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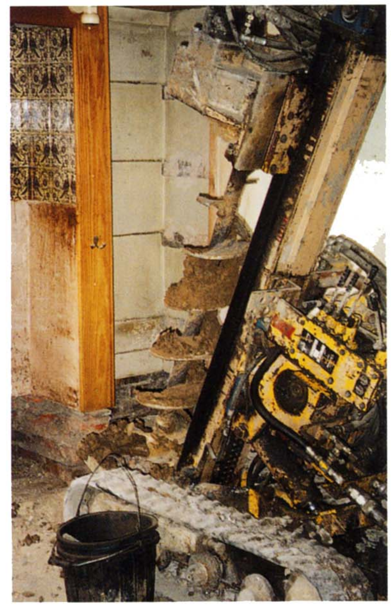
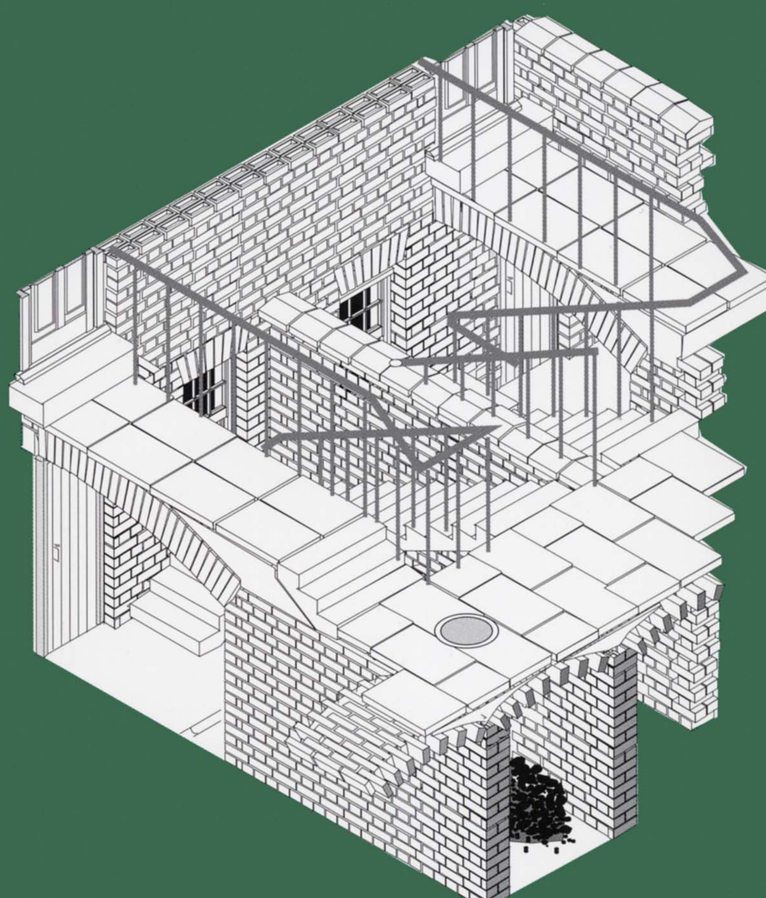


BRE Building Elements

Foundations, basements and external works

H W Harrison
and
P M Trotman

Performance, diagnosis, maintenance, repair and the avoidance of defects



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BRE Building Elements

Foundations, basements and external works

Performance, diagnosis, maintenance, repair and the avoidance of defects

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Contents

Preface

This book is the fifth of the BRE Building Elements books and completes the planned series which was begun in 1996. The first four books are *Roofs and roofing* (first published in 1996), *Floors and flooring* (1997), *Walls, windows and doors* (1998) and *Building services* (2000).

Readership

As with the other books, *Foundations, basements and external works* is addressed primarily to building surveyors and other professionals performing similar functions; for example, architects and builders who maintain, repair, extend and renew the national building stock. Surveyors and architects undertaking routine surveys of existing buildings may identify site problems or issues – in particular concerning the behaviour of foundations – which need to be referred to specialists for advice. The larger non-domestic buildings built in the second half of the twentieth century, and perhaps even some in the first half of the century – the standard textbooks of the time were quite explicit – will most likely have had the benefit of adequately designed foundations. In the case, though, of relatively small buildings such as houses, many decisions concerning ground and foundations will have been made by building professionals who had little or no training in geotechnical engineering.

Some topics, such as deterioration in drainage installations, may often be amenable to straightforward rectification, but other aspects, such as the installation of dampproofing in basements, may be outside the experience of individual surveyors. Clients need to be advised on when to call in other consultants to rectify existing problems. The book is certainly not addressed to the geotechnical engineer or the landscape architect, though it will in all probability find application in the education field.

Scope of the book

The descriptions and advice given in this book concentrate on practical details. But there also needs to be sufficient discussion of principles to impart understanding of the reason for certain practices. In previous books in this series, some of the information which applied generally to the subject matter of the book was given in Chapter 1, but here the topics, though all closely related to the site, are rather more disparate, and the principles which govern practice will in consequence be found dispersed in individual chapters.

Included in foundations and basements is all work below DPC level, including strip foundations, piles, retaining walls to basements; but not including ground floor slabs or rafts, which were included in *Floors and flooring*, and building services within the footprint of the building, which were included in *Building services*.

Many points relating to the use of particular materials in close proximity to the ground, such as the durability of brick, block and concrete have been dealt with in *Walls, windows and doors* to which reference can be made.

Large civil engineering structures such as port installations, bridges and tunnels, underground car parks and very large non-building structures such as storage tanks are excluded from the scope of this book.

Included in external works are all items outside the building footprint but inside the site boundary, encompassing wastewater and surface water drains, supply of utilities (eg gas, electricity and cabled services), footpaths, and access for vehicles including car parks and hard standings to be found in the vicinity of buildings. Perimeter and freestanding boundary walls are also dealt with, as is security fencing and, in outline only, lighting; CCTV surveillance systems, though, are normally left in the hands of specialist consultants and contractors, and are therefore not covered in detail.

With such a broad scope, it will be apparent that only brief reference can be made to most topics, and the text therefore concentrates on those aspects with which BRE has been most heavily involved, whether in laboratory research, site investigation or development of legislation.

In principle, all types of buildings are included. However, it is inevitable that the nature of foundations becomes very sophisticated in some building types such as those which are very tall, and these installations rarely lend themselves to simple guidance for use by non-specialists. Indeed, there may well be no professional role whatsoever for them in this respect. However, even the relatively simple systems used in the majority of domestic construction provide adequate potential for improvement.

Foundations, basements and external works is not a manual of construction practice, nor does it provide the reader with the information necessary to design foundations, basements or external works. Both good and bad features of these elements are described, and sources of further information and advice are offered. The drawings are not working drawings but merely show either those aspects to which the particular attention of readers needs to be drawn, or simply provide typical details to support text. The discussion, for the most part, is deliberately neutral on matters of style and aesthetics and is wary of suggesting that there is ever a unique optimum solution.

In a similar fashion to the other books in this series which deal with other building elements, the present text concentrates on those aspects relating to the subject matter of the book, in this case the site, and which, in the experience of BRE, lead to the greatest number of problems or greatest potential expense if carried out unsatisfactorily. It follows that these problems will be picked up most frequently by maintenance surveyors and others specifying and carrying out remedial work. Occasionally there is information relating to an item, perhaps a fault, which is infrequently encountered, and about which it may be difficult to locate information. Although most of the information relates to older buildings, much material concerning observations by BRE investigators of new buildings under construction in the period from 1985 to 1995 is also included.

The case studies provided in some of the chapters are selected from the files of the BRE Advisory Service, and the former Housing Defects Prevention Unit, and represent the most frequent kinds of problems on which BRE has been consulted.

The standard headings within the chapters are repeated only where there is a need to refer the reader to earlier statements or where there is something relevant to add to what has gone before. An exception to the sequence of standard headings occurs in Chapter 2.1 where the amount of material to be described requires a further breakdown into diagnosis, monitoring and remedial work. Chapter 3 also does not follow the standard headings; it was found to be more appropriate to deal separately with structure and waterproofing of basements which is reflected in the sub-chapter headings.

In the United Kingdom, there are three different sets of building regulations: The Building Regulations 1991 which apply to England and Wales; The Building Standards (Scotland) Regulations 1990; and The Building Regulations (Northern Ireland) 1994. There are many common provisions between the three sets, but there are also major differences. The book has been written against the background of the building regulations for England and Wales, since, although there has been an active Advisory Service for Scotland and Northern Ireland, the highest proportion of site inspections has been carried out in England and Wales. The fact that the majority of references to building regulations are to those for England and Wales should not make the book inapplicable to Scotland and Northern Ireland.

Although practically all topics relating to the construction of buildings are encompassed in the Construction (Design and Management) Regulations 1994, the ramifications for each of the topics covered in this book are quite different. It is therefore not practical to spell them out, beyond noting that there must be a Health and Safety Plan and File for all construction work which should include information on how to manage health and safety issues after the installation is completed and throughout its life until demolition[(1)].

Design criteria

While this book is mainly about existing buildings and not specifically about the design of new buildings, it has been necessary in several circumstances to give some design criteria so that subsequent performance of the completed building may be assessed against what was required or intended.

Some important definitions

The term ‘footprint’ has been used to describe the area actually covered by the building fabric. Note that this term is not synonymous with the term curtilage, as used in legislation, which in its normally accepted meaning includes any ground forming a part of the enclosure within which the building stands.

The term ‘surcharge’ as used in this book has two distinct meanings: a preloading of the ground (eg to induce consolidation), and a condition in which water is held under pressure within a gravity drain, but which does not escape to cause flooding.

So far as water terms are concerned, there has been a significant change in usage since the 1980s. The term ‘potable water’ to describe water of a quality suitable for drinking is now no longer popular though it is still contained in current Standards, and the words ‘drinking’ and ‘wholesome’ to describe water are preferred.

The use of the term ‘foul water’ in relation to sewage has fallen out of official use, being superseded by the term ‘wastewater’ which is often more closely defined as ‘greywater’ or ‘blackwater’; ‘greywater’ is wastewater not containing faecal matter or urine, ‘blackwater’ is wastewater that contains faecal matter or urine. However, for the purposes of this book, we tend to retain the term foul water when referring to greywater and blackwater; wastewater, though, can include surface water (eg run-off from car parks).

The term ‘aerobic’ indicates conditions in which free oxygen is present, and ‘anaerobic’ in which it is not present.

Since the book is to a considerable extent about the problems that can occur in the below-ground fabric of buildings, two words, ‘fault’ and ‘defect’, need precise definition. Fault describes a departure from good practice in design or execution of design; it is used for any departure from requirements specified in building regulations, British Standards and codes of practice, and the published recommendations of authoritative organisations. A defect – a shortfall in performance – is the product of a fault, but while such a consequence cannot always be predicted with certainty, all faults have the potential for leading to defects. The word failure has occasionally been used to signify more serious defects and catastrophes.

Where ‘investigator’ has been used, it covers a variety of roles including a member of BRE’s Advisory Service, a BRE researcher or a consultant working under contract to BRE.

Particular terms relating to topics under discussion will be found in the various chapters which follow.

Acknowledgements

Photographs which do not bear an attribution have been provided from our own collections or from the BRE Photographic Archive, a unique collection dating from the early 1920s.

To the following colleagues, and former colleagues, who have suggested material for this book or commented on drafts, or both, we offer our thanks:

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HWH
PMT
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Chapter 2.2 Old brick and stone footings

Before the introduction of concrete strip foundations for masonry walls, it was common practice to provide masonry footings wider than the wall above in order to spread the imposed load on the soil. Where the ground was of poor bearing capacity, with high water tables leading to boggy areas, there may even have been brushwood faggots or fascines placed beneath the footings in the hope of improving bearing capacity.

As well as describing the lower courses of corbelled brickwork, this chapter deals with masonry below DPC level – particularly its durability.

Characteristic details

Basic description

In Georgian and Victorian times the foundations of small buildings tended to be very shallow in depth, often no more than half a dozen or so courses of bricks. This brickwork below ground level was often stepped in order to spread the load, as shown in Figure 2.24. Before the widespread introduction of concrete in footings towards the end of the nineteenth century, unless the walls were founded on rock, progressively wider courses of bonded masonry were absolutely necessary to spread loads over adequate widths of subsoil. It was common practice to use as many bricks as possible laid as headers, that is to say, normal to the line of the wall so that the corbelling action was maximised. Where the wall was of stone, the same principle would apply, with the maximum use of through stones (Figure 2.25).

Local authority byelaws in the last years of the nineteenth century required the course above the concrete to be twice the width of the wall to be carried, with successive courses above that reducing by quarter brick width each side until the required thickness of wall was achieved. In modern construction, this stepped profile has been dispensed with as a simple mass concrete strip adequately distributes the load.

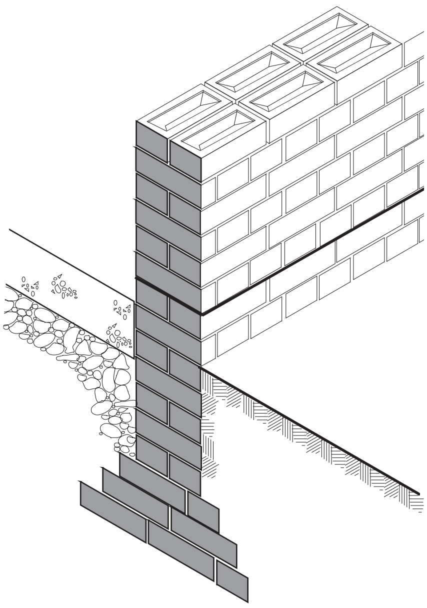

Figure 2.24 Maximum use of brick headers in footings gives the best loadbearing qualities

Main performance requirements and defects

Strength and stability

There is an important difference between the behaviour of brickwork built in lime mortar, and brickwork built in cement mortar. Masonry footings which used lime mortars are much more tolerant of movement than are those built with cement mortars, the ductile nature of the lime mortar allowing the bricks to move slightly relative to each other when under stress. In consequence, footings of buildings built before the 1930s, before lime mortars began to be superseded by cement mortars, are much less likely to crack when the soils on which they are founded shrink or heave.

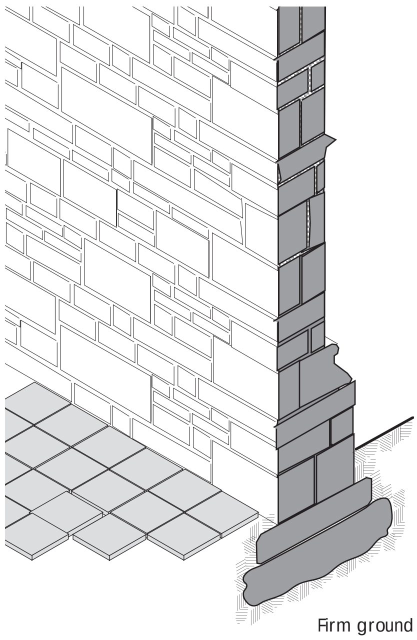

Figure 2.25 Typical stone footings widely used until the end of the nineteenth century

Figure 2.26 A narrow diameter hole has been excavated in a confined space alongside a one brick solid external wall to establish the depth and width of what turned out to be brick footings. Both depth and width had to be established by probing with a long crowbar. The footings were on shrinkable clay, and were unusually deep for an Edwardian house. Tree roots are visible in the sides of the excavation

Figure 2.27 A variety of contaminants has obviously been in contact with this 100 year old clay brickwork below DPC level, but only minor damage has resulted. There is also evidence of previous alterations and some repointing

Where alterations are to be made to an old building, it is crucial to expose and measure any masonry footings, and to carry out an assessment of the loadbearing capacity of the soil on which they are carried (Figure 2.26).

Durability

It should be noted that discussion of this topic in this chapter applies only to those materials used below ground level. Different considerations apply to materials used above ground level, and reference should be made to the appropriate parts of *Walls, windows and doors*[101].

Only a few influences are known to reduce the normally indefinite life of materials recommended for construction of foundations, the most significant of these being sulfate attack and frost. Mortar for brick and blockwork can have very variable durability. Breakdown may be hastened by the use of unsuitable, poor quality or incorrectly prepared materials. The relevant codes give extensive guidance on the preferred specifications for given circumstances. Local building control departments should have information on the presence of aggressive soil or groundwater in particular areas. Where any doubts exist, samples should be taken for analysis.

Washing out mortar from footings or fines from the ground beneath foundations can result from leaking water mains or drains.

Clay bricks

So far as the bricks themselves are concerned, there is a wide range of performance. Engineering bricks are highly durable, the inherently good resistance of these materials being due principally to their low porosity. The deterioration of brick depends on the nature of the contamination to which it is exposed, and can occur as a result of either a chemical interaction with the ceramic materials – leading to the dissolution of the glassy phase, which in some cases can constitute as much as 60% of the brick – or a physical expansion mechanism due to the crystallisation of salts within the brick pores[77]; this is potentially a more serious problem (Figure 2.27). The salts are transported by water to the interior of the brick and can derive from the external environment or from the rehydration of the soluble phase of the brick. The most deleterious salts are those that are readily hydratable (eg sulfates of sodium and calcium).

The site of crystallisation is determined by the dynamic balance between the rate of evaporation of water from the brick surface and the rate of solute migration to the site of crystal growth. If the rate of solute migration is faster then the rate of evaporation, then crystallisation occurs on the surface of the brick (efflorescence). Although efflorescence is unsightly it is not harmful. If the rate of solute migration is slow, or if the salt is relatively insoluble, crystallisation will take place within the pores of the brick. This is usually referred to as sub-florescence or cryptoflorescence, and it can result in delamination, flaking and spalling[77].

A more detailed explanation of the effect of crystallisation of soluble salts on clay bricks is to be found in Chapter 2.2 of *Walls, windows and doors*.

Calcium silicate bricks

Calcium silicate bricks are resistant to attack by most sulfate salts in the soil and groundwater. The durability of calcium silicate bricks under salt crystallisation attack can be attributed to a combination of their very low soluble salt content, and their low porosity and coarse pore structure. However, calcium silicate bricks may be attacked by high concentrations of magnesium and ammonium sulfate. They may also suffer severe deterioration if they are impregnated by strong salt solutions, such as calcium chloride or sodium chloride, and then subjected to frost[77].