Chapter

4.4

Raft, pile, pier and beam foundations

This chapter gives guidance on meeting the Technical Requirements for raft, pile, pier and beam foundations.

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4.4.1 Compliance

Also see: Chapter 2.1

Raft, pile, pier and beam foundations shall comply with the Technical Requirements and provide adequate support to load-bearing elements.

Raft, pile, pier and beam foundations that comply with the guidance in this chapter will generally be acceptable.

Relevant Standards and codes of practice include:

BS 8004	Code of practice for foundations
BS EN 1991	Actions on structures
BS EN 1992	Design of concrete structures
BS EN 1997-1	Geotechnical design — General rules
BS 10175	Investigation of potentially contaminated sites. Code of practice

Elements of the building requiring foundations include:

- external walls
- separating (party) walls
- internal load-bearing walls
- chimney breasts
- piers
- sleeper walls
- internal masonry walls.

4.4.2 Provision of information

Designs and specifications shall be produced in a clearly understandable format, include all relevant information and be distributed to all appropriate personnel.

All dimensions and levels should be indicated and relate to at least one benchmark and reference point on site. Design and specification information should be issued to site supervisors, relevant specialist subcontractors and/or suppliers, and include the following information:

- dimensions, type and depth of foundations
- detailing of ducts
- junctions
- steps
- movement and construction joints
- location of services
- critical sequences of construction.

Both designers and site operatives need to be aware of:

- ground conditions
- any features requiring special attention, such as existing sewers or other services
- water table levels
- the presence of any hazardous substances, including sulfates.

4.4.3 Site conditions

Also see: Chapters 5.2 and 4.1

Raft, pile, pier and beam foundations shall be designed to take account of site conditions. Issues to be taken into account include:

1) **the results of the site and ground appraisal**
2) **dwelling design, layout and site levels**
3) **trees and hedges**
4) **frost susceptible soils**
5) **potential for differential settlement.**

4.4.3.1 Site and ground appraisal

All information relating to the site and its ground conditions which is necessary for full and proper foundation design should be obtained.

Building over changes in ground characteristics should be avoided.

4.4.3.2 Dwelling design, layout and site levels

Foundation design should take account of site layout, shape, size and construction of the dwelling.

Stepped foundations and suspended floors may be required for sloping sites.

4.4.3.3 Trees and hedges

Where the soil is shrinkable and nearby trees and hedges are existing, proposed or have been recently removed, foundations should be designed as shown in Chapter 4.2 Building near trees.

4.4.3.4 Frost susceptible soils

To avoid damage from frost action, the depth to the underside of the foundation in frost susceptible ground should be at least 450mm below finished ground level.

4.4.3.5 Differential settlement

Foundations should be designed to avoid any local stress points or any differential settlement.

Foundations for terraced homes, or those adjoining an existing building, may require special precautions to prevent damage from differential settlement. Foundations for attached bays, porches, garages, conservatories and other structures should be a continuation of those for the main home, unless the design indicates an alternative which takes account of differential movement.

4.4.4 Hazardous ground

Also see: Chapters 3.1, 4.1, 4.2 and BRE Special Digest 1

Raft, pile, pier and beam foundations shall take account of ground conditions and hazards. Where hazardous ground has been identified, notice shall be given to NHBC before work commences.

Where there is hazardous ground, the design of foundations must be carried out by an engineer in accordance with Technical Requirement R5.

Where hazardous ground has been identified, NHBC should be notified in writing at least eight weeks before work on site begins, in accordance with NHBC Rules.

Where toxic materials, or those likely to present a health hazard, are found, all available information should be supplied to NHBC, together with proposals for remediation.

Sulfate and acids

Sulfates and other chemicals can cause expansion and disruption of concrete. High acidity, for example in peat, or permeable soil with acidic groundwater can cause damage to concrete. Where sulfates or high acidity in ground or groundwater are present, reference should be made to Chapter 3.1 Concrete and its reinforcement for guidance concerning acceptable concrete mixes.

Where concrete is at risk from chemical attack from the ground, or where the groundwater is highly mobile, the level of sulfate and other chemicals should be determined in terms of the ACEC class (aggressive chemical environment for concrete class), in accordance with BRE Special Digest 1.

4.4.5 Services and drainage

Also see: Chapters 5.1, 5.3 and 8.1

Raft, pile, pier and beam foundations shall take account of new and existing services. Issues to be taken into account include:

1) provision for new services

2) adequate protection of existing services and drainage.

4.4.5.1 Provision for new services

Where services are to pass through, above or under foundations, openings should be provided using suitable ducts, sleeves or lintels that:

- are detailed so as not to impair structural stability
- do not affect the ability of the foundation to carry loads
- make suitable provision to allow for movement
- have sufficient space to maintain line and gradient of drainage where movement occurs.

4.4.5.2 Existing services and drainage

Existing services or drains should:

- be supported and protected
- be bridged, to prevent any load carrying
- not be rigidly encased in concrete, masonry, etc.

Land drains should be diverted to a suitable outfall; other drains should be diverted or bridged.

4.4.6 Safe transmission of loads

Also see: Chapter 4.6

Raft, pile, pier and beam foundations shall be designed to transmit loads from the structure to the ground safely, without excessive settlement.

Raft, pile, pier and beam foundations should safely transmit loads. The following issues should be taken into account:

- adequate stiffness to ensure that differential movement does not adversely affect the supported structure
- nature and bearing capacity of the fill material to be placed under the foundation
- specification of concrete and cover to reinforcement.

Raft and semi-raft foundations

Raft and semi-raft foundations should be designed:

- to prevent the erosion of ground beneath the raft
- (where required) to accommodate warm air ducts, service ducts or services without any adverse effect upon the performance of the foundation
- to limit the risk of ducts becoming flooded
- to support the building envelope without the risk of differential movement between leaves of cavity walls.

Fill for raft foundations should be in accordance with Chapter 4.6 Engineered fill.

Semi-raft foundations on engineered fill

The following notes are to be used as a guide for engineers designing raft foundations, but are by no means exhaustive. Special consideration will be required for certain sites.

- raft foundations are to be designed by a chartered civil or structural engineer, taking account of ground conditions and the results of the site appraisal and ground assessment
- sufficient internal beams are to be provided to stiffen the slab adequately
- the area between downstand beams should not be greater than 35m^2
- the ratio of adjacent sides on plan should not exceed 2:1
- the minimum depth of perimeter and party wall beams is to be 450mm. On larger homes, some internal beams should be of the same depth as the perimeter beams
- perimeter and internal beams should be sufficiently wide at their base to carry their total loading at the allowable bearing pressure for the site
- beams are to be designed to span 3m simply supported and cantilever 1.5m
- beams are to use properly formed reinforcement in accordance with BS EN 1992-1-1
- where mesh is used in beams, it should be delivered to the site pre-bent
- all beams should be cast on a minimum of 50mm concrete blinding
- minimum cover to reinforcement should be 40mm
- floor slabs should be a minimum 150mm thick, with nominal top face reinforcement as a minimum and anti-crack reinforcement in the bottom face, where appropriate
- stools or similar should be used to support floor slab mesh during casting
- corners and junctions to beams should be adequately tied using similar reinforcement to the beams
- a minimum cavity drain of 225mm below the DPC is to be maintained.

Piled foundations

The design of all piled foundations should specify precautions for cohesive soils where volume changes can occur.

The bearing capacity and integrity of piles should be confirmed by testing, when required.

4.4.7 Construction

Also see: Chapter 4.2

Raft, pile, pier and beam foundations shall be constructed in accordance with the design. Issues to be taken into account include:

1) **setting out and excavations**
2) **localised effects and trench bottoms**
3) **installation of piles, piers and ground beams**
4) **load capacity verification of piles.**

4.4.7.1 Setting out and excavations

The accuracy of setting out should be checked by control measurements of trenches, including their location relative to site boundaries and adjacent buildings. Levels should be checked against benchmarks, where appropriate. For excavations, check:

- trench lengths
- trench widths
- length of diagonals between external corners.

In addition, for piled, pier and beam foundations, check:

- spacing
- alignment
- positions in relation to the proposed superstructure.

Walls should be located centrally on the foundation, unless specifically designed otherwise. Inaccuracy may prevent walls and piers being located centrally, resulting in eccentric loading and possible foundation failure.

Discrepancies to the design of the foundations or variations in the ground conditions should be reported formally to the engineer.

Variations in design or ground conditions should be recorded and distributed to NHBC and others concerned with sitework.

Foundation excavations should:

- be kept free from water
- not be excessive.

Figure 1: Minimum pile setting out requirements

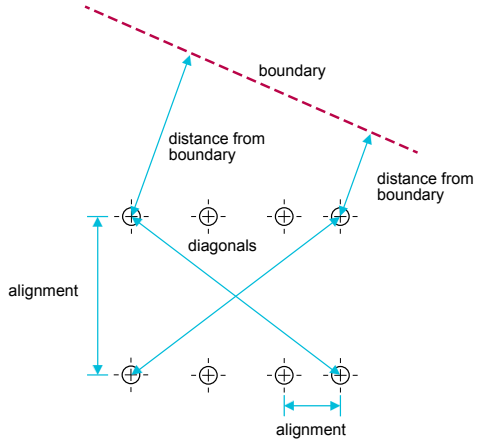
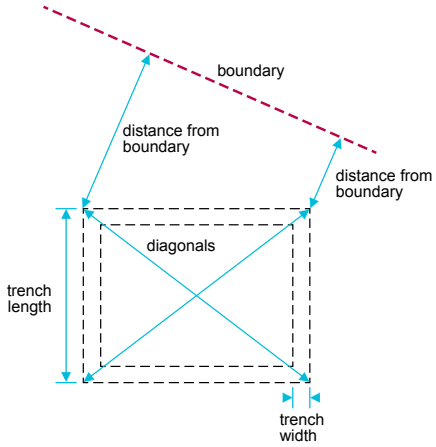


Figure 2: Minimum foundation setting out requirements



4.4.7.2 Localised effects and trench bottoms

Trench bottoms affected by rainwater, groundwater or drying should be rebottomed to form a sound surface.

Table 1: Localised effects

Situation	Action
Differences in bearing capacity (eg from localised changes in strata)	Consult the engineer
Soft spots	Excavations should be deepened locally to a sound bottom, or the concrete should be reinforced
Hard spots	Should be removed
Visible roots, especially in clay soils	Consult the engineer and modify the design depth

4.4.7.3 Installation of piles, piers and ground beams

Piles are to be installed by an appropriate specialist and under the supervision of an engineer.

Piles are to be vertical, unless designed otherwise.

Where piles are more than 75mm out of position, or out of alignment by more than 1:75, the engineer should reconsider the adequacy of the foundation design.

Where piles are misaligned by more than 150mm in any direction, or more than 5° from their specified rake, they should be replaced, unless otherwise recommended by the engineer. Alternatively, additional piles should be provided in accordance with the design modifications provided by the engineer.

Care should be taken to ensure that the bond of beams to piers and piles is in accordance with the design and is adequate.

4.4.7.4 Load capacity verification of piles

Test loading of piles should be undertaken when required. The builder is to obtain written confirmation that the piles are suitable for their design load.

4.4.8 Engineer checks

Engineer-designed foundations shall be inspected by the engineer during construction.

The engineer should undertake site visits to ensure that the design of the foundation is suitable for the actual ground conditions encountered, and that the construction is in accordance with the design.

4.4.9 Compressible materials

Also see: Chapter 4.2

Compressible materials shall be capable of absorbing potential heave forces.

Materials used to accommodate heave should be assessed in accordance with Technical Requirement R3, and used in accordance with the manufacturer's recommendations and independent assessment when applicable.

Depending on the type of material used, the thickness of the material adopted should take account of the minimum void required, and the residual thickness of the material when compressed.

4.4.10 Reinforcement

Reinforcement of raft, pile, pier and beam foundations shall be in accordance with the design, sufficient to ensure the safe transfer of loads and suitable for localised ground conditions.

Reinforcement should be:

- appropriately sized
- placed correctly
- clean and free from loose rust
- secured at laps and crossings
- properly supported to ensure that the cover indicated in the design is maintained.

Reinforcement may be necessary, for example at construction joints or over small localised soft spots or changes in bearing strata.

4.4.11 Concrete

Concrete for raft, pile, pier and beam foundations shall be:

1) **of a suitable mix design to achieve the required strength and resistance to chemical and frost action**
2) **correctly mixed, placed and cured.**

Mixing, placing, testing and curing of concrete should be carried out as indicated in Chapter 3.1 Concrete and its reinforcement; and when work is carried out in cold weather, Chapter 3.2 Cold weather working.

4.4.11.1 Suitable mix

Concrete should be of a mix which:

- will achieve the required strength and not impair the performance of the foundation
- is sufficiently resistant to chemical and frost action.

4.4.11.2 Correctly mixed, placed and cured

Before concrete is placed, excavations and reinforcement may need to be approved by the engineer or their representative. In England and Wales, foundations should be approved by the person responsible for building control inspections.

Concreting should:

- be carried out in one operation (as far as possible)
- take account of weather conditions and available daylight
- be placed as soon as possible after the excavation or after the reinforcement has been checked
- be placed in even, compact and reasonably dry trenches.

4.4.12 Movement joints

Raft, pile, pier and beam foundations shall have movement joints suitable for their intended purpose and be formed using appropriate materials.

Movement joints should be located so as to limit the risk of damage caused by movement. The design of movement joints and choice of sealing materials should consider:

- anticipated movement
- movement capability of seal
- designed joint width
- actual joint width
- joint depth
- surface preparation
- backing medium
- projected life span of the joint.

4.4.13 Resistance to moisture

Also see: Chapters 5.1, 5.2 and 5.4

Raft, pile, pier and beam foundations shall prevent the passage of moisture to the inside of the home and, where necessary, include a drained cavity and damp proof membranes.

Cavity walls should drain below the DPC and should:

- prevent water crossing from the outside to the inside
- prevent the flooding of cavities above the DPC
- have a minimum 225mm clear cavity below the DPC where strip, trenchfill or ground beams are used, or have a minimum 150mm clear cavity below the DPC where other types of foundations are used, provided that weepholes and other necessary measures are taken to ensure that the cavity can drain freely.

DPC cavity trays are not an acceptable waterproofing to the edges of specialised foundations, such as rafts and ground beams.

Figure 3: Typical DPC detail to an external wall at ground level where a suspended ground floor is used over a piled foundation

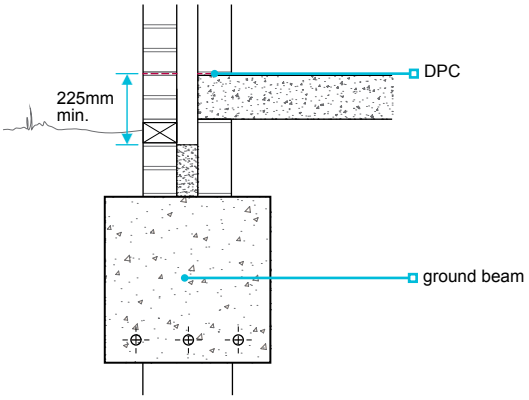
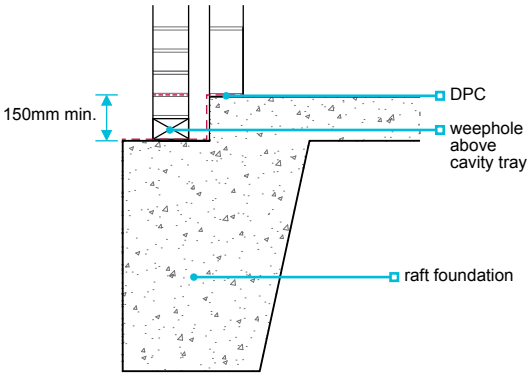


Figure 4: Typical DPC detail to an external wall at ground level when built off a raft foundation



4.4.14 Further information

- *BRE Special Digest 1 — Concrete in aggressive ground. 3rd edition*

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