stone buildings were also erected.

In freestone areas, where stones are relatively easily quarried and easy to subsequently dimension, ashlar was commonly used around openings, for water-shedding elements like hood and string moulds, for the structurally important quoins and occasionally for entire façades.

Ashlar is a style of stonework in which finely cut stones of uniform height, with true squared face surfaces, are laid with very thin joints (3–4mm). Ashlar stones are expensive and used in relatively thin dimensions (100–175mm was common) and, as such, were always 'backed' with a lesser material (random rubble and later brick) to make up the finished thickness of the wall. In order to bond the ashlar to the backing, occasional bonding stones were provided. These were commonly a piece of ashlar returned at 90° to the face of the wall and running the full thickness of the finished wall. Later, bonding stones were omitted in favour of iron cramps or ties, which bonded the two halves of the wall together. Ashlar was the most skilled and expensive of stonework, demanding care in its planning and execution.

Fine-jointed (3mm) limestone laid in a lime mortar. Many limestones and some sandstones – both sedimentary rocks – are described as 'freestones' meaning that they are relatively easy to dimension and this has encouraged their use as ashlar. In this example, the entire façade is in ashlar. It is backed with rubble to make up its overall thickness. Ashlar is also commonly used in combination with less expensive masonry for the structurally significant quoins, window and door openings and for horizontal water-shedding elements, e.g. sills, string course and cornices.

The majority of vernacular stone work was of rubble construction. There were various forms of this.

**Random rubble**

This is the simplest of stonework techniques. Here the individual stones are laid roughly level, with little attempt to produce horizontal courses. Stones would be of irregular size, and there would have been little attempt to shape, or dress, the stones.
All rubble walls are built as two halves with the two faces being as flush as possible and with the irregularities of the stones meeting in the middle of the wall. Gaps between stones are filled with smaller stones and copious quantities of mortar. Continuous vertical joints are avoided as much as possible to try to bond the wall up its height. In order to bond the two ‘halves’ of the wall together through its thickness, ‘through’ stones (running through the thickness of the wall from face to face) and ‘bonding’ stones (running through at least two-thirds the thickness) are required at regular intervals. Without these, the two halves of the wall can act independently.

Random rubble is not ideal at the most structurally critical areas of stone walls: the quoins and around window and door openings. Here large, more substantial and regular masonry were often required. Bricks, ashlar or more carefully dressed and selected stones were commonly used here.

There is significant evidence that the overwhelming majority of vernacular houses with random rubble walls would have had them rendered, or at the very least lime-washed, or both, for waterproofing and decorative purposes.

Coursed rubble

This is a more sophisticated form of rubble construction. Stones are dressed to enable greater regularity of both the horizontal courses height and vertical perpendicular joints. If there are any small gaps, these are filled with smaller stones and mortar. Again, occasional through and bonding stones link the two halves of the wall together.
Squared or snecked rubble

In this type relatively finely cut stones are used to enable them to be laid on accurate and regular horizontal and vertical joints. The horizontal courses were not of uniform height. The term ‘sneck’ referred to smaller stones used to make up the height in courses using different sized stones.

Two examples of snecked sandstone walling. The example on the right has a bed mortar coloured with stone dust which has been ‘tuck pointed’ with a 1:1 lime putty and very fine aggregate mortar. This has been carefully added to a groove which was ruled into the unset bed mortar. This gives the impression, from a distance at least, of a finely jointed masonry wall – a desirable but expensive proposition.

Sedimentary stones

The most widespread group of stones which have been used in building are the sedimentary stones. These limestones and sandstones were formed over geological time as particles from erosion, chemical and biological processes accumulated in shallow lakes, seas, rivers and even deserts, and underwent chemical and physical changes: compressing and cementing the particles together. As they were laid down in layers (often referred to as beds) over time, these stones have a series of laminations. This has the dual effect of making them easy to split, but also makes them subject to potential defects associated with the ease of delamination.

Limestones are used to a greater extent than sandstones and this is a factor due to their geographical location, their ease of use and durability. Essentially limestones are made from calcium carbonate. Their character varies according to their origin. The organic limestones are formed from shells and other body parts of tiny sea creatures and other organic materials. The inorganic limestones are formed from chemical precipitation and have no organic matter. Jurassic limestones, which are found in a wide band across the country running from Dorset’s coast (Portland being the most famous quarrying location) right up to the north-east coast in Yorkshire, are the best-known and widely used limestones for building. Chalk is also a soft form of limestone and was much used in the past (together with harder limestones where these were more available) to be kilned and slaked into lime the binder.

The commonest constituent of sandstones is quartz with little or no organic material. The quartz is held in a matrix made up of varying materials, but most commonly silica and calcium. The siliceous sandstones form the best and most durable building stones. The colour spectrum of sandstones ranges from green to purple and the texture too varies considerably. Sandstones in the west and north of the country are the most renowned. Sandstones are used in all forms of stone construction from ashlar to random rubble.

Granite is a very durable and particularly hard igneous stone. As such, it is difficult to cut and carve. It is common in the south-west of England, Leicestershire and Cumbria.
Flint is found in mostly in the south and east of the country as bands of hard nodules of irregular size and shape in chalk deposits. Here, because of the lack of better stones, it was quite widely used in building. The stone is brittle and is ‘cut’ by knapping or splitting. This process exposes the darker interior of this siliceous stone and the cut or split face laid flush to the face of the wall. Flints can also be used whole without knapping. Because of its relatively small size, it is laid as a form of rubble walling and will always require brick or coursed stone quoins or jambs. In better-quality work, stone or brick horizontal bands formed at regular intervals would ensure the wall was stable and effectively bonded.

**Buildings made of timber**

England and Wales have a fine inheritance of vernacular timber architecture. For thousands of years, indigenous timber species provided the main source of structural material for building. During this time a management system – coppicing – developed for woodland which provided a renewable and sustainable supply of timber and woodland products. Medieval carpenters were supplied with timber from a commercially managed woodland economy that was already ancient.

*Timber’s innate flexibility and the fact that many frames seasoned slowly (over many decades) in situ can be misinterpreted as a defect. Sometimes this is the case, but frequently the distortion is cosmetic only and adds a significant and unique character to many timber-framed buildings. Understanding the construction and the tradition, together with experience, is critical to making judgements about what is, and what is not a defect.*
The predominant timber species used for structural purposes in England and Wales was oak. This is an immensely strong, durable and long-grained timber. Elm, sweet chestnut, hornbeam and other timbers were also used. Typically timbers were used unseasoned, shortly after felling. ‘Green’ oak and other timbers were considerably easier to work and joint than seasoned timber and, given the typical cross-sections, air seasoning (the controlled evaporation of moisture) would have been impractical. The timber would season slowly in situ and quite often slowly takes up the gradual distortion caused by subsequent substructure movement.

In the twelfth century, a significant change occurred in timber construction techniques. Prior to this, builders had fixed and stabilised timber structures by sinking the posts into the ground. While these ‘earth-fast’ systems provided a stable structure, it was at the cost of their longevity. The new technique where posts were jointed into a sill beam, which was raised above the damp ground on a plinth wall, was developed and became widespread. This arrangement has become known as the ‘timber framing’. It provided buildings of far greater longevity, but also required a higher level of technical competence.

Timber framing is a classic vernacular technique as there is no known historic text explaining the craft of timber framing and it is clear that the builders of timber-framed buildings worked on a practical basis, resolving structural problems as they arose. The majority of surviving timber-framed buildings of all periods were constructed for the upper classes. This reflects the build quality which could be afforded by this group rather than a constructional preference. There is also very significant variation in approach in different localities across the British Isles. The
builders of these structures had no recourse to theoretical calculation; measurement was based on proportion and made use of the developing knowledge of geometry. Problems were solved through a combination of experience (including failure) and knowledge passed from generation to generation orally.

Frames and bays are essential terms in understanding the general structural arrangements of timber-framed buildings. Frames can be designed in a variety of forms and are the points in the structure where loads from the roof and walls are collected and transferred to the ground. Frames are also the point at which the structure of the building is tied together across its span. Cross-frames are found within the building and end frames for the flank or gable walls. Bays are the spaces between frames. Thus, a two-frame house will have a single bay, a three-frame house will have two bays, and so on.

Essentially timber frames consist of a series of jointed vertical, horizontal and inclined timbers:

- **Vertical timbers** were either **posts** – carrying substantial loads as part of a cross- or end frame – or **studs** – lighter-weight intermediate uprights supporting or connecting horizontal timbers.

- **Horizontal timbers** (known as beams or plates) span along both the length and across the width of the building. A **sill plate** sits on the plinth wall and all the lower ends of studs and posts are jointed into it. A **wall plate** has all the tops of studs and posts jointed into it, but it also provides the location for the feet of the rafters. A **tie beam** connects the cross- and end frames across the width of the building. It is frequently connected to the wall plate too and reduces the likelihood of roof spread at the feet of the rafters.

- **Inclined timbers** form both the roof structure and are also used to avoid structural deformation. **Principal rafters** form part of a triangular roof truss – describing the pitch and profile of the roof – the primary structure unit which forms the upper part of the cross- and end frames. Individual **rafters** support the roof covering and are fixed at their apex to one another or sometimes a ridge beam and, at their feet, to the wall plate; the wall plate would be connected to the top of the vertical posts and studs. An essential structural element of this form of construction was the pairs of inclined **braces**. These stiffen the frame and provide a structural connection between the posts and horizontal timbers. This form of triangulation was essential to keep the frames plumb, level and square. They are required to be in pairs to avoid deformation in either direction. Braces are found in each frame element, i.e. cross-frames, end frames, in the roof structure and along wall frames.

The most commonly used joint in timber framing was the mortice and tenon. The mortice is a squared slot or hole in one of the timbers while the tenon is formed by reducing the

The sill beam reduced the degree to which the vulnerable end grain of timber was exposed to saturation; it was a simple but revolutionary change.
end of the other timber to fit into the mortice. Like all the joints in timber framing, they were secured by tapered timber pegs. Other joinery includes scarf joints, which were used where long horizontal timbers were required, e.g. sills, purlins or wall plates.

The most complex joint in the timber-framed tradition was the structurally critical meeting of the post, wall plate, tie beam and principal rafter. This is known as the tie beam lap dovetail assembly.

The cross-frame and end frame, which collect all the building loads, have to resist significant forces. A critical point for load transfer was at the joint between the principal rafter, the inclined timber of the roof truss, the tie beam, running across the width of the building avoiding roof spread, the vertical post and the wall plate which supports the common rafter feet. This complex joinery arrangement is unique to the UK’s tradition of timber framing.
It is possible to divide timber-framed buildings into four building types:

- **Box frame** construction consists of wall frames connected at bay intervals by cross-tie beams. The roof is a separate structural element which bears onto the external walls, the roof acting as a lid on a box. Box frames have rafter roofs with no purlins supporting the rafter at mid-span. Although the tie beams helped to avoid the weight of the roof spreading the walls outward, collars were added to the pairs of rafters to lessen the spreading action of the roof. Box framing was superseded by the more structurally efficient post and truss framing.

A rare and high-status roof – the Crown Post. This roof is only found in high-status and relatively early box frame buildings. It is not a truss, as such, and is used with rafter roofs, i.e. those where there are no purlins.

- **The post and truss** form is by far the most common surviving timber-framed building form. They make use of the purlin roof. Roof and wall elements are structurally united within each cross-frame, which also includes tie beams, as they do in box-framed construction. The important difference in post and truss construction is that principal rafters are jointed into the tie beam and this forms roof trusses to carry purlins which in turn support the rafters and roof covering. A wide variety of truss forms exist, dealing with a variety of differing requirements and situations. The king post truss, for example, developed in the north of England where heavy stone slates used for roof covering required a structurally robust roof form.

- **Aisled construction** provides additional internal space by dividing the structure into a central nave and two side aisles. Wall posts become internal arcade posts, and the aisles are roofed over with lean-to roofs at an angle matching the main roof. The incidence of aisled construction is predominant in south-east England. Most examples of domestic aisled construction pre-date 1400 and were largely examples of prestigious buildings; from this point onwards, it became principally an agricultural form, but no less spectacular for that.
• **Cruck construction.** Crucks are cross-frames made up of pairs of inclined timbers, most frequently book-matched halves of the same tree, which meet at the apex and are tied together by some form of collar. Typically this ‘A’ frame supports the purlins and the wall plates. Thus, crucks transfer the load of the roof to the ground. This means the external walls are not necessarily structurally significant and frequently act simply as an enclosure. There are over 3000 examples remaining, found almost exclusively in the west and north of England and in Wales. This region contained the more marginal agricultural lands, was home to a poorer peasantry and a lower density of both occupation and building. Here larger, more mature trees and more curved timbers available from the less intensively managed woodlands played a greater part in the development of a regional style. Crucks are economic in their use of timber.

The majority of timber-framed buildings were built with externally exposed timber frames. The most common form of enclosure was applied between the exposed timbers of the frame and is known as wattle and daub. It consisted of vertical timbers or staves fixed between two horizontal members of the timber frame, which supported timber laths woven between them. This element is the wattle. It supported the daub which was a rough cob-type plaster which was thrown onto the wattle and finished flush with the external and internal face of the timber frame. The most common treatment following the application of wattle and daub was to lime-wash both the panels and the frame.

Brick nogging – the use of brick between the timbers of the timber frame – was mostly a retro-fit, often replacing wattle and daub panels. This finish can cause problems – load and water retention have caused some serious defects to timber-framed houses.

In the east of the country, plaster was applied to laths covering the external surface of the timber frame and a moulded finish to the lime plaster was created. This took the form of a pattern or elaborate mouldings and is known as pargetting.

Window frames and door frames were incorporated into the timber frame itself rather than as separate components, as is the case nowadays. The glazing of windows became increasingly common in the early 1600s; until then most windows were open to the elements with protection being provided by sliding or hinged internal or external shutters.
The left-hand pair of these late timber frames has had brick noggins retro-fitted at some point in the past. On the right-hand side, the wattle and daub panels have been retained.

Timber frame pargetting.

Left: Timber frame door. Right: Timber frame window.
In the South, close studding – a structurally unnecessary number of studs – was commonly adopted. This seems to be a ‘conspicuous consumption’ approach in this, the wealthiest part of the country. In the North and West, square panelling was more commonly adopted.

As towns and cities expanded, the plot size of dwellings reduced. Land was expensive and building plots were generally long and narrow. This required the maximisation of space; where there was a need for additional space, this had to be created by additional storeys. Particular solutions to these new design criteria developed. Jettying is one such solution. This is where the upper floor projects and overhangs the lower storey. It provided improved weathering characteristics and there were also positive constructional advantages in that only the internal end of the floor joists needed jointing into a beam. The projecting ends of the joists required nothing but optional decorative treatment. Jetties were also an external demonstration of the existence of an upper floor, something relatively few could afford and, therefore, there was an element of displaying the status of the owner. Indeed, many of the decorative features applied to the façades of timber-framed buildings probably originate in the towns. Although jettying developed in urban locations in response to increasing pressure on space, it was rapidly adopted in rural dwellings.

The tradition of timber framing fell into decline in the late 1600s and, by the 1700s, it became a rural tradition. Many timber-framed buildings, particularly in towns, were refaced with more fashionable (and more fireproof) materials – brick, stone tiles and render. Carpentry and the use of timber within buildings became more and more refined and largely became restricted to floor and roof framing and other elements within masonry buildings. While the same is true to an extent in other European countries, the rapid industrialisation and urbanisation of British society meant that the tradition of timber framing was almost completely lost. Other European countries have never entirely lost their tradition.
The terms ‘Georgian’ and ‘Regency’ refer to specific historic periods between 1714 and 1837. Following the death of Queen Anne in 1714, the ruler of Hanover, a small German state, became King George I of England, and, together with subsequent similarly named monarchs (George II (1727–1760), George III (1760–1820), George IV (1820–1830) and his brother William IV (1830–1837), provides the name for the Georgian era of 1714 to 1837. Between 1811 and 1820, George IV, then the Prince Regent, ruled in place of his medically indisposed father, and this specific period is known as the Regency. It now also refers to a period of architectural and stylistic change which spans a longer period – roughly 1790–1840 – where Georgian style and building, which had dominated for the best part of a century, underwent some stylistic and construction changes.

The Georgian and Regency periods were times of significant change – so significant that we now refer to the two most dramatic sets of changes as the Agrarian and Industrial Revolutions.

The Agrarian Revolution provided for a significant improvement in agricultural production. The enclosure of common land, changes in cropping techniques and invention saw food production rise dramatically. This changed the structure of society, which at the beginning of the period, was predominantly rural and in many ways still medieval, i.e. farmed on a small-scale, subsistence basis. A growing population could be fed more efficiently by a production system which required significantly fewer labourers, thus ‘freeing’ them up to move to the burgeoning centres of industrialisation. The increased financial returns accruing to landowners could be profitably reinvested into speculative schemes such as industrial production and property development.

The Industrial Revolution saw dramatic shifts in population as manufacturing, together with all the associated industrial developments – science and engineering, steam power, coal mining
and iron production – drew a primarily rural population to the new centres of production for work. Trade within the country expanded as significant improvements in the transport system (turnpike and toll roads, canals, and latterly, railways) provided better communications. Colonisation and slavery boosted international trade, which in turn provided new raw materials and increased the demand for manufactured goods and a further expansion of production. Between 1700 and 1750 the population of England rose from 5.5 million to 6.5 million, but between 1750 and 1840 it grew from 6.5 to 16 million. Housing these people, including a rapidly expanding new middle class, in new and enlarged existing urban centres was a challenge that was tackled entirely by the private sector with virtually no state support.

The market, the methods and the rate of house construction significantly changed from earlier periods: speculative housing developments on large tracks of agricultural land adjacent to existing town and cities were undertaken; new design ideas and the means to convey such new ideas, new methods and new materials were used and increasingly a national style, rather than the local vernacular, gradually emerged for the first time. In contrast to the fraught and turbulent political and social times, the style emphasised proportion, harmony and good manners and was based on an increasingly disseminated understanding of classically based Palladian design principles.

**Architectural styles**

Palladian design principles had arrived in England in the seventeenth century with Inigo Jones. He, like many other wealthy young men at that time, travelled around the remnants of the classical world found in Italy, and brought back an interest in and desire to use the classical...
building style in England. Ideas and designs from the classical world had been of interest in England for a century before this. The early use of classical style in England was generally arbitrarily applied, simplistic and ill-proportioned. Inigo Jones translated the works of Andreas Palladio, a sixteenth-century Italian building designer who had carefully studied and recorded the remains of many Roman buildings. Jones used this information to develop clearly expressed and accessible design principles which he applied to several buildings he was commissioned to construct for King Charles I in London – the Banqueting House in Whitehall, the Queen’s House in Greenwich. Inigo Jones’ career was truncated by the Civil War and his association with the monarchy. Although some aspects of Palladian design were taken up in the post-Great Fire of London reconstruction, it was not until the early part of the Georgian period that a stricter adherence to Palladian principles really took off.

Early Georgian style (1714–1760)

Palladian design principles emphasise and rely upon careful attention to proportion. Proportion was of supreme importance. This applied across the whole of the house and in its individual parts, i.e. the entire façade, the individual elements such as windows, room widths, length and heights, and so on. Palladio also promoted the use of the classical ‘orders’, which form a significant part of the proportional and design principles of the Roman temples he had measured and studied. Uniformity within individual buildings and through terraces of buildings, and symmetry were also significant principles. Symmetry was compromised at times – particularly when it came to where to locate the main entrance door and get a usable front room on a narrow plot. Reapplying these classically derived design principles to domestic British architecture was a challenge.

Later Georgian style (1760–1800)

The strict adherence to Palladian proportion continued to be applied to façades and all other elements. In the latter half of this period the rate of house building increased substantially. In industrial cities an even less ornate Palladian style was common. In wealthier areas, the detailing of the elements became less uniform and this allowed for greater freedom of expression. The influence of discoveries and academic interest in Greek buildings, and later Egyptian classicism, provided a wider range of design possibilities – though these tended to be quite austere in nature. What really began to free up the obsession with an adherence to accuracy and uniformity of the past was the arrival on the design scene of the Adam brothers. Robert Adam particularly became the most influential designer of the period. He produced designs that took in the entire house and, though he was primarily known for interior design for the very wealthy, his influence affected many features and aspects of all types of houses and successfully challenged the orthodoxy of strict Palladianism.

Regency style (1790–1837)

The Regency period witnessed a range of new and diverse stylistic innovations. Palladian classicism still had a significant influence on many developments in terms of proportion but increased exploration and trade brought in Chinese and Egyptian influences too. The Romantic and Picturesque movements of the early nineteenth century drew inspiration from landscape, nature and medieval gothic architecture and the gothic style began to be revived for house construction. Some wealthier landowners built in a romanticised rural style – known as Cottage
Compare the photograph on the top right to that on the top left taken from an eighteenth-century builder’s guide. Note the façade’s symmetry and that there is a perfect square formed on the façade around the top six windows and that this ‘harmonious’ shape is reproduced in the top square windows. Note too that the form of a classical column is implied by the proportions and setting out of the façade. For example, the cornice at the start of the parapet wall reproduces the cornice at the top of a column. The entablature is ended at the head of the top (square) windows. The column’s shaft is implied by the piers of stonework running down to a horizontal sill/string course at the sill of the lower window – this represents the base of the column. Beneath that, the ‘pedestal’ of the column is implied in the façade before the rusticated ashlar.

All these are typical of Palladian design principles. The buildings below do not imply a classic temple, but have applied decoration directly imitating a classical temple. The bottom left photograph shows part of John Wood’s Queen Square (1729) and displays clearly Palladian design. Here the classical orders and the elements of a Roman temple have been applied directly to the façade of this domestic building. This early ‘palace façade’ with its symmetrical elevation, its central triangular pediment and harmonious proportions, enabled the tenants of the individual terraced houses to enjoy the grandeur of being part of a spectacular ensemble. Palace façades became a frequently used technique for Georgian and Regency terraces – the predominant urban domestic form of the era. The example bottom right is from Liverpool and shows typical Georgian features in a brick palace façade. Liverpool, like other port cities in the Georgian period, benefitted from the increasing international trade, including slavery, and wealth that flooded in to speculative housing development in the period.

Orné – on their estates. Romanticism and a somewhat nationalistic search for the true spirit of Englishness both encouraged a re-examination of medieval gothic style. In the late eighteenth and early nineteenth centuries, ‘Gothik’ became a fashionable design idiom.
Chapter 2: Building history

The use of the Doric order was constrained until the later Georgian period. Top: This rather austere building uses Greek Doric order to produce a severe and archaeologically informed façade. Left: More commonly, brick-built terraces with simple detailing based on Palladian principles became an increasingly widespread urban form across the country. Right: In the country, Georgian style was also popular: in this later-Georgian, rural example the prestigious nature of brick becomes apparent – stone gable walls with brick principal façades. Note that even here there are vernacular influences— the rubble gables, the stone slate eaves courses of the roof covering. It could well be that this façade was “added” to an existing pre-Georgian structure as a serious up-dating. Such rebuilding processes are common throughout history.

Left: A typical Cottage Orné – which became a popular Romantically inspired style for the wealthy landowner to develop for their estate workers. Right: An early nineteenth-century Gothik house.
Chapter 2: Building history

The biggest influence on style was probably the increasing demand for house building in urban centres where trade and industrialisation very significantly boosted demand, particularly after 1815 when the end of the Napoleonic Wars witnessed a series of building booms. This prolonged period of building, together with better communications and transport, led to an increasingly nationally adopted range of materials and elements on houses.

Brickwork was increasingly hidden behind stucco, a wet-applied render that was used to emulate more expensive stone, but also used to cover cheap and poor walling materials. Stucco could have simple lines incised into the drying mix to imitate ashlar, but it could also be moulded into complex and realistic imitation stone features.

A series of classic Regency houses. Left: High-class Regency end-of-terrace house in London displaying all the characteristics of the period, i.e. white lime-washed stucco, semi-circular multi-storey bay windows, ornate cast-iron and wrought-iron work, classical and elegant proportions. Middle: A middling-quality Regency terrace with stucco, classical proportions and Chinese-inspired pent roof above the delicate cast and wrought ironwork balconette. Right: A lower-class house with far fewer features and smaller, tighter accommodation.

The Regency period also saw the development of detached and semi-detached housing.

Left: This appears to be a masonry building, but is in fact a relatively rare Regency timber frame with glazed black ‘mathematical’ tiles. These are hung on horizontal battens fixed to the timber frame to emulate bricks – a way to avoid the despised Brick Tax levied in 1784 and only repealed in 1850. The wide overhanging eaves and low pitch slated roof were typical of Regency semi- and detached houses. Right: This is a more substantial detached Regency villa with ornate ironwork and railings and lime-washed stucco. Note that the stucco does not extend around to the side elevations, where facing brick is used.
The other significant technological development affecting style was the use of cast-iron and wrought-iron balconies, railings, fireplace and other architectural features which were widely produced by the new metal industries. Windows and doors became even more elegant, with reduced size glazing bars and more complex fanlights.

**Housing development, layout and amenity**

Throughout the Georgian and Regency periods, the predominant form of housing development was speculative. As the country industrialised, more marginal agricultural land close to industry or on the edges of existing urban centres became potential development sites. Landowners (generally the aristocracy and upper middle classes) sought to realise their land assets. Throughout the period, there was an obsession with speculation: housing and urban development provided many potentially lucrative possibilities. This was not a constantly expanding and rewarding proposition, however. Many fortunes were made and many were lost as the market took violent swings of fortune – sometimes very rapid swings.

With its roots in methods developed in the seventeenth-century housing market in London, speculative development in the Georgian period was generally undertaken by a principal developer who would take a 99-year lease from a landowner. The principal developer would agree a scheme (fashionable and likely to be desirable) with the landowner and would then sub-lease individual plots to smaller developers – often tradesmen – who would individually borrow to build to the agreed scheme. They would have a two-year peppercorn rent on their individual plots during which time they would hope to construct, complete and sell on their house – at a profit. It is astonishing to consider that many of the most uniform terraces from this period were built by several different builders – frequently a different builder for each separate house. The principal developer would then collect the ground rent from all the occupiers, paying the landowner his annual dues, and would hope to make a substantial annual profit over and above this. After 99 years, the landowner’s descendants would own the freehold of the completed development.

The ‘architect’ (there was no official definition of this until the nineteenth century) and the builders were strongly supported by published and widely distributed building guides or ‘pattern books’ which provided drawn examples of appropriate and fashionable plans, elevations and a range of building elements. This affordable and easy-to-use dissemination of contemporary design ideas provided a very significant push towards the development of the first modern national, non-vernacular building style.

Although a range of different house types throughout the Georgian and Regency period existed, the commonest urban form of construction, and one encouraged by speculative development, was the terraced house. The terrace maximised the efficiency of the development process, maximised the profitability of a site and encouraged a greater concern with urban design to flourish. The Building Act 1774 set out national standards for the first time (previous Acts really applied to, or were only effectively taken up, in London). This Act established four classes of house and stipulated the minimum quality for construction: it led to standardised plan and construction forms.

At the front of the house, typical construction would include a front retaining wall topped with iron railings, forming a void below street level in front of the basement. This area often contained steps which provided a tradesmen’s entrance directly into the kitchen, located commonly in the front basement room with a scullery at the rear. The subsequent plan of the house would be relatively simple, with one room at the back and one at the front on each floor with a passage and staircase at one side. There were variations, but this plan form was very
common. In middle- and upper-class houses, the ground floor was reserved for reception of the public. The first floor, referred to as the Piano Nobile, was intended for formal and private socialising and had the highest ceilings and tallest windows. Upper floors were for bedrooms and the storey within the roof void was the servants’ accommodation. The party walls usually contained the chimney flues – these added strength to the structure, as well as serving at least one fireplace in each room.

Left: A model of a substantial late Georgian townhouse. The slender masonry is buttressed by the timber floors, roofs and partitions. The original ground level was somewhere within the height of the basement level. This provided a substantial excavation in order to complete the basement structure which in turn provides a substantial masonry foundation for the subsequent superstructure. Right: A typical construction at the lower front of a Georgian townhouse. The excavated basement is protected by iron railings and forms an open area enabling light to penetrate into the basement rooms. These usually contained the service areas, kitchen, scullery, etc. Under the pavement, substantial vaulted masonry structures were commonly provided for each house. These enabled storage for a variety of household requirements – most commonly coal and other non-perishable items.

Construction

Construction during the Georgian period was primarily hand-made and, even on some of the larger schemes such as in London and Bath, was produced by small-scale developer/builders who would have employed separate trades – and they were frequently a tradesman themselves. As industrialisation gathered pace in the latter part of the period, particularly in the Regency period, greater industrial production and improved transportation began to impact on both materials and building techniques. Larger-scale development (particularly in London as well as various spa towns, seaside resorts and port cities), the increased professionalisation and education of the building professions and trades, also provoked the growth of large-scale building contractors – or Master Builders – such as Thomas Cubitt, whose firm employed a full range of building trades and were thus not reliant on individual subcontractors.
**Roof structure**
Houses during this period had timber pitched roofs, generally of softwood imported from the Baltic. For some bigger structures, and where local supply was good, oak was also used. Shorter spans were formed with common rafters and ceiling joists, while longer spans incorporated purlins, which spanned between load-bearing walls, or timber trusses (which were installed at regular intervals where there were no internal walls to provide support to a roof). Trusses could be found in a variety of designs, but King Post trusses dominate. In larger town house terraces, it was common to find mansard roofs: these have two different pitches within the roof structure in order to provide accommodation, generally for servants. In order to span the depth of the houses and to avoid the need for a very tall pitched roof, thus negating the classical ‘look’, a double-pile roof was common, this was partially hidden behind a parapet wall to reduce its visual impact. In smaller poorer houses, a duo-pitched ‘Butterfly roof’ was adopted – again, this was designed to minimise the impact of having to have a pitched roof.

**Roof coverings**
At the start of the Georgian period, local vernacular roofing materials were common – clay tiles in the east, stone slates in limestone and sandstone areas, and so on. Natural slate became more and more available and in many urban settlements by the end of the period, it was dominant. In poorer housing, clay tiles (pantiles and plain tiles) were common and thatch continued in some country areas.

**Roof drainage**
Although some roofs drained into lead or cast-iron gutters and downpipes, many of the roofs of the period were concealed behind parapet walls that drained into lead-lined parapet gutters supported by softwood boarding. Valley gutters, which were formed on double-pile roofs, were also common. This central valley was frequently drained via a ‘secret gutter’ – an open lead-lined channel through one of the roof voids to the parapet gutter.

**External walls**
These were of solid construction. The most common material was brick. Facing bricks for areas on the principal façades, lesser-quality facing bricks for rear walls and often poor-quality ‘place’ bricks where they were hidden. Thickness ranged from 337 to 450mm for the lower storeys of
multi-storey houses with 225mm thickness at higher levels or for houses of two or fewer storeys and also for cheaper houses. A 112.5mm (or half-brick) thickness was common for single-storey annexes. In gauged arches, ‘rubbers’; i.e. soft bricks which are easy to shape by rubbing in order to form purpose-made voussoirs, were relatively common.

In the latter half of the period, stucco – a wet-applied render – was commonly adopted for brick buildings. It became widespread during the Regency period where it was used to form mouldings and other architectural features reminiscent of carved stone.

External walls were constructed of a mixture of brickwork and stone. Sometimes, stone details were provided around door and window openings and for stringcourses, plinths, quoins and other details.

Timber lintels were used behind masonry arches to provide structural support above openings. Window sills were commonly formed in stone.

Many better-class houses had basements. Some had barrel vaults which extended out under the pavement in front of the house for the storage of coal and other household goods. These were constructed with thicker walls, at least 337mm if of brickwork and 500mm if of stonework.

**Bricks**

The industrialisation process, and hence its standardisation, started in this period. Brick sizes were relatively similar in the eighteenth century, but not standardised nationally. As a largely hand-made and localised activity, there could be significant variability in size, shape and quality.

Flemish bond was the most commonly adopted bond. ‘Snapped headers’ were commonly employed. Here the expensive facing bricks were either cut in half, or were deliberately made as half-bricks, and bonded into the wall to give the appearance, but not the strength, of Flemish bond. Garden wall bonds were used in hidden areas and on cheaper construction.

**Stonework**

Local stone was often used where available and cost-effective, e.g. limestone in Bath, limestone and sandstone in Bristol, sandstone in Cumbria and Yorkshire, granite in Cornwall and Devon, flints in Sussex, rag in Kent. At the start of the period, it was only ever imported from one district to another where it was used for very prestigious and expensive housing; at the end of the period, transport improvements meant that stone was being transported more frequently.
Buildings could be constructed wholly of stone or, with, for example, ashlar veneer (150–200mm thick) and backed with either rubble or brick. Rubble walls were either solid stone through the thickness of the wall or, particularly in the latter half of the period, the rubble was backed brickwork. Rubble walls would have been finished in a lime-render and lime-wash or a series of lime-wash coats.

**Mortars**
Throughout the period, masonry, whether brick or stone, was bedded in lime mortar. Lime mortar hardens slowly and this meant that any initial settlement and much subsequent settlement of a building was accommodated by the walls. Most aggregates would be locally sourced and thus of variable quality, particularly, in poorer-quality houses.

**Internal walls**
Internal walls were normally formed with common bricks, sometimes in stonework. Non-load-bearing walls were frequently formed with ‘place’ bricks (i.e. improperly fired/soft bricks). Often, internal walls were only a half-brick thick, even for structural walls of tall buildings of several storeys. All walls were faced with lime plaster.

Internal partitions of timber studding covered in lath and plaster were common. These were braced with extra timbers where required to act structurally. Stud partitions were sometimes infilled with bricks-on-edge to provide sound insulation.

**Foundations**
These originally depended on the size and quality of the building being constructed. Cheaper housing had either no foundation or a shallow foundation, often consisting of a layer of flat stones, sometimes a bed of clinker. More expensive houses normally had some form of deeper foundation. Often this was a substantial basement and sub-basement structure. It was common for the sub-basement to be excavated, with the basement above that being built at the original ground level. This means that often the ground-floor levels of many Georgian and Regency houses is a storey or so above the original ground level of the site. This effectively means that the basement or sub-basement acted as a giant masonry foundation.

**Windows, doors and joinery**
Box-framed sliding sash windows in softwood were the standard approach in the period. Glass technology (essentially hand-blown ‘Crown’ glass) limited the size of glass panes available. The division of the two sliding sashes by glazing bars resulted and was the norm throughout the entire period.

The double-hung sliding sash window was commonly adopted and developed over the Georgian and Regency periods. Imported as an idea from the Netherlands in the seventeenth century, early Georgian sashes had thick glazing bars with quite crude features. It was not uncommon to find that just the bottom sash opened. Through the later Georgian period, sashes became lighter, more refined and the glazing bars finer and finer until the Regency period where daringly thin glazing bars are common. In the earlier period, the box frames of these windows were exposed and nearly flush with the façade. Over the period, and pretty universally after the 1774 Building Act, the boxes were hidden behind masonry rebates.

Doors throughout most of the period were of either four or six panels, comprising two square panels (or glazing sometimes) above two longer panels, above two shorter panels. Doors were usually of softwood and were intended to be painted. More expensive hardwood joinery of oak or mahogany was polished or varnished.
Chapter 2: Building history

Upper floors
These were constructed with timber joists (usually of softwood), herringbone strutting and square-edged softwood floorboards. In larger houses, double ‘framed’ floors were used. Here the floor joists do not span the whole distance, but are jointed into a larger section beam running at right angles to the joists – this enabled large open spans in the rooms below. Ceilings were formed with lime plaster over softwood laths – additional plaster mouldings – cornices, friezes and other decorative mouldings were commonly added to enhance the spaces.

Ground and basement floors
Floors at ground level were commonly of suspended timber construction with softwood joists and square-edged softwood floorboards. Solid floors with flagstones, brick pavers or ceramic tiles over compacted earth were often used for rear extensions and in basements, where the kitchen and scullery in houses of all classes were found. In more prestigious developments, the floor of the main entrance could be finished in marble, Purbeck stone or ceramic tiles.

Services
Services and amenities were crude by today’s standards, but very advanced compared to what had preceded them. Running water was very rare – collection and storage of rainwater,
from springs and streams was very common. Drainage was primarily concerned with surface and rainwater disposal/storage. Sanitation was generally very crude with a privy or bog house covering a communal cesspit in the rear courtyard – shared with many people in working-class districts. Some wealthy owners had flushing toilets and WCs by the end of the period, but these were relatively rare. Coal and timber burning in chimneys and, latterly, in cast-iron chimney pieces and ranges provided heat, cooking, light and hot water production in all houses.

**Typical defects of Georgian and Regency houses**

These are discussed in Part D below.

**PART C: VICTORIAN AND EDWARDIAN HOUSING (1837–1914)**

The period between the accession of Queen Victoria and the start of the First World War falls into two distinct architectural periods: Victorian (1837–1901), covering the reign of Queen Victoria; and Edwardian (1901–1914), the latter also covering the first four years of the reign of King George V as well as the reign of King Edward VII.

When Victoria became Queen in 1837, the United Kingdom was still essentially a rural economy, but by 1914, it had become a fully industrialised nation. The Industrial Revolution of the late eighteenth century and the nineteenth century led to the mass movement of the population from the countryside to the urban centres where manufacturing took place. It created the need for huge numbers of houses to be constructed for workers, managers and employers. The total population roughly doubled between 1801 and 1851 and did so again between 1851 and 1911 to approximately 43 million people.

Much of the demand for new housing was achieved by speculative development. Landowners and builders often undertook this in a piecemeal fashion and this can be seen today where Victorian streets often follow original field patterns. Housing for workers was rapidly erected as cheaply as possible in streets of small and medium-sized terraced housing, generally of two to four storeys and sometimes five-storey buildings, many being subdivided to house several families. Separate streets of higher-quality and more spacious terraced houses together with semi-detached and detached villas were also constructed for managers and employers. The total number of houses rose by about five-fold between 1801 and 1911 (from approximately 1.6 million to 7.6 million). House building had mini-peaks in the 1830s, 1840s and 1850s. These were followed by major building booms in the late 1860s and the late 1870s as well as at the turn of the twentieth century.

Some of this Victorian property expansion did provide houses and suburbs of acceptable quality in terms of appearance, internal design and external space. Unfortunately, the cheapest housing, especially in the first half of the period, was of extremely poor quality and this resulted in many thousands of sub-standard houses constructed with questionable materials and design, e.g. the use in some areas of sun-baked bricks, the lack of a damp-proof course or a foundation. Such houses were also adversely affected by rising and penetrating damp, had little or no proper natural light and ventilation and normally had no water or toilet facilities, the occupants having to make use of communal standpipes and toilets. The extremely high density of much housing development was another problem and resulted in overcrowding and conditions like the back-to-back houses of many northern towns.

Part of the underlying causes for these types of development was that, before the First World War, 90 per cent of housing was rented. Landlords (not just speculators, but also factory owners) often had little or no incentive to provide buildings of better quality, while they had every
Terraced Victorian middle-class housing in Bristol showing that money was spent on the street elevation, with rubble and freestone details evident. However, cheaper brick was used for the flank and the (unseen) rear elevations.

Note the high density and the lack of off-street amenity in this example of back-to-back housing in Leeds.

Incentive for high-density developments, as both factors directly affected the return on their property investment.

From the middle of the nineteenth century onwards, there was a gradual realisation and acceptance by various leading authorities and, finally, by Parliament, of the link between poor and overcrowded housing and ill-health. This resulted in various Acts of Parliament including the Public Health Act 1875. This, together with the introduction of various regulations and the 1877 model by-laws, set minimum basic standards of design and construction as well as layout for new housing. Minimum requirements and standards were also set for sanitation, water supply, natural light and ventilation as well as the prevention of damp. In modern terms, these standards were relatively low and they were not applied retrospectively to houses already in existence. Subsequent legislation by central and local government in the remainder of the nineteenth century as well as the twentieth and early twenty-first centuries has periodically raised these early standards to the current level of building standards and regulatory control.
Although speculative building at the lower end of the housing market still took place, the new regulations led to better standards of construction generally, especially at the upper end of the housing market. Many houses built in the last decade of the nineteenth century and the first decade or so of the twentieth century (the Edwardian Period) are considered by construction experts to be of the highest quality in terms of workmanship and in materials, in particular, the timber and craftsmanship used for carpentry and joinery.

Architectural styles

A number of different architectural styles were developed over the period for the appearance of better-quality housing for the middle and upper classes throughout the whole period. These were rarely reflected in the design of cheaper housing, which was often of unadorned brickwork or render.

The relatively unadorned flank wall of a worker’s house constructed in 1884 – very few builders are as helpful in dating their work.
In brief, the range of architectural styles included:

- **Classical.** Inspired by classical Greece and Rome, the houses had symmetrical design features, their façades including columns and pediments and often involved the use of stucco.

  ![Classical Style House](image)

  Left: A terrace in Clifton, Bristol, was constructed in freestone in the classical style in 1875. Right: A classical-style terrace with stucco finish.

- **Gothic revival.** Based on medieval buildings, the heyday of gothic revival was between 1855 and 1885. Such houses often had an extravagance of detail to their roofs and elevations, asymmetrical features and pointed arches above external openings.

  ![Gothic Revival House](image)

  Left: The Foster’s Almshouses in the centre of Bristol were constructed between 1861 and 1883 and are an example of French Burgundian Gothic Revival Style, being modelled on the Hôtel Dieu in Beaune, France. In 2007, they were converted into private residences. Right: A slightly more restrained example of a Gothic Revival house.

- **Old English.** More likely to be used for rural housing, this style had steeply pitched roofs, pointed gables with finials and much fancy detailing as well as false half-timbering, usually painted black.

- **The Arts and Craft Movement.** An influential, but to some degree peripheral style, this movement, led by William Morris, flourished from the 1880s until the 1930s and was inspired by the writing of Augustus Pugin and John Ruskin. It was arguably an anti-industrial movement and was based on the use of local building materials by traditional craftsmen and a return to medieval, Romantic or folk styles of decoration. It had considerable influence on the Garden City Movement and on the designers of Garden Suburbs.
Chapter 2: Building history

Housing layout, landscape and amenity

From the 1860s onward, the quality of the environment within which a house stood was also recognised as an important factor of housing quality. Dense housing layouts plus the lack of natural landscape as well as the lack of amenities in terms of private gardens, public open spaces, trees and the like were identified as being detrimental to both the health of the occupants and the quality of life generally.

The initial impact of this enlightenment was on middle-class suburban development. In 1875, Bedford Park in Chiswick, West London, was developed. Whilst not a true Garden Suburb, it was an early forerunner as it included houses of different designs and appearances and, although the layout was rather too cramped, the houses did have the benefit of being set in an informal and unregimented environment that retained existing trees. Bedford Park also had some influence on future house appearance, especially in the period 1890–1910, with its use of gables of red brickwork and/or tile-hanging and multi-paned leaded windows. However, most developments continued to be on the basis of the grid-iron layout of straight and parallel ‘by-law’ streets beloved by local authorities of the time, with the focus on terraced housing (which comprised almost 90 per cent of all housing by 1911).

Bedford Park had a considerable influence on a number of enlightened employers who sought to improve the living conditions of their employees. As a result, a number of industrial model villages were created, including Port Sunlight, Cheshire, in 1886 (Lever Bros), Bourneville,
Birmingham, in 1894 (Cadbury) and New Earswick, York (Rowntree) in 1904. Such villages ranged in size from a few hundred inhabitants to the 25,000 of Bourneville, where the houses were of traditional design, but with modern interiors and large gardens and set among parks and recreation areas.

Typical cramped Victorian working-class housing: a terrace with rear annexes and small back yards.

These two photographs show houses and streets in Bourneville. Note how green and leafy it is.

Another scheme for creating a higher-quality residential environment in terms of housing and an attractive man-made landscape was **Hampstead Garden Suburb** in North London. This development started in 1906 and was based on a planning design by Raymond Unwin, the joint designer of Letchworth Garden City. It was aimed at all classes of people and income and involved low-density housing with natural boundaries of hedging rather than walls, and wide, tree-lined roads with woods and public gardens.

In 1898, Sir Ebenezer Howard inspired the **Garden City Movement** with his book *Tomorrow: A Peaceful Path to Real Reform*. A social and political reformer, he argued for a self-contained city for 32,000 people planned on a concentric pattern of open spaces, public parks and greenbelt, plus six radial boulevards and better-quality housing for the working classes. From 1904, he developed **Letchworth Garden City** in Hertfordshire, although the final design was more ‘organic’ and less symmetrical than Howard’s original proposals. The next Garden City was not developed until after the First World War (Welwyn Garden City, again in Hertfordshire, in 1919) and further Garden Cities have subsequently been developed in the UK and elsewhere in the world.
Construction during this period was based on a mixture of traditional and newly introduced building techniques and materials. The industrialisation of manufacturing processes linked to mass production and efficient transportation by the increasingly extensive railway system reduced the cost of materials and components. Research and development of chemicals, metals and other base materials led to both new building materials and new ways of using existing materials. However, the basic principles of domestic construction did not change a great deal from those used in the seventeenth and eighteenth centuries.

Roof structure
Timber pitched roofs, generally of softwood, were formed with common rafters and often incorporated purlins. Trusses, including King Post trusses and Queen Post trusses, were commonly used. Mansard roofs were sometimes formed to provide accommodation or storage. Terraced houses often had a butterfly roof construction, the roof slopes draining to zinc or lead valley gutters that ran from front to back.

In speculative housing, flat roofs were only constructed for small projections, such as above bay windows. They were formed with softwood joists and boarding and covered with lead or zinc sheeting.
Roof coverings
These were normally of clay tiles or slates although the use of thatch or stone slates continued in some country areas. Clay tiles were supplied in a number of profiles including pantiles and plain tiles. Both of these had been in use for some time, but fell out of general use in the nineteenth century, although clay plain tiles became popular again in the Edwardian period. On the other hand, single and double roman clay tiles, first produced in the nineteenth century, were extremely popular roof coverings. Slates were produced in their millions during this period in Cornwall, Wales and the Lake District, and because of cheap rail transport were used as a roof covering throughout England and Wales.

Roof drainage
The roofs of cheaper houses drained to cast-iron ogee gutters fixed to fascia boards secured directly to the face of external walls. Parapet walls were commonly formed around the roofs of more expensive Victorian houses (and over party walls more generally) in the nineteenth century, but fell out of favour in the Edwardian period. Roofs behind parapet walls drained into parapet gutters of lead or zinc over softwood boarding, zinc being used for cheaper construction. Valley gutters, which were formed between two or more adjoining roof slopes, and hidden box gutters (which drained through a roof void) as well as flashings and soakers were also formed in lead or zinc.

External walls
Normally of solid construction and in a range of thicknesses similar to those set down for Georgian houses (see Part B). Early forms of cavity wall construction (known as hollow walls) were sometimes built from the 1830s onward, initially with vitrified clay wall ties, latterly ties of cast or wrought iron; sometimes, these metal ties were dipped in tar.

External walls were constructed of brickwork or stonework, sometimes a mixture of both. Frequently, stone details (or bricks of a different type) were provided around door and window openings and for stringcourses, plinths, quoins and other details. Other materials, such as terracotta (fine-grained and very durable unglazed fired clay of various colours) or faience (glazed fired clay) were also used for moulded facings and details. Vertical tile hanging became popular in the Edwardian period.

Brick, stone or terracotta arches provided structural support above door and window openings. Window sills were commonly formed in stone or terracotta. Timber lintels were commonly provided behind the masonry or brick external arches.

Many houses had basements, which were formed with thicker walls, as with Georgian houses (see Part B). Sometimes, external walls would be coated with asphalt externally (as an early form of vertical damp-proof membrane) before being covered up.

Bricks
Brick sizes gradually became standardised from 1850 onwards and, in 1859, mass production of bricks commenced. This enabled many varieties of machine-made brick to become available, e.g. Flettons from the 1870s.

Flemish bond was often used for more expensive property, while English bond was used for cheaper, speculative construction. Snapped header bond was also used where more expensive bricks with snapped headers (sometimes called blind headers) were used for the outer course, secured every so often to a solid inner wall so that it replicated Flemish bond in appearance. Another form of brick construction was rat-trap bond, where bricks were laid on edge in two skins and bonded by a through brick, i.e. a form of early cavity; it formed a cheaper, but not strong, wall.
Stonework
As in earlier periods, local stone was often used, especially where it was a readily available and cheap material. It was also transported to other parts of the country for more expensive housing and, as the century progressed and transportation costs dropped, for cheaper housing.

Buildings could be constructed wholly of stone or, frequently for reasons of cost, were built of brick with stone details. Often, a stone face was applied to a brick or cheaper stone backing. The stone could be finished in various ways, e.g. ashlar (smooth-faced) or rubble (crudely finished) and built in courses or in a random fashion.

Mortars
Throughout the nineteenth century, bricks were bedded in lime mortar, which was also used for stonework. Lime mortar sets slowly and because of its inherent flexibility can accommodate reasonable levels of initial settlement and other movement within a building.

Portland cement (PC) was invented in 1824 and by the end of the nineteenth century the use of PC mortar for brickwork was becoming popular. However, it was not in widespread use for residential buildings until after the First World War. However, while it was cheaper than lime mortar and had a fast set, it is a less flexible mortar, cracks more easily and is less tolerant of building movement.

Internal walls
Construction was similar to that used in the Georgian period, i.e. internal walls of common bricks or stonework; non-load-bearing walls of place bricks, i.e. improperly fired/soft bricks; walls normally only a half-brick thick, even for structural walls of tall buildings of several storeys, and faced with lime plaster. Internal partitions of timber studding, sometimes braced to act structurally, sometimes infilled with brick to give sound insulation, and all covered in lath and plaster were common.

Damp-proof course (DPC)
The Public Health Act 1875 made DPCs compulsory for new houses. A variety of DPCs were installed, including lead-cored felt, bituminous felt, two courses of dense (engineering) bricks or slates laid in cement mortar to break joints. Unfortunately, the (hessian-based) felts were often not installed with proper laps and joints and have degraded with age. Brick or slate DPCs laid in a cement mortar, being formed in rigid materials, were adversely affected by building movement and often failed to prevent rising damp due to the resultant cracks in the DPC.

Foundations
In the earlier years of the period, more expensive houses had some form of foundation which might be of stone slabs or, as the nineteenth century progressed, corbelled brickwork became more frequently used. Cheaper housing often had no foundation or merely a simple shallow layer of flat stones or of clinker. By the end of the century, concrete foundations (often with corbelled brickwork as well) were required for all buildings unless built on rock.

Windows, doors and joinery
Fully rebated timber sash windows were the norm throughout most of the period, although timber and metal casement windows did appear in the late Victorian period and the Edwardian period due to the influence of the Arts and Craft Movement and the development of Edwardian mock Tudor housing. Removal of the special taxes on glass (in 1845) and windows (in 1851) plus the development of plate glass in 1832 meant that, by the mid-1800s, the number of windows in a building was no longer restrained and larger panes of glass could be used. This also resulted in