BARRY'S INTRODUCTION TO CONSTRUCTION OF BUILDINGS

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Preface

Robin Barry's *The Construction of Buildings* was first published in 1958. The books quickly became an established source of information for students of building design and construction, with their popularity demonstrated in numerous reprints and revised editions. Since the late 1950s we have seen many changes in construction technology and the manner in which buildings are designed and constructed, some of which have been little more than passing fashions, many of which have had a lasting impact. Although some of our buildings may look very similar to those built in the past, the reality is that buildings are now built to higher performance standards and have to comply with far more extensive legislation than ever before. With the desire to build faster, cheaper and to higher standards we have seen a shift in emphasis from the building site to off-site production in remote factories, a growing trend, but one that is by no means universal. Currently it is possible to find highly industrialised processes sitting, quite literally, next to craft based activities and also to find new products and materials being used in conjunction with those that have been used for centuries. We have also started to develop a better awareness of the environmental impact both of construction activities and the building in use, combined with increased emphasis on the health and wellbeing of building users. When combined, these factors help to colour our approach to the construction of buildings and for students and practitioners alike these are exciting times.

In an attempt to reflect these changes and assist students in their studies we have embarked on a major revision of the Barry series. More specifically, we have revised the series in the light of changes to building regulations, standards and codes, changes in technologies and increased concern for the environmental impact of construction. In doing so we felt that we should re-design the five volume series and present it as a discrete two-volume set: *Barry's Introduction to Construction of Buildings* (previously *Barry 1, 2* and part of *5*) and *Barry's Advanced Construction of Buildings* (previously *Barry 3, 4* and part of *5*). The rationale behind using the words 'introduction' and 'advanced' is grounded in a recognition of how construction technology is taught in universities and colleges, with this volume addressed primarily to first year (Level 1) students and the advanced volume (currently in production) to second year (Level 2) students. Barry's original concept was based on the sound principle of introducing key functional/performance requirements for the main elements common to all buildings: a concept that has been maintained here, and an approach now common to the UK's building regulations. As part of the major update of the Barry series we have provided typical details and alternative approaches (where applicable), thus ensuring that the series is topical and relevant for work to new and existing buildings. We have also included photographs from construction sites in an attempt to further the understanding of the technologies described.

We are acutely aware of the fact that the Barry series can only deal with a limited range of 'concrete' issues. As such these two books provide an overview of construction methods that are intended as guidance for students learning the fundamentals of building construction. We are also conscious that this is an ongoing project and would welcome comments and suggestions for future editions. We hope that the spirit of the Barry series continues to inform and stimulate those interested and engaged in the construction of buildings.

Stephen Emmitt

Christopher Gorse

Acknowledgements

We are indebted to many people who have, in a variety of ways, helped us to realise the revisions to this work. Julia Burden was instrumental in giving us the chance to take on this project and once again Blackwell Publishing have retained their collective faith in our ability to deliver, for which we are very grateful. Over the years our students have continued to be the inspiration for writing books and they deserve our heartfelt credit for helping to keep our feet firmly on the ground by asking the 'why' and the 'how' questions.

Our colleagues and friends in industry and academia also deserve acknowledgement. In particular we would like to thank: Mike Armstrong at Shepherd Construction; Peter DraCup at Taylorwoodrow; Andrew Aitchison, Gavin Charlton, Ian Fawset, Michael Jenkinson and Stuart Gray at Bryant Homes; Dr Robert Ellis, David Highfield, Dr David Johnston and Dr David Roberts at Leeds Metropolitan University; Shaun Long at Fordham Jones (Cameron Taylor Group); and Gordon Throup.

We would also like to extend our gratitude to Taylorwoodrow and Bryant Homes for allowing access to their construction sites to see examples of good practice. We also extend our gratitude to Roger Bullivant Ltd for information and photographs of their precast concrete piles and ground beam system (Photographs 3.1 copyright Roger Bullivant Ltd).

The THERM program was used to generate Figure 5.64. This was supplied courtesy of Windows & Daylighting Group, Building Technologies Program, Environment Energy Technologies Department, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA, © Regents of the University of California.

1 Introduction

The aim of this short introductory chapter is to highlight some of the factors that determine how buildings are constructed and also to provide some context to the chapters that follow. An overview of the function and performance of buildings leads into a discussion about the basic principles of construction. The chapter concludes with some comments on legislation, making choices and sources of additional information.

1.1 The function and performance of buildings

Buildings are constructed, altered, upgraded, restored or demolished for a variety of reasons. Whether the aim is simply to provide more space or to make a financial gain from speculative development, all building projects need to fulfil a function and meet set performance requirements, no matter how fundamental or sophisticated the client's requirements may be.

Function

The primary function of a building is to provide shelter from our weather, a container for living, working and playing in. The principal functional requirements include:

- ❑ shelter
- ❑ security
- ❑ safety (and comfort)
- ❑ ease of use and operation (functionality)
- ❑ ease of maintenance, periodic repair and replacement
- ❑ adaptability and durability
- ❑ ability to recycle materials and components

The overall goal is to achieve these functions in an economical, safe and timely fashion using the most appropriate resources available.

Performance

The performance of the building will be determined by a number of interrelated factors set by the client, legislation and society. Clients' performance requirements will vary from project to project. However, the main considerations are likely to be:

- space, determined by a figure for floor area and/or volume
- thermal and acoustic performance
- design life and service life of the building and specific building elements
- cost of construction, cost in use and cost of demolition and recycling
- quality of the finished building
- appearance of the finished building

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

Design and constructability

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

Constructability (or buildability) is an approach to building design and construction that seeks to eliminate non-productive work on site, make the production process simpler and provide the opportunity for more efficient site management and safer working. Thus designing and detailing for constructability requires an understanding of how components are manufactured off site, as well as how the building is to be assembled (the sequence of work packages) on the site. The core message of constructability is more simplicity, greater standardisation, and better communication between designer, manufacturer and builder. These three principles also relate to the eventual disassembly of the building at some date in the future when materials will be recovered, reused and recycled, hopefully with minimal waste. Some of the practical considerations are concerned with:

- Time scale
- Availability of labour and materials (supply chain logistics)
- Sequence of construction and tolerances

- ❑ Reduction of waste (labour, materials and time)
- ❑ Protection from the weather
- ❑ Integration of structure, fabric and services
- ❑ Maintenance and replacement
- ❑ Disassembly and recycling strategies

Quality

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

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

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

(3) Quality of the finished artefact will be determined by a number of variables constant for all projects, namely the:
   - ○ interaction and characteristics of the participants engaged in design, manufacture and assembly
   - ○ effectiveness of the briefing process
   - ○ effectiveness of the design decision-making process and resultant information
   - ○ effectiveness of the assembly process
   - ○ effectiveness of communications
   - ○ time constraints
   - ○ financial constraints
   - ○ manner in which users perceive their built environment

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

Economics

The building site and the structures constructed on the land are economic assets. In addition to the cost of the land there are three inter-related costs to consider. The first is the initial cost, the cost of designing and erecting the building. This is usually the primary, and sometimes the only concern of clients and developers. It covers professional fees and associated costs involved in land acquisition and permissions, the capital cost of materials and components and the labour costs associated with carrying out the work.

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

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

Construction defects

Despite everyone's best intentions it is likely that some faults and defects will be found in the completed building. Some of these will be evident at the completion of the contract, others may not reveal themselves until some time in the future and are known as 'latent defects'. We can, for simplicity, divide defects into two categories: those concerning products and those associated with the process of design and construction.

Product defects

With the constant drive to improve the quality of materials and building components from the manufacturing sector it is unlikely that there will be a problem with building products; assuming that they have been carefully selected, specified correctly and assembled in accordance with the manufacturers' instructions. Reputable manufacturers have adopted stringent quality control and quality management tools to ensure that their products are consistently of a specified quality, are delivered to site to programme and technical support is available as required. A well-written performance specification or a carefully selected proprietary specification, combined with careful implementation on site should help to reduce or even eliminate product related defects. Problems can usually be traced back to hastily prepared specifications, cost cutting and specification of lesser quality products, and/or poor practice on the building site. Products recently launched on to the market and to a lesser extent products new to a particular design office carry an increased degree of uncertainty over their performance, and hence a perceived increase in risk.

Process defects

Problems with the process of design and construction are the most likely cause of defects. The design and construction process, regardless of the degree of automation, relies on people to make decisions and to implement the result of those decisions. Designers record and communicate their decisions primarily through drawings and the written specification. Thus the quality of the information and the timing of the delivery of the completed information (i.e. communication) will influence the likelihood of defects occurring. Quality of work on site will depend on the interpretation of the information provided, control and monitoring of the work. Design changes, especially during construction may cause problems with constructability and subsequent maintenance. If a fault or defect is discovered then it needs to be recorded, reported and appropriate action agreed to correct the defect without undue delay.

1.2 General principles of construction

Whatever approach we take to the design and erection of our buildings there are a number of fundamental principles that hold true. The building has to resist gravity and hence remain safe throughout its design life and substantial advice is provided in regulations and standards. Every building is composed of some common elements:

- Foundations (see Chapters 2 and 3)
- Floors (see Chapter 4)
- Walls (see Chapter 5)
- Roof (see Chapter 6)
- Windows and doors (see Chapters 7 and 8)
- Stairs and ramps (see Chapter 9)
- Surface finishes (see Chapter 10)
- Services (see Chapter 11 and 12)

It is vital for the success of the building project and the use of the constructed building that an integrated approach is adopted. It is impossible to consider the choice of, for example, a window without considering its interaction with the wall in which it is to be positioned and fixed.

Loadbearing construction

Masonry loadbearing construction is well established in the British building sector and despite a move towards more prefabrication, loadbearing construction tends to be the preferred option for many house builders and small commercial buildings (see Chapter 5). There is a heavy reliance on the skills of the site workers and on wet trades, e.g. bricklaying, plastering, etc. Quality control is highly dependent upon the labour used and the quality of the supervision on site.

In a typical loadbearing cavity wall construction the main loads are transferred to the foundations via the internal loadbearing wall. The external skin serves to provide weather protection and aesthetic quality. Primarily 'wet' construction techniques are employed.

Framed construction

Framed construction has a long pedigree in the UK, starting with the framed construction of low rise buildings from timber and followed by early experiments with iron and reinforced concrete frames. Subsequent development of technologies and industrial production have resulted in three main materials being used for low-rise developments: timber, steel and concrete. Framed construction is better suited to pre-fabrication and off-site manufacturing than masonry loadbearing construction. Dry techniques are used and quality control is easier because the production process is repetitive and a large amount of the work is carried out in a carefully controlled environment. Site operations are concerned with the correct placement and connection of individual component parts in a safe and timely manner.

In a typical framed cavity wall construction the main loads are transferred to the foundations via the structural frame. The external skin serves to provide weather protection and aesthetic quality. It is common in England to clad timber and steel framed buildings with brickwork, thus from external appearances it may be impossible to determine whether the construction is framed or loadbearing (see Photograph 1.1).

Pre-fabrication and off-site production

Post-Egan the emphasis is firmly on pre-fabrication and off-site production. This is, of course, only one of many different approaches and is usually more suited to repeat building types than one-off projects. However, the range of prefabricated units is expanding and considerable improvements in product quality and health and safety may be made through the use of prefabricated components and proprietary systems. This has tended to move the skills away from the building site into the controlled environment of the factory. Site operations become limited to the lifting, positioning and fixing of components into the correct position and emphasis is on delivery of components to site 'just in

A

B

Photograph 1.1 Timber framed construction (courtesy of D. Johnston).

time' and the specification of the correct tolerances to allow operations to be conducted safely.

Tolerances

In order to be able to place individual parts in juxtaposition with other parts of the assembly a certain amount of dimensional tolerance is required. Construction involves the use of labour, either remote from the site in a factory or workshop, or on site, but always in combination. Designers must consider all those who are expected to assemble the various parts physically into a whole, including those responsible for servicing and replacing parts in the future, so that workers can carry out their tasks safely and comfortably.

With traditional construction the craftsmen would deal with tolerances as part of their craft, applying their knowledge and skill to trim, cut, fit and adjust materials on site to create the desired effect. In contrast, where materials are manufactured under carefully controlled conditions in a factory, or workshop, and brought to site for assembly, the manufacturer, designer and contractor must be confident that the component parts will fit together since there is no scope to make adjustments to the manufactured components. Provision for variation in materials, manufacturing and positioning is achieved by specifying allowable tolerances. Too small a tolerance and it may be impossible to move components into position on site resulting in some form of damage; too large a tolerance will necessitate a degree of 'bodging' on site to fill the gap – for practical and economic reasons both situations must be avoided. There are three interrelated tolerances that the designer must specify, which are related specifically to the choice of material(s).

(1) **Manufacturing tolerances** Manufacturing tolerances limit the dimensional deviation in the manufacture of components. They may be set by a standard (e.g. ISO), by a manufacturer, and/or the design team. Some manufacturers are able to manufacture to tighter tolerances than those defined in the current standards. Some designers may require a greater degree of tolerance than that normally supplied, for which there may well be a cost to cover additional tooling and quality control in the factory.
(2) **Positional tolerances** Minimum and maximum allowable tolerances are essential for convenience and safety of assembly. However, whether the tolerances are met on site will depend upon the skills of those doing the setting out, the technology employed to erect and position components and the quality of the supervision.
(3) **Joint tolerances** Joint tolerances will be determined by a combination of the performance requirements of the joint solution and the aesthetic requirements of the designer. Functional requirements will be determined through the materials and technologies employed (see below). Aesthetic requirements will be determined by building traditions, architectural fashion and the designer's own idiosyncrasies.

As a general rule the smaller (or closer) the tolerance, the greater the manufacturing costs and the greater the time for assembly and associated costs. Help in determining the most suitable degree of tolerance can be found in the technical literature provided by trade associations and manufacturers. Once the tolerances are known and understood in relation to the overall building design it is possible to compose the drawings and details that show the building assembly. Dimensional coordination is important to ensure that the multitude of components fit together correctly, thus ensuring smooth operations on site and the avoidance of unnecessary waste through unnecessary cutting. A modular approach may be useful, although this may not necessarily accord with a more organic design approach.

Alternative approaches

There are a wide variety of approaches to the construction of buildings and with increased attention focused on ecologically friendly construction a number of different approaches are possible. Some have their roots in vernacular architecture and others in technological advancement, although most approaches combine features present in both old and new construction techniques. Strategies adopted can include, for example, the re-use of salvaged and recycled materials from redundant buildings, designing buildings that may be disassembled with minimal damage to the components used, buildings that are designed to decompose after a predetermined time frame, incorporation of renewal energy sources, etc. Care is required as many of these methods are largely untried (or the techniques have been forgotten) and it will take some time before we can really know for certain how they perform insitu. We do, however, urge all readers to consider the impact on the environment of their preferred construction method by adopting a whole life approach to the design, construction and use of buildings. With space in this book at a premium we can only highlight a few examples, but urge readers to investigate the issues for themselves before making a decision as to what construction method(s) to employ.

1.3 Regulations and approvals

Regardless of the approach adopted, a number of approvals need to be in place before building work commences. The two main consents required are from the appropriate planning authority and building control, both of which will be determined by the location of the construction site.

Planning consent

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

Building control and building regulations

During the last 50 years there has been a considerable increase in building control legislation, which initially was the province of local authorities through building bylaws and later replaced by national building regulations. In the UK building control is governed by three differing, though broadly similar sets of legislation, for England and Wales, Northern Ireland and Scotland respectively. Building regulations aim to ensure the health and safety of people in and around buildings by setting functional requirements for the design and construction of buildings. The regulations also aim to promote energy efficiency of buildings and contribute to the needs of people with disabilities, and in the case of the Scottish legislation promote sustainable development.

In England and Wales the Building Act 1984 and Building Regulations (1985) set out functional requirements for buildings and health and safety requirements that may be met through the practical guidance given in the Approved Documents; these in turn refer to British Standards and Codes of Practice. In Northern Ireland construction is covered by the Building Regulations (Northern Ireland) 2000 with Approved Documents, similar to those for England and Wales.

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

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

Although the guidance in this book is meant to be as broad as possible, when we make specific reference to regulations we have, both for consistency and to avoid confusion, worked to the Approved Documents for England and Wales. However, the principles for readers in Northern Ireland and Scotland are broadly similar, differences in detailing buildings arising from a combination of legislation, response to local climate and building tradition. Full details of the Acts as well as the Approved Documents and Guidance Documents are available online (see Appendices).

Robust details

One of the latest developments linked to the Approved Documents (for England and Wales) is the publication of 'Robust Details'. The aim of the Robust Details is to assist the construction industry in achieving the performance standards published in Approved Document L1, by specifying performance standards and providing details (drawings) that show the intersection of various components. The details are intended to reduce risks and problems that can arise as a result of building to higher energy efficiency standards and, in the spirit of the Approved Documents, are intended as guidance. The Robust Details aim to reduce risk and uncertainty relating to:

- Interstitial condensation, which can deteriorate the structure
- Surface condensation, which can lead to mould growth
- Blockage of essential ventilation paths, which can lead to condensation building up
- Risk of rain penetration
- Higher heat loss than assumed/calculated
- Higher air leakage than assumed/calculated

The details have been prepared by the Department of Transport, Local Government and the Regions (DTLR) with support from the Department for Environment, Food and Rural Affairs (DEFRA). Current regulations and consultation papers are available from the office of the Deputy Prime Minister (see Appendices).

Associated legislation

In addition to the legislation set down in the Building Regulations, other legislation affects the way in which buildings are designed and built. For example, health and safety and fire safety legislation is covered in a number of documents that sit alongside the Approved/Guidance Documents. The European Union Council Directive 89/106/EEC (1988), the Construction Products Directive (CPD), requires all construction products to satisfy the Essential Requirements, which deal with health and safety issues, namely: Mechanical resistance and stability, Safety in case of fire, Hygiene, health and environment, Safety in use, Protection against noise, and Energy economy and heat retention. Over 600 CEN standards have been mandated under the CPD.

1.4 Making choices and sources of information

The design and construction of buildings is concerned with making choices. Decisions have to be made about the design of the building and its details, which necessitates the selection of materials and components to realise the design intention and aspirations of the client. At the construction stage decisions have to be made about what mechanical plant to use, how best to sequence the work so that operations are conducted safely and efficiently and what to do when an unexpected problem occurs. The contents of this book are designed to assist with that decision-making exercise.

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

Sources of information

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

- ❑ Building Regulations and Codes
- ❑ British (BS), European (CEN) and International (ISO) standards
- ❑ British Board of Agrément (BBA)
- ❑ Building Research Establishment (BRE) publications
- ❑ Trade associations' technical literature
- ❑ Manufacturers' technical literature
- ❑ Technical reports in journals and the trade press

A note of caution

Finally, we must end this introductory chapter with a note of caution. Before proceeding any further it is necessary to make an important observation about the contents of this book. The principles and details illustrated here are meant as a guide to the construction of buildings. The details should not be copied without thinking about what is really going on, how the building is to be assembled and whether or not the detail in question is entirely suitable for the task in hand. We make this point because approaches to detailing and to construction vary from region to region (e.g. a building located in a wet and sheltered area of the UK may benefit from a pitched roof with a large overhang, but a similar building in a dry and exposed part of the country may benefit from a pitched roof with clipped eaves or even a flat roof). Building practices also differ from country to country (for example England and Denmark) and so it is impossible to cover every eventuality for every reader. Instead we would urge readers to engage in some critical thinking, analyse the details and seek out alternative approaches where necessary. Buildings exist within a local context and they should be detailed to be in harmony with nature. The other point we must make is that regulations and building practices will change over time, therefore this book should carry a 'best before date'; as the regulations change some of the details will need to be revised. On a more positive note, the details will be a useful source of reference for readers involved in refurbishment and conservation projects at a future date. Our advice is to work closely with consultants, manufacturers and suppliers with the aim of applying their specialist knowledge to the benefit of the construction process, thinking critically and making informed decisions.

Further reading

Bett, G., Hoehnke, F. and Robinson, J. (2003) *The Scottish Building Regulations Explained and Illustrated* (*Third edition*), Blackwell Publishing, Oxford.

Billington, M.J., Simons, M.W. and Waters, J.R. (2003) *The Building Regulations Explained and Illustrated* (*Twelfth edition*), Blackwell Publishing, Oxford.

Emmitt, S. (2002) *Architectural Technology*, Blackwell Science, Oxford.

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2 Site Analysis and Set-up

The physical characteristics of the site and its immediate environment will influence the decisions to be made about a building's design and construction. The information gathered from a thorough site analysis is, therefore, a vital exercise and must be completed before any construction work commences. This information can then be collated in a performance appraisal document from which informed decisions about the best way to proceed may be made.

2.1 Function of the site analysis

Prior to any construction operations, the client/developer will want to know whether it is economically viable to build on the proposed site. As the nature and condition of the ground and soil below the site are an unknown quantity they pose a considerable risk to the construction project, with the potential to cause delays and additional costs, both of which can be substantial. Inadequate soil investigation and hence inappropriate foundation design can lead to structural problems at a later date, which is a problem for the building owners and users as well as the building insurers. Many projects are built on brownfield sites (land that has been previously built on and used) and it may be necessary to seal, stabilise or remove any contaminated ground, toxic waste or other dangerous substances before commencing the main construction works. The extent of contamination must be established before any work commences on the site.

The main purpose of site analysis is to identify and hence reduce the risks associated with the development by recording site features and soil characteristics, helping to determine the design and cost of suitable foundations and structure. A thorough site analysis is an essential first step that will assist development, design and construction decisions. The site analysis helps:

- The client to assess whether the project is viable
- The client, designer, structural engineer and contractor to locate the best position for the building, avoiding identified problems where possible and making the best possible use of physical features and environmental conditions
- The engineers to design the most suitable foundation system
- The mechanical and electrical consultants to design the service provision
- The designers and contractor to ensure that safe construction methods are used

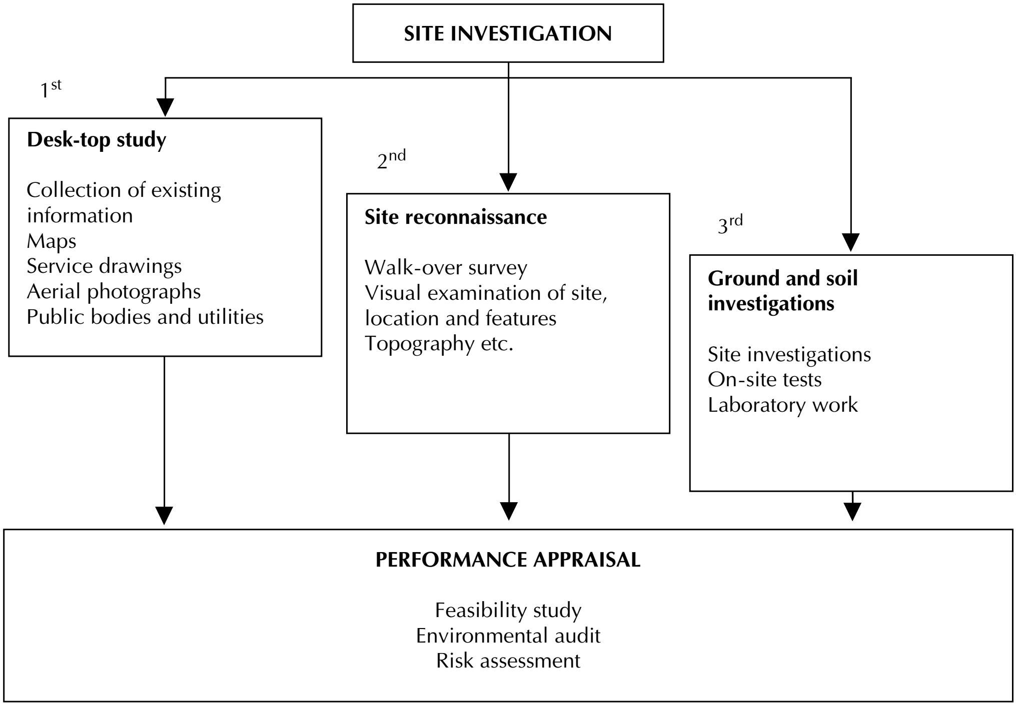

Figure 2.1 Sequence of site analysis.

- The environmental consultants to identify the most suitable way of dealing with any contaminants and problem materials, e.g. remediation works, material re-use, on-site treatment and disposal options.

Sequence of activities

The site analysis comprises three inter-related research activities; the desk-top study, the site reconnaissance and the ground and soil investigations. The soil investigation may also involve laboratory tests on liquids and gases found in soil samples. The order in which these activities are carried out will depend to a large extent on the nature of the development and the timescales involved. However, the preferred sequence of overlapping activities is shown in Figure 2.1.

2.2 The 'desk-top' study

The 'desk-top study' is a vital element in any site analysis exercise. The study involves the collection of all documents and materials that can be obtained without having to visit the site. There is a considerable amount of information available from local and national authorities, museums, private companies and research groups. The client or previous owners may also have relevant information to hand.

Although the different site investigation operations often overlap, care should be taken not to commence with expensive ground exploration and soil tests before the desk-top study is completed. This is partly to avoid unnecessary work and expenses – for example, information from the desk-top study may reveal that recent site and soil investigations are available – and partly a health and safety issue since the approximate location of services and potential hazards must be known before carrying out any physical investigations. Early and thorough investigation of the available information may also show that the site is unsuitable for development or that special measures are required before proceeding further.

Information required

Ownership(s) and legal boundaries

The client should provide, via a legal representative, information pertaining to the exact location of the site boundaries and responsibilities for maintaining the boundaries. These will need to be checked against a measured survey and any areas of uncertainty checked by the legal representative. Other issues to be determined by the client's legal representative include:

- ❑ Rights of way
- ❑ Rights of light
- ❑ Rights of support (for adjoining properties)
- ❑ Legal easements
- ❑ Ownership of land (essential where parcels of land are being assembled to make a larger site)
- ❑ Rights of tenants, etc.

Ground conditions

As a first step it is usual to collect information on soil and subsoil conditions from the county and local authority, whose local knowledge from maps, geological surveys, aerial photography and works for buildings and services adjacent to the site may in itself give an adequate guide to subsoil conditions. In addition geological maps from the British Geological Survey, information from local geological societies, Ordnance Survey maps, mining, river and coastal information may be useful.

Services

All suppliers of services should be contacted to confirm the position of pipes and cables and the nature of the existing supply.

Contaminated land and methane
Previous use of land can give some clues as to the likely contaminants to be found and the local authority may have records that can help. However, extensive soil testing should be carried out to ascertain the nature and extent of any contamination. (See also Chapter 3.) Methane is associated with landfill sites, and local knowledge of old tips can prove useful at an early stage.

Radon
In certain areas of the UK, radon gas occurs naturally within the underlying ground and poses a threat to the inhabitants of buildings. Local authorities provide advice on the likely level of contamination and will advise on the extent of protection required to prevent the radon from entering the building.

Mining activity
The UK has a long and varied history of mining. Coalmining is the most common; however, certain geographical areas may have specific mining issues, for example salt mining in areas of Cheshire and tin mining in Cornwall. The position of mines and mine shafts, and their size, depth and condition may affect the positioning of buildings on a site and work to make old workings safe may add significant costs to the development proposal.

Flooding
Flooding of buildings and the subsequent damage to property and possessions and the associated disruption to businesses and family life has become a serious concern in recent years, as the frequency of flooding has increased. Factors include heavy rainfall, buildings sited on flood plains and inadequate maintenance of rivers and watercourses. Thorough checks should be made about previous flooding of the proposed site (if any) and any special requirements suggested or required by the various authorities.

Typical sources of information

Information will always be site-specific; however, the following list of information sources serves as a general guide:

- ❑ Ordnance Survey – detailed maps in many different formats are available from Ordnance Survey customer information, Romsey Road, Southampton S016 4GU (www.ordnancesurvey.co.uk)
- ❑ Historical maps (www.old-maps.co.uk) – local libraries
- ❑ Geological maps – the British Geological Survey is the national repository for geosciences data in the UK. Information provided includes maps, records and materials, including borehole cores and specimens from across the UK. Address: London Information Office, British Geological Survey,

Earth Galleries, Natural History Museum, Exhibition Road, London SW7 2DE (www.bgs.ac.uk)

- Hydro geological maps – soil reports and publication lists are obtainable from soil survey and Land Research Centre, Cranfield University, Silsoe, Bedford MK 45 4DT
- Meteorological information – monthly and annual reports are available on air temperature, wind speed, rainfall and sunshine. Such information is useful for construction and potential use of the building. Statistics on averages and extremes for various elements are also available. The Met Office, Room JG6, Johnson House, London Road, Bracknell, Berks RG12 2SY (www.metoffice.gov.uk)
- Hydrological information – surface water run-off data are collected by water authorities, private water undertakings and local authorities
- Site history:
  - previous owners and developers
  - site surveys and drawings used for previous development
  - records held by Building Control
  - local newspaper archives
  - records held by the local planning authority
- Gas supplier – location of gas mains
- Electricity supplier – location of electricity cables
- Electricity generating board – mains electricity cables
- Water suppliers – water supply mains
- Mains sewers
- Local authority – local sewers
- Telecommunications authority – telephone and optical cables
- Rail authority – railways
- British Water Board – canals
- British coal – underground working building inspector
- Aerial photographs – there are many collections of aerial photographs dating back over many decades. A directory of organisations and agencies that hold aerial photographs can be obtained from Publications Department, Aslib, The Association for Information Management, Information House, 20–24 Old Street, London EC1V 9AP

2.3 Site reconnaissance

Written permission should be acquired from the client and/or owners before entering the site and especially before any invasive investigations are carried out (which may require separate written permission). Obvious considerations are related to trespass and criminal damage, although the prime concern must be the safety of those doing the investigations. The majority of sites will have been used previously (and may still be in use) and may contain buildings that may be structurally unsound (which may be redundant or still in use despite