warranty

LABC TECHNICAL MANUAL

CIAT

RIBA · CPD ASSESSED MATERIAL ·

Version 7

INTRODUCTION

The 2014 **LABC Warranty Technical Manual** has been produced to assist the Developers of buildings and dwellings in meeting technical requirements.

LABC Warranty has always prided itself on offering flexible solutions to meet warranty requirements, and although there is substantial guidance within the Manual, flexibility can still be maintained.

This Technical Manual is produced for the purposes of identifying compliance with the defects insurance period of the New Homes and Social Housing policies. The guidance may be used to assist in other policies covered by **LABC Warranty**; however, the restrictions on the relevant policy will prevail.

HOW THE MANUAL STRUCTURE WORKS

The Technical Manual is divided into 12 Chapters, and each Chapter has sections. Each section has Functional Requirements, which must be met to achieve warranty standards, and which are supported by guidance that provides a suggested method for meeting the requirements.

Please note that if an alternative solution is available then it can be incorporated, providing that the alternative method of meeting the requirement can be proven.

THE DIFFERENCE BETWEEN BUILDING CONTROL AND WARRANTY

What's the difference between Building Control and Warranty? Why do Warranty Surveyors sometimes ask for more information or more detail, than a Building Control Surveyor?

It can be for a number of reasons, and it should be remembered that on occasion the Building Control Surveyor will for certain elements require more information than the Warranty Surveyor, for example smoke control to common areas of an apartment type development.

The Building Regulations are statutory requirements; the Approved Documents provide guidance on how these Regulations may be achieved – however these are minimum standards, derived in the main from building failures.

Warranty Technical Requirements are generally founded upon the Building Regulations, but in many instances go into greater depth due to claims experience, an example being basements – a Warranty Surveyor will ask for strict compliance with the guidance in the British Standard, referred to in the Building Regulations, whereas the Building Control Surveyor may only require compliance in principle.

The Building Control Surveyor is interested mainly in compliance on the day that they visit, or at the time that a completion certificate is issued. Warranty Surveyors are generally required to consider the performance on an ongoing basis, therefore have to be satisfied that a basement waterproofing is appropriate for all ground conditions and water table events, or as another example that a flat roof will not pond excessively and fail within a 15 year period due to increased pressure from ponding on joints in any membrane or deflection of structure, whereas a Building Control Surveyor may only be concerned that there is no water ingress at inspection, or upon completion.

INTRODUCTION

MAIN CHANGES IN THE 2014 MANUAL

Chapter 2: Materials

- Requirements for developments within 'Coastal Locations' is added in respect of corrosion and the durability of components
- Further guidance on our requirements on the suitability of materials is added

Chapter 4: Site Investigation Reports, Geology and Contamination

- A new sub-section on 'Solution Features in Chalk' is provided

Chapter 5: Foundations

- Further clarification on testing in engineered fill and testing of piles is provided
- Reference is made to a 'Piling Good Practice Guide', which can be found on our website

Chapter 7: Superstructure

- The use of Green Oak is clarified
- Further guidance on 'Lead Work' is added

Chapter 8: Superstructure (Internal)

- A new sub-section is added on 'Fire Stopping'

Chapter 11 External Works

- Section 11.2 has been removed

Chapter 13: Sustainability

- This Chapter has been removed

EXTERNAL CONTRIBUTION

It should be recognised that a large proportion of the updated Technical Manual has been written by external consultants. The main reason for this is to ensure that the standards are buildable and reasonable whilst providing an acceptable level of detail. **LABC Warranty** would like to thank the consultants who have contributed to the production of this Manual.

MOVING FORWARD

The Technical Manual will be updated regularly to fall in line with changes to the construction industry and to meet legislative requirements. If you would like to recommend that we consider the inclusion of additional guidance, please email technical.manual@labcwarranty.co.uk with your suggestions.

Please note that the **LABC Warranty** is protected under copyright, and all text and images are deemed to be correct at the time of printing.

INTRODUCTION

CONTENTS PAGE NO.

CHAPTER 1: TOLERANCES

1.1	MASONRY	7
1.2	INTERNAL WALLS AND CEILINGS	9
1.3	JUNCTIONS	9
1.4	FLOORS	9
1.5	DOORS AND WINDOWS	10
1.6	SKIRTINGS	12
1.7	FINISHES AND FITTED FURNITURE	12
1.8	EXTERNAL WORKS	12

CHAPTER 2: MATERIALS

2.1	TIMBER	14
2.2	CONCRETE	18
2.3	OTHER COMPONENTS	24

CHAPTER 3: MODERN METHODS OF CONSTRUCTION

3.1.1	INTRODUCTION	31
3.1.2	SUITABILITY OF SYSTEMS AND COMPONENTS	31
3.1.3	TYPES OF MODERN METHODS OF CONSTRUCTION (MMC)	32
3.1.4	SUITABILITY OF SYSTEMS TO MEET WARRANTY REQUIREMENTS	33

CHAPTER 4: SITE INVESTIGATION REPORTS AND GEOLOGY AND CONTAMINATION

4.1	INTRODUCTION AND OBJECTIVES	37
4.2	ROLES AND RESPONSIBILITIES	38
4.3	FLOW CHART OF SITE INVESTIGATION PROCESS	38
4.4	PHASE 1 GEOENVIRONMENTAL ASSESSMENT (DESK STUDY)	39
4.5	PHASE 2 GEOENVIRONMENTAL ASSESSMENT (GROUND INVESTIGATION)	45
4.6	MAIN REFERENCES	49
APPENDIX A	CHECKLIST FOR GEOENVIRONMENTAL ASSESSMENT (PHASE 1 AND 2)	50
APPENDIX B	SOIL AND ROCK CLASSIFICATION	53
APPENDIX C	LABORATORY TESTING	55

CHAPTER 5: FOUNDATIONS

5.1	GROUND IMPROVEMENT	58
5.2	FOUNDATIONS, TREES AND CLAY	68
5.3	STRIP AND MASS FILLED FOUNDATIONS	77
5.4	PILED FOUNDATIONS	81
5.5	RAFT FOUNDATIONS	85

CHAPTER 6: SUBSTRUCTURE

6.1	BASEMENTS	90
6.2	WALLS BELOW GROUND	102
6.3	DAMP PROOFING	105
6.4	GROUND FLOORS	107

CHAPTER 7: SUPERSTRUCTURES

7.1	EXTERNAL MASONRY WALLS	116
7.2	STEEL FRAME	131
7.3	TIMBER FRAME	135
7.4	WINDOWS AND DOORS	156
7.5	CHIMNEYS	165
7.6	BALCONIES	168
7.7	CLADDING	176
7.8	ROOF STRUCTURE	181
7.9	ROOF COVERINGS - TRADITIONAL SLATE AND TILE	192
7.10	ROOF COVERINGS - CONTINUOUS MEMBRANE ROOFING	210
7.11	ROOF COVERINGS - GREEN ROOFING	228
7.12	ROOF COVERINGS - METAL DECK ROOFING	237

INTRODUCTION

CHAPTER 8: SUPERSTRUCTURES (INTERNAL)

8.1 INTERNAL WALLS 248
8.2 UPPER FLOORS 255
8.3 STAIRS 259
8.4 FIRE STOPPING AND FIRE PROTECTION TO FLATS AND APARTMENTS 262

CHAPTER 9: BUILDING SERVICES

9.1 DRAINAGE (BELOW GROUND) 266
9.2 DRAINAGE (ABOVE GROUND) 271
9.3 ELECTRICAL INSTALLATIONS 274
9.4 HEATING AND MECHANICAL SERVICES 278

CHAPTER 10: FINISHES

10.1 PLASTERWORK 288
10.2 SECOND AND THIRD FIX FINISHES 291

CHAPTER 11: EXTERNAL WORKS

11.1 PAVING AND DRIVEWAYS 296
11.2 THIS SECTION HAS BEEN REMOVED 304
11.3 OUTBUILDINGS 305

CHAPTER 12: CONVERSION AND REFURBISHMENT

12.1 EXISTING ELEMENTS 310
12.2 NEW ELEMENTS CONNECTING TO EXISTING STRUCTURE 326

CHAPTER 13: THIS CHAPTER HAS BEEN REMOVED

13.1 THIS SECTION HAS BEEN REMOVED
13.2 THIS SECTION HAS BEEN REMOVED
13.3 THIS SECTION HAS BEEN REMOVED
13.4 THIS SECTION HAS BEEN REMOVED

CHAPTER 1: TOLERANCES

CONTENTS

1.1 MASONRY

1.2 INTERNAL WALLS AND CEILINGS

1.3 JUNCTIONS

1.4 FLOORS

1.5 DOORS AND WINDOWS

1.6 SKIRTINGS

1.7 FINISHES AND FITTED FURNITURE

1.8 EXTERNAL WORKS

FUNCTIONAL REQUIREMENTS

INTRODUCTION

This Chapter provides guidance on the required standard of finishes in new homes. It is important that all workmanship carried out during construction is completed in accordance with the relevant tolerances, so that the required finishes are achieved.

CHAPTER 1: TOLERANCES

1.1 MASONRY

1.1.1 Brickwork: straightness on plan

There should be a 10mm maximum deviation in any length of wall up to 5m.

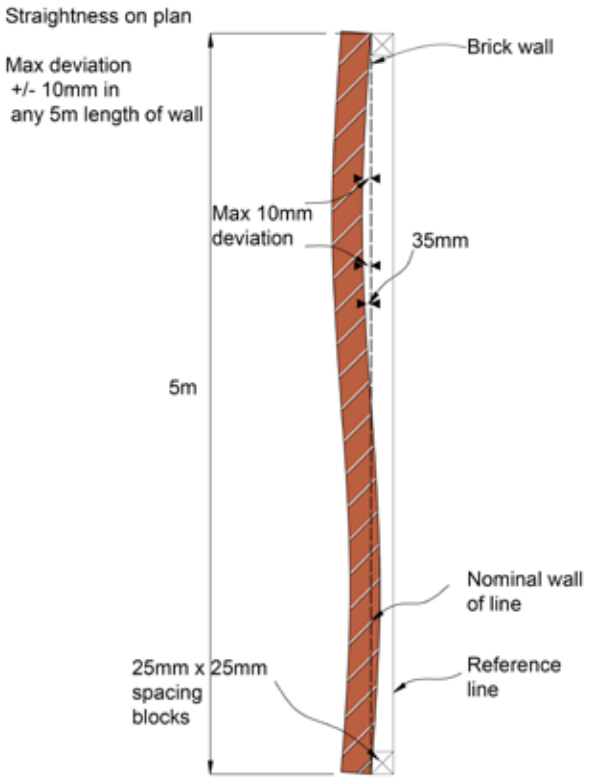


Figure 1: Brickwork: straightness on plan

1.1.2 Level of bed joints

A 10mm deviation is suggested for walls 5m long (a pro rata tolerance is applicable for walls less than 5m long), and a 15mm maximum deviation for walls over 5m long. There should be no recurrent variations in the level of the bed joint line.

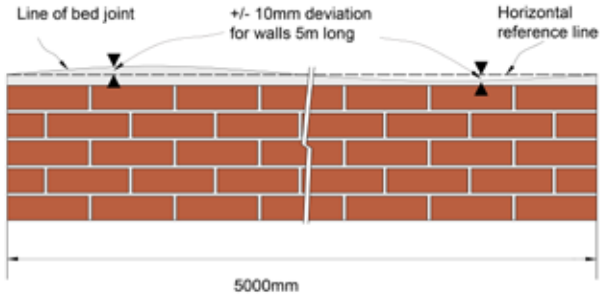


Figure 2: Level of bed joints

1.1.3 Thickness of bed joint

The thickness of an individual bed joint should not vary from the average of any eight successive joints by more than 5mm.

1.1.4 Perpendicular alignment

Vertical alignments of perpend joints should not deviate drastically from the perpendicular. As a result of the manufacturing process, not all bricks are uniform in length. Therefore, not all perpend joints will align. However, there should be no collective displacement of the perpend joints in a wall.

1.1.5 Plumb of wall: overall height

There should be a maximum deviation of 20mm in the overall height of a wall.

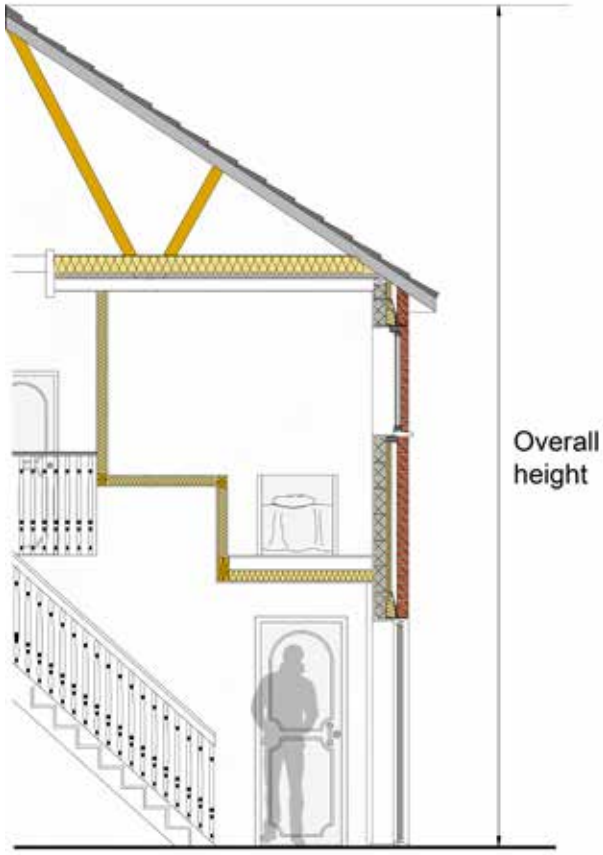


Figure 3: Overall height

1.1.6 Plumb of wall: storey height

The maximum deviation is 10mm in a storey height of approximately 2.5m. Using a 50mm wide spacing block, the plumb bob should be between 40mm and 60mm away from the wall.

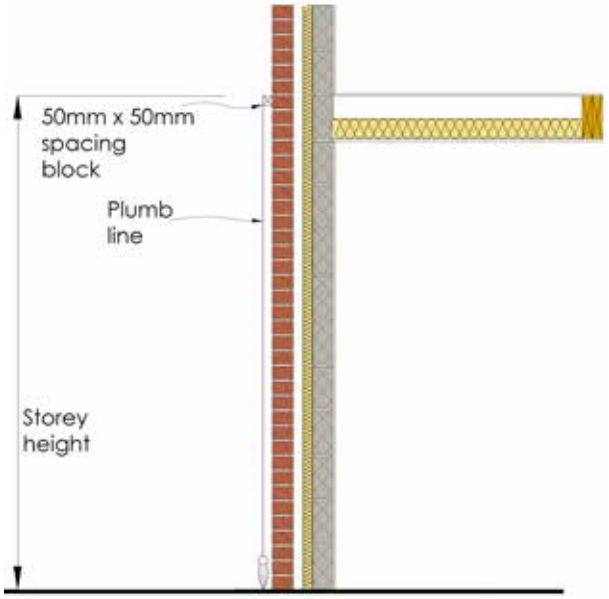


Figure 4: Plumb of wall (storey height)

1.1.7 Straightness in section

The maximum deviation is 10mm in any 2.5m height of wall. Using 25mm wide spacing blocks, the masonry line should be anywhere between 15mm and 35mm from the reference line.

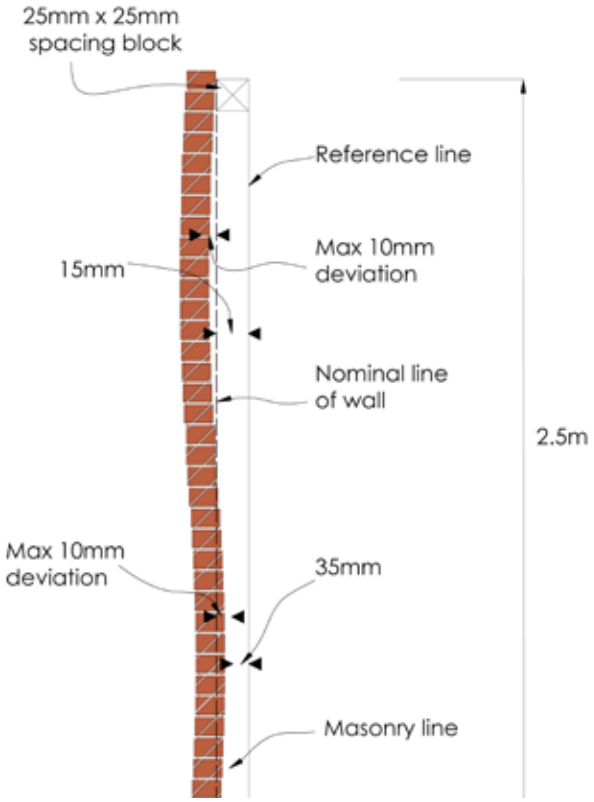


Figure 5: Straightness in section

1.1.8 Rendered walls (plain)

Unless otherwise specified, apply the render coats to produce as flat a surface as possible, and where appropriate check the surface by measuring between the face and any point along a 1.8m straight edge placed against it. The flatness of the rendered finish will depend upon the accuracy to which the background has been constructed, the thickness of the render specified and whether grounds and linings are provided and fixed to a true plane. For render less than 13mm thick, a no tolerance limit is realistic. Significant cracks in the render, or other damage, such as chips and marks greater than 15mm in diameter, are considered unacceptable.

1.1.9 Fair-faced brickwork and blockwork

Fair-faced masonry should be completed to a reasonable level, ensuring texture, finish and appearance are consistent. A reasonable appearance for single leaf 102.5mm brick walls should be to have one finished side only. A neat and tidy finish should be applied to the other side. Shrinkage due to drying out could lead to the fracturing of unplastered blockwork walls, although cracks of up to 3mm are generally normal due to thermal movement and drying shrinkage.

1.1.10 Tile hanging

The uniform appearance is to be maintained for panels of tile hanging, especially at abutments.

CHAPTER 1: TOLERANCES

1.2 INTERNAL WALLS AND CEILINGS

1.2.1 Walls and ceilings (plastered and dry lined)

There should be no sharp differences of more than 4mm in any 300mm flatness of wall; the maximum deviation is +/-5mm from a 2m straight edge with equal offsets, horizontally and vertically, for all wall and ceiling surfaces.

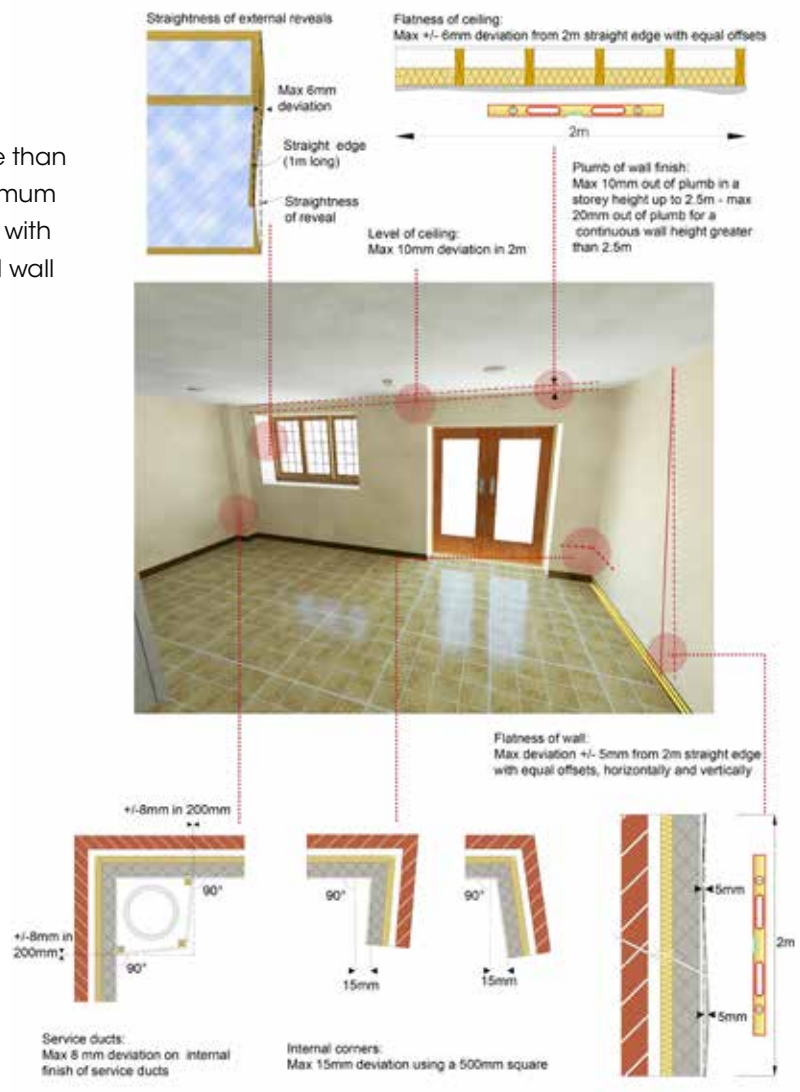


Figure 6: Maximum deviation in walls and ceilings

1.3 JUNCTIONS

If there are changes in the construction materials used due to shrinkage and the differential movement of materials; small cracks (up to 3mm wide) may become visible in the surface at wall, floor and ceiling junctions.

1.4 FLOORS

Floors up to 6m across can be a maximum of 4mm out of level per metre, and a maximum of 25mm overall for larger spans. The effects of normal drying shrinkage on screeded floors could cause some fracturing. Shrinkage of timber floors and staircases is a natural occurrence when drying out, which could result in the squeaking of materials as they move against each other. This again is a natural occurrence, and cannot be eliminated entirely.

On upper floors (intermediate floors), although the permissible deflection may be in accordance with a relevant British Standard or TRADA recommendation, deflections must be within the tolerances defined in this Chapter.

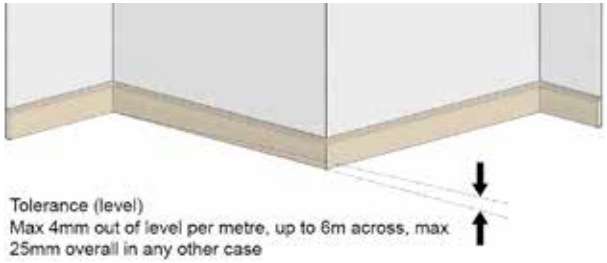


Figure 7: Level of floor

1.5 DOORS AND WINDOWS

1.5.1 Doors

Reference of +/-3mm maximum deviation in 1m head and sill.

The maximum out of level tolerance is 5mm for openings up to 1.5m wide, and 8mm for openings more than 1.5m wide (see Figure 8).

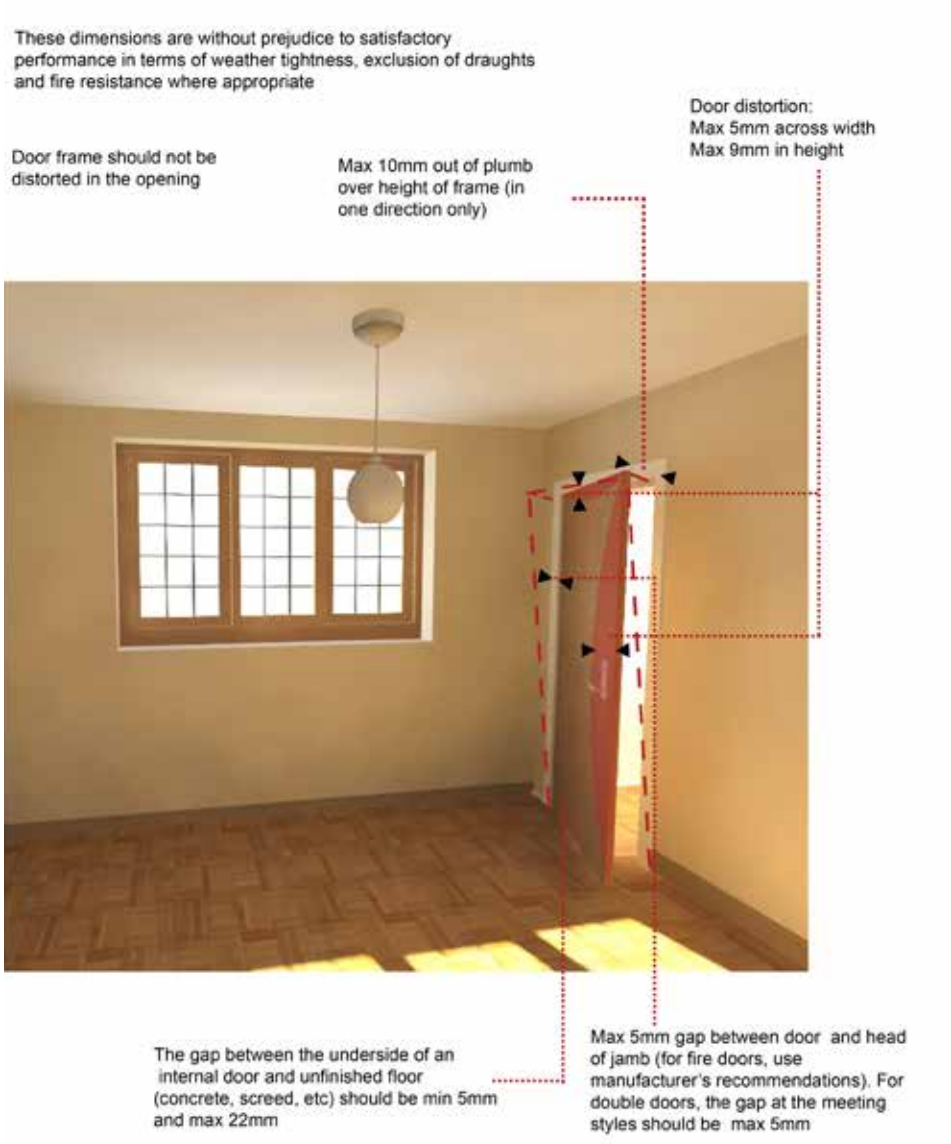


Figure 8: Gaps and distortion in doors

1.5.2 Windows

For square reveals, a maximum +/-8mm deviation off square is applicable for a reveal up to 200mm deep.

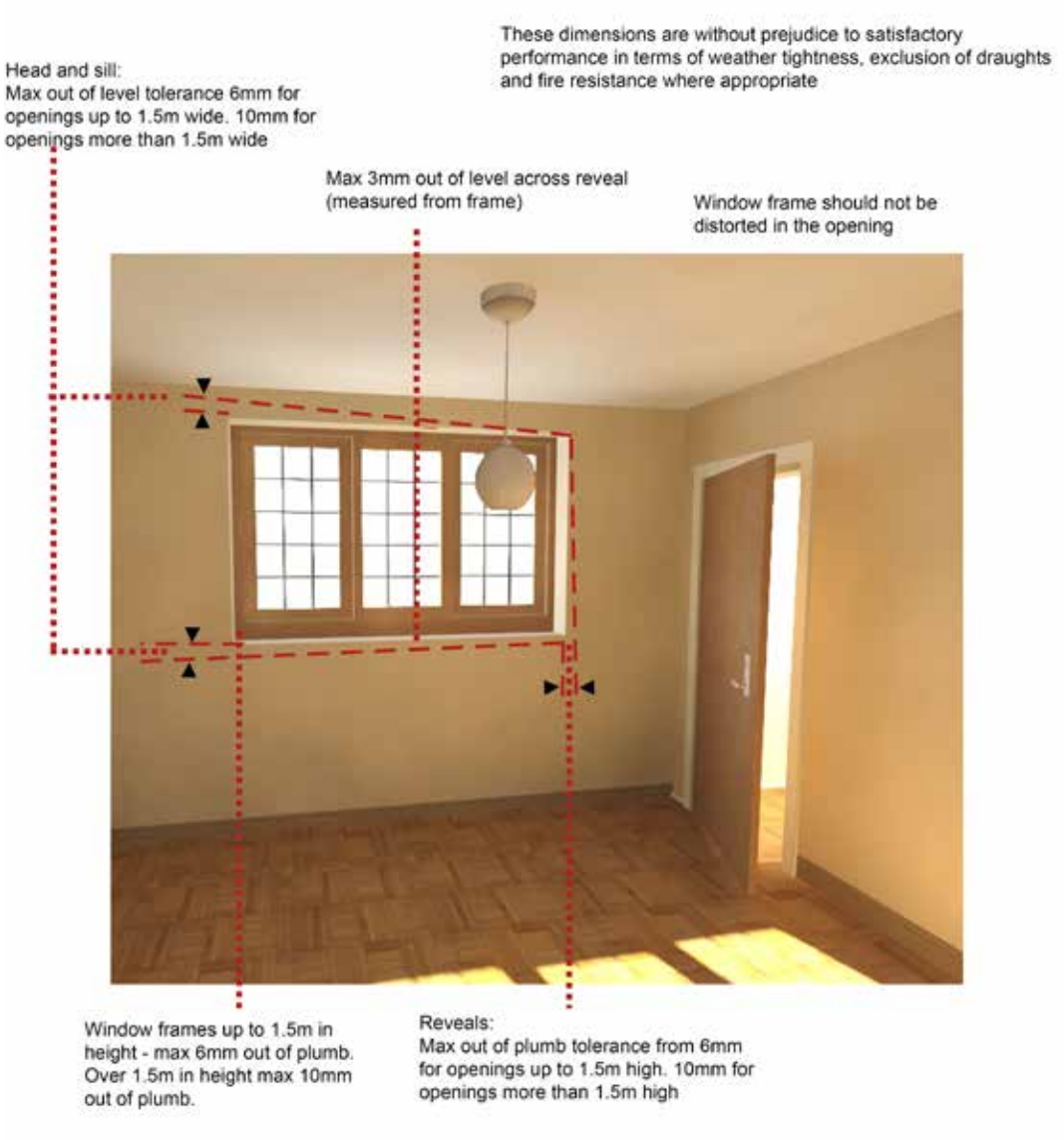


Figure 9: Distortion in windows/reveals

1.5.3 Glazing

Glass must meet the visual assessment criteria of CWCT Technical Note 35 (TN 35). The total number of faults permitted in a glass unit shall be the sum total of those permitted by the relevant BS EN Standard for each pane of glass incorporated into the unit concerned.

Faults include:

- Bubbles or blisters
- Hairlines or blobs
- Fine scratches not more than 25mm long
- Minute particles

When assessing the appearance of glass:

- The viewing distance used shall be the furthest stated in any of the BS EN Standards for the glass types incorporated in the glazed unit. In the event of doubt, the viewing distance shall be 3m.
- The viewing shall commence at the viewing distance, and shall not be preceded by viewing at a closer distance.
- The viewing shall be undertaken in normal daylight conditions, without use of magnification.
- The above does not apply within 6mm of the edge of the pane, where minor scratching is acceptable.

1.5.4 Scratches on doors, windows and frames

Factory-finished door and window components should not have conspicuous abrasions or scratches when viewed from a distance of 0.5m.

- Surface abrasions caused during the building-in process should be removed in accordance with the manufacturer's instructions, which may include polishing out, re-spraying or painting.
- In rooms where there is no daylight, scratches should be viewed in artificial light from fixed wall or ceiling outlets, and not from portable equipment.

1.6 SKIRTINGS

It is possible that there will be joints in skirtings on long walls. When viewed from a distance of 2m in daylight, joints will need to show a consistent appearance. It is anticipated that there will be some initial shrinkage of the skirting after occupation of the building.

1.7 FINISHES AND FITTED FURNITURE

Fitted furniture with doors and drawers should be aligned vertically, horizontally and in plan. It should also function as designed by the manufacturer. Adjacent doors and/or drawers with any gaps between them should be consistent. At the intersection of adjacent worktops, there should not be a visible change in level.

1.7.1 Painted and varnished surfaces

All surfaces should be smooth, and nail holes, cracks and splits should not be seen. Colour, texture and finish should be consistent, with any joints filled where necessary.

1.7.2 Knots in timber

Some seeping of resin from knots is a natural occurrence that may cause paintwork discolouration both internally and externally. The standard will be met providing the Developer finishes the timber in accordance with Functional Requirements.

1.8 EXTERNAL WORKS

1.8.1 Drives and paths: standing water

Surface variation should not exceed +/-10mm from a 2m straight edge with equal offsets. Some fracturing or weathering may also appear if using natural stone due to the make-up of the material. This tolerance applies to principle pathways and driveways to the dwelling that are required to meet the standards of Part M (Access to Dwellings).

1.8.2 Drainage system covers

Drainage system covers in hard standing areas should line up neatly with the adjacent ground.

CHAPTER 2: MATERIALS

CONTENTS

2.1 TIMBER

2.2 CONCRETE

2.3 OTHER COMPONENTS

FUNCTIONAL REQUIREMENTS

2.1 TIMBER

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. External timber should be adequately treated or finished to resist insect attacks. Timber treatment should be in accordance with relevant British Standards and Codes of Practice.
iv. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.
v. Timber used in the dwelling to provide support to the structure must be appropriately seasoned to prevent excessive shrinkage and movement.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials used for construction must meet the relevant Building Regulations, Eurocodes and other statutory requirements.
iv. Specialist works must be provided and supported by structural calculations completed by a suitably qualified Engineer where necessary.
v. Any engineered beams/posts manufactured off-site must have structural calculations endorsed by the manufacturer.

CHAPTER 2: MATERIALS

2.1.1 Storage

Timber should be stored correctly to ensure it does not deteriorate. It should be kept dry and covered in cold conditions to prevent surface freezing, and should be kept off the ground and spaced to allow air to move around freely. Timber should be kept flat to prevent warping or twisting.

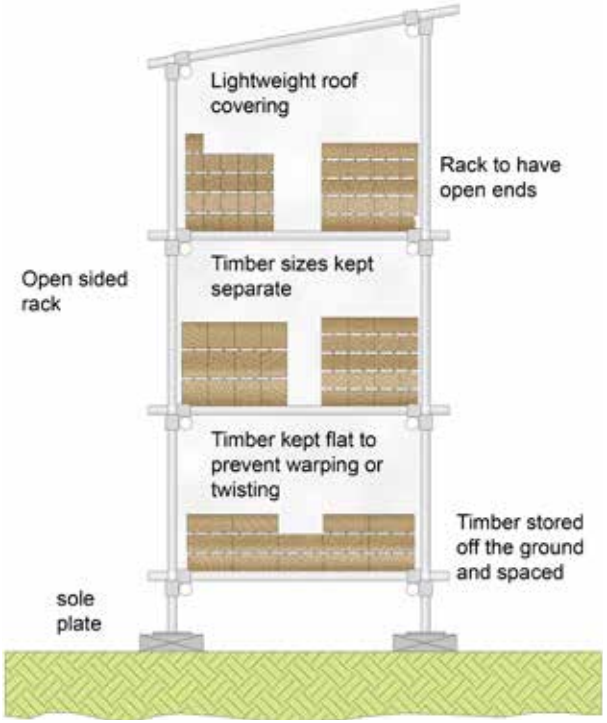


Figure 1: Storage of timber on-site

2.1.2 Timber durability

Timber should be appropriately treated to resist insect attacks. Some timber species have a natural ability to resist attack; Table 1 identifies various species of timber and whether treatment is required.

2.1.3 Timber grading

Timber should be of the appropriate strength classification in order to meet its design intention. For timber that is to be used for structural purposes, e.g. floor joists, rafters and ceiling joists, the strength classification should be assumed to be C16 unless it is appropriately stamped with its specific strength classification.

CHAPTER 2: MATERIALS

Durability class	Timber type	Species	Variety	Typical strength grade*
Very durable	Softwood	None		
	Hardwood	Opepe		D50
		Padauk-Andaman		N/A
		Afromosia		N/A
		Greenheart		D70
		Guarea		N/A
		Iroko		D40
		Jarrah		D40
		Okan		N/A
		Pyinkado		N/A
		Teak	Malaysian	D40
		Kapur	Sabah	D60
			Burma	D60
		Padauk	White	N/A
		Peroba		N/A
Durable	Softwood	Cedar	Western Red (non-UK)	C18
	Hardwood	Besralocus		N/A
		Ekki		D70
		Chestnut	Sweet	N/A
		Karri Kampas		D50
		Louro	Red	N/A
		Oak	American White	D50
			European	D30
		Mahogany	American	N/A
Moderately durable	Softwood	Pine	Caribbean Pitch	C24
			American Pitch	N/A
		Cedar	Western Red (UK)	C18
		Fir	Douglas (North America)	C16-C24
			Douglas (UK)	C18
			Dunkeld (UK)	N/A
		Larch	European	C16-C30
			Hybrid	C16-C30
			Japanese	C16-C30
			Tamarack	C16-C30
			Western	C16-C30
			Maritime	C16-C30
	Hardwood	Keruing	Sabah	D50
			Malaysian	D50
		Oak	Tasmanian	N/A
			Turkey	N/A
		Mahogany	African	N/A
Slightly durable	Softwood	Fir	Noble	C16-C24
			Silver	C16-C24
			Balsam	C16-C24
			Grand	C16-C24
		Pine	Canadian Red	C16
			Corsican	C16
			Jack	C16
			Parana	C16
			Ponderosa	C16
			Radiata	C16
			Scots	C16-C24
			Southern	C16-C30
			Western White	C16
			Yellow	N/A
			Lodgepole	N/A
		Redwood	European	C16-C24
		Hem-fir	USA and Canada	C16-C24
		Spruce	Eastern Canadian	C16
			Engelmann	C16
			European (whitewood)	C16
			Sitka	C16
		Spruce-pine-fir	Western White	C16
			Canada	C16-C24
	Hardwood	Elm	Dutch	N/A
			English	N/A
			White	N/A
			Rock	N/A
			Wych	N/A
		Oak	American Red	D40
		Beech	Silver	D35-D40
Not durable	Softwood	None		
	Hardwood	Alder		N/A
		Beech	European	D35-D40
		Birch	Silver	N/A
			European	N/A
			Paper	N/A
			Yellow	N/A
		Chestnut	European Horse	N/A
		Lime		N/A
		Sycamore		N/A

* Denotes typical strength grade and is for guidance purposes only.

Table 1: Characteristics of timber species

CHAPTER 2: MATERIALS

2.1.4 Timber treatment

Timber should ideally be preserved in a factory environment; it is accepted, however, that this is not always possible. Timber treatments should be approved according to the relevant Code of Practice or British Standard, or have third-party accreditation. Careful consideration should be given to Health and Safety when applying timber treatment products. It is important that any pre-treated timber be re-treated if it is cut to expose untreated end grain. The treatment should be coloured so it can be proven that the end grain has been treated.

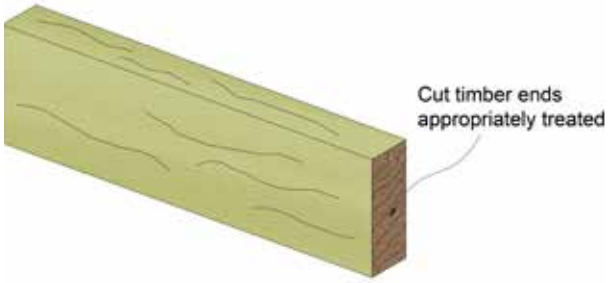


Figure 2: Pre-treated timber exposing un-treated end grain

2.1.5 Metal fixings

Metal components should be galvanised where they are to be fixed or used adjacent to treated timber.

2.1.6 Standards referred to:

- BS EN 1912: 2004+A4: 2010 Structural timber- strength classes – Assignment of visual grade and species
- BS EN 1995 1 1: 2004 & 2008 Eurocode Design of timber structures
- BS EN 5999-Part 1 – Durability of wood and wood-based products

FUNCTIONAL REQUIREMENTS

2.2 CONCRETE

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Concreting shall not take place during cold weather periods or where ground conditions are frozen.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials used for construction must meet the relevant Building Regulations, Eurocodes and other statutory requirements.
iv. Reinforced concrete elements must be supported by structural calculations and details produced by a suitably qualified Structural Engineer.
v. Precast structural elements must have structural calculations that prove their adequacy, as endorsed by the manufacturer.

2.2.1 Cold weather working

To meet the Functional Requirements of this Chapter, the minimum working temperature should not fall below 2°C. It is important that during cold weather periods, regular temperature readings should be taken. Thermometers should be placed away from direct sunlight, preferably in a shaded area. When assessing the temperature, it is also important to consider wind chill and weather exposure, and make the necessary allowances for sites that have a higher level of exposure.

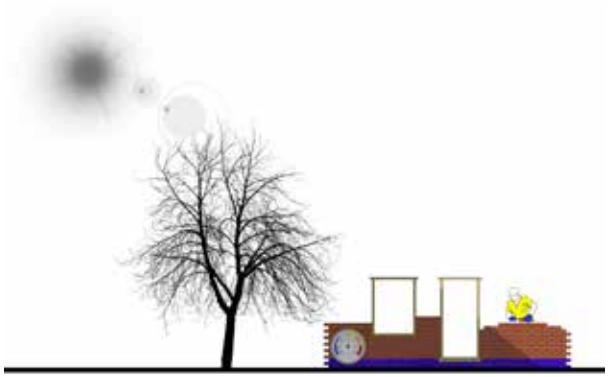


Figure 3: Cold weather working

2.2.2 Ready mixed concrete

It is a requirement of BS 8500 and BS EN 206-1 that the temperature of fresh concrete shall not be below 5°C at the time of delivery. Measures should also be put in place to ensure immature concrete is prevented from freezing before sufficient strength has been achieved.

2.2.3 Site mixed concrete

Site mixing is acceptable at low temperatures, provided:

- The minimum temperature is no less than 2°C
- The concrete is appropriately protected during curing
- Ground conditions are not frozen

2.2.4 Concreting of foundations and oversite

Concrete should not be poured if the ground is frozen; frozen ground can change in stability and volume during thawing, and therefore may cause damage to the recently poured concrete.

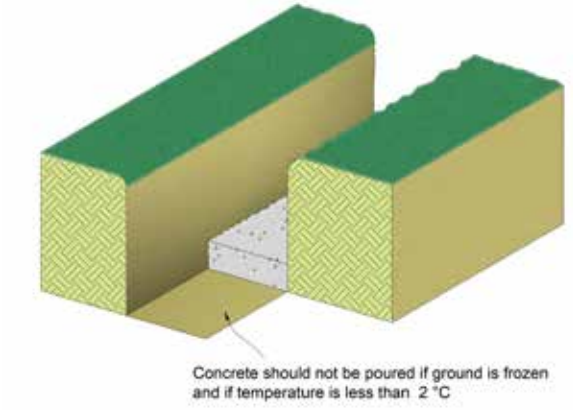


Figure 4: Concrete pouring in cold weather conditions

During cold weather, it may be appropriate to cover the ground to prevent freezing and, in some extreme cases, heating of the ground may be required.

Other concreting: Concrete reinforcing and formwork should not be frozen and be free from snow and ice.

2.2.5 Curing of concrete

Concrete may take longer to cure in cold conditions, and an additional six days may be required in extreme cases. Concrete may be covered with a rigid insulation to prevent freezing during curing periods. This is particularly useful for oversized slabs.

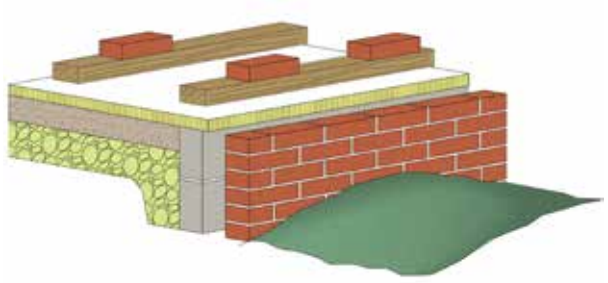


Figure 5: Concrete curing in cold weather conditions

2.2.6 Concrete suitability

Concrete of the appropriate durability and strength should be used in all circumstances.

Table 2 gives details of the correct concrete for varying applications.

2.2.7 Concrete mixes

2.2.7.1 Ready mixed concrete

Concrete must be mixed using the correct proportions of cement, sand, aggregate and water. Ready mixed concrete should be delivered as close as possible to the site works and should be poured immediately to prevent settlement or separation of the mix. Ideally, ready mixed concrete should be poured within two hours of the initial mixing at the concrete plant.

Ready mixed concrete should only be sourced from a supplier who has a quality control system in place to ensure the correct standard of concrete is delivered. The quality control scheme should be either QSRMC (Quality Scheme for Ready Mixed Concrete) or a relevant British Standard Kitemark scheme.

It is important to pass all design specifications of the concrete to the ready mixed supplier to ensure that the delivered concrete meets the design intention.

Application	Ready mixed concrete	Site mixed concrete	Consistence class
Substructure Blinding (unreinforced) Backfilling	GEN1	N/A	S3
Substructure (unreinforced) Structural blinding Strip, trench and mass filled foundations Concreting of cavity walls to ground level	GEN1	N/A	S3/S4
Floor (dwellings unreinforced and unsuspended) With screed added or other floor finish Floor slab as finish, (e.g., power float)	 GEN1 GEN2	 N/A N/A	 S2 S2
Garage floors (unreinforced and unsuspended)	GEN3	N/A	S2
Reinforced slabs (dwellings and garages suspended or unsuspended)	RC35	N/A	S2
Superstructure	As specified by a Structural Engineer	N/A	As specified by a Structural Engineer
External works Pathways Bedding for paving slabs	 PAV1 GEN1	 ST5 ST1	 S2 S1

Table 2: Concrete suitability

Delivery notes should be kept and made available for inspection if required.

Additional water should not be added to the concrete on-site; nor should the ready mixed concrete be poured into water filled trenches unless the concrete has been specifically designed for this purpose.



Figure 6: Ready mixed concrete

2.2.7.2 Site mixed concrete

Site mixed concrete should generally be avoided unless it is for non-structural applications, e.g. backfilling or bedding of paving slabs, etc. There may be exceptional circumstances where site mixing is unavoidable. Where this is the case, extra caution must be taken to ensure that the correct mix proportion is used; delivery notes should be provided if necessary, and a provision for testing may be required.

2.2.8 Reinforcing

Reinforcing bars and mesh should be clean and free from loose rust and any other contaminants that may cause deterioration of the reinforcing material or the durability of the concrete.

Reinforcing bars and mesh should be placed in accordance with structural drawings; bars that are to be bent should be done so using the correct tools for the job.

Reinforcing bars should be correctly positioned, ensuring there is appropriate concrete cover, and reinforcing mesh placed in the right direction (main bars parallel to span).

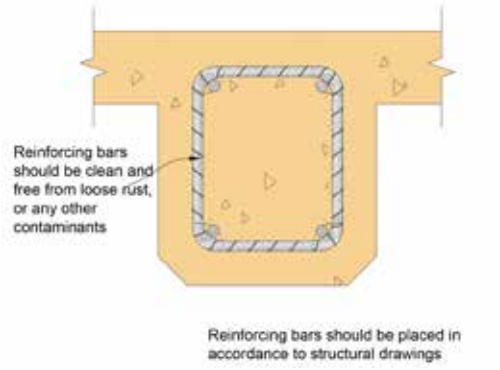


Figure 7: Reinforced bars in concrete beam

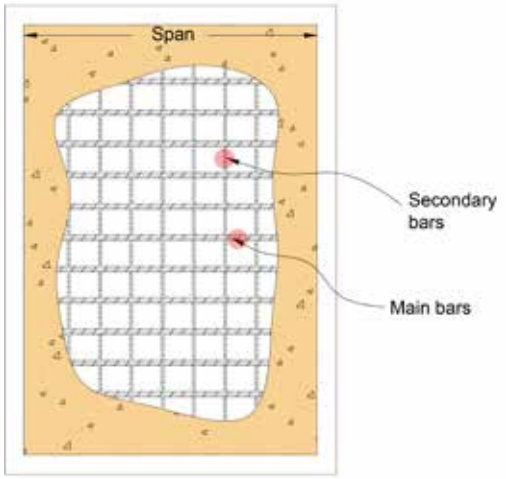


Figure 8: Position of bars on reinforced concrete slab

2.2.8.1 Reinforcing cover

An appropriate level of concrete cover should be provided to the reinforcing; the cover thickness will depend on the exposure of the concrete and its application. Concrete cover should be specified by a qualified Structural Engineer, or alternatively by using Table 3.

Application (concrete position)	Minimum cover (mm)
Concrete in direct contact with the ground	75
All external applications e.g. shuttered walling	50
Floor slabs and other applications where concrete is cast onto a membrane	40
Concrete over blinding concrete	40
Internal conditions	25

Table 3: Minimum concrete reinforcing cover

Reinforcing should be supported by proprietary chairs or spacers, and can be made of concrete, plastic or steel. The thickness and depth of a concrete spacer should not exceed 50mm x 50mm. Spacers should be placed at a maximum of 1m centres, and when supporting mesh should be staggered.

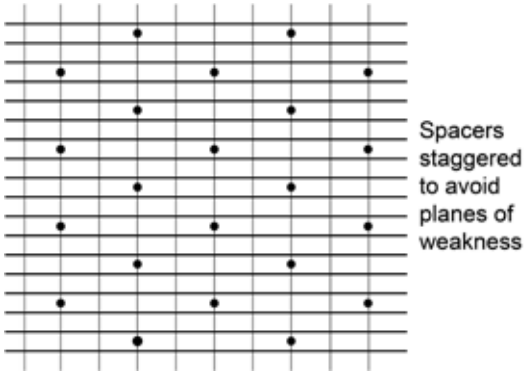


Figure 9: Position of spacers

2.2.9 Admixtures

Admixtures should only be used if stipulated as part of the original design specification. If an admixture is to be proposed where it was not intended as part of the design, a Structural Engineer must confirm that the admixture is appropriate and required.

It is important that the appropriate amount of admixture is applied to any mix. Any overdosing may cause concrete deterioration or poor workability.

Common admixtures

- **Plasticisers** – improve the workability of concrete, especially when pumped; they can also improve concrete adhesion, which is particularly enhanced when concrete is reinforced.
- **Air entraining agents** – increase the air void volume of concrete, which in turn produces a surface more resilient to cold weather, and is therefore ideally suited to outdoor conditions where cold weather exposure is high, such as pathways or roads.
- **Accelerators** – provide an improved curing time, but caution should be taken to allow for reasonable time to 'finish' the concrete.

Admixtures in cold weather

Admixtures may be used in cold weather, but usually will not assist in preventing concrete from freezing; therefore, they should not be relied upon to compensate for freezing conditions. The guidance for cold weather working should be followed in these circumstances.

Admixtures and reinforcing

Admixtures containing chloride will cause corrosion to occur, meaning they should not be used in concrete containing reinforcing.

2.2.10 Expansion/movement joints

Joints in concrete should be provided to prevent cracking caused by shrinkage; shrinkage will be less significant if the concrete is reinforced.

A larger number of expansion joints should be provided to concrete where weak spots may occur. This could include a narrowing width of floor slab for example.

2.2.11 Vibration and compaction of concrete

Reinforced concrete should be compacted using a vibrating poker, but care must be taken to ensure the concrete is not over-compacted and the concrete mix separated. Tamping of floors by hand is acceptable for floor slabs that do not exceed 150mm in thickness.

2.2.12 Curing of concrete

Concrete should be adequately cured before loads are applied. It is acceptable that masonry walls may be built up to Damp Proof Course (DPC) on a foundation that is not fully cured; however, care must be taken to prevent any damage to the foundation. The concrete should be at least durable enough to carry the masonry.

The speed at which concrete mixes cure depends on the mix ratio and whether there are any additives within the concrete. Where curing time is critical, such as cast in-situ upper floors, curing times should be indicated as part of the design and formwork struck, as advised by a Structural Engineer.

To prevent concrete curing too rapidly after initial drying, exposed concrete should be covered with hessian, polythene or sand. This prevents the surface drying too quickly and protects the concrete. This level of protection is particularly critical in hot or adverse weather conditions.

2.2.13 Standards referred to:

- BS 8110 Structural use of concrete
- BS EN 1992 – 1-1 Design of concrete structures, general rules and rules for buildings (incorporating UK National Annex to Eurocode)
- BS 8500 Concrete – Complementary British Standard to BS EN 206-1
- BS EN 206-1 Concrete. Specification, performance, production and conformity
- BS EN 12620 Aggregates for concrete
- BS EN 197 Cement. Conformity evaluation

FUNCTIONAL REQUIREMENTS

2.3 OTHER COMPONENTS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials used for construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

2.3.1 Cold weather working

To meet the Functional Requirements of this Chapter, minimum working temperatures should not fall below 2°C when working with masonry. It is important that during cold weather periods, regular temperature readings should be taken.

Thermometers should be placed away from direct sunlight, preferably in a shaded area. When assessing the temperature, it is also important to consider wind chill and weather exposure, and make necessary allowances for sites that have a higher level of exposure.

2.3.1.1 Protection of materials

Covers should be provided to protect materials from frost, snow and ice, particularly bricks, blocks, sand and cement. Frozen materials should never be used under any circumstances.

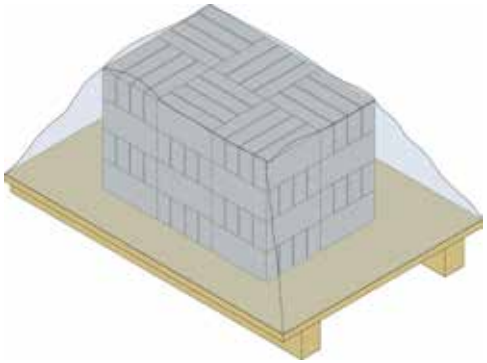


Figure 10: Protection of blockwork

2.3.1.2 Protection of masonry

Any new walls or other masonry construction will require protection against frost where temperatures are expected to drop below 2°C. Ideally, all masonry should be protected with polythene or hessian. If temperatures are expected to fall to an extremely low level, insulation boards may be required, and heating may even be considered.

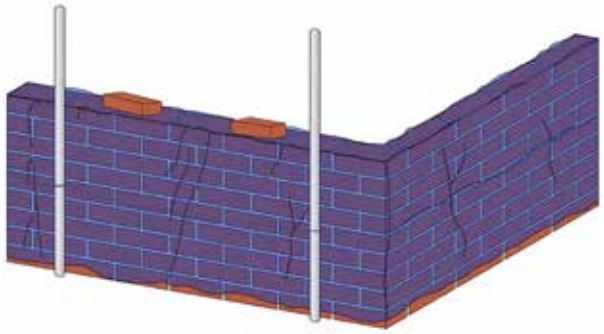


Figure 11: Protection of masonry walls

2.3.1.3 Finishes including rendering, plastering and screeds

Rendering should only be completed if the outside temperature is at least 2°C; there should be no frost within the construction that is to be rendered and, where possible, rendering should not take place where freezing weather conditions are anticipated prior to adequate curing.

No plastering or screeding should take place unless the building is free from frost. It is acceptable to use internal heating to warm the building effectively; however, it is important to ensure that heaters do not emit excessive vapour into the dwelling. Adequate ventilation should be provided to allow moist air to escape. The dwelling should be appropriately pre-heated before plastering, and continue to be heated whilst the plaster dries.

2.3.2 Masonry

2.3.2.1 Bricks

Bricks should be of an appropriate durability to meet the design intention. The type of brick to be used will affect the specification of the mortar. Bricks with greater durability should be used where there is a higher potential for saturation or severe exposure to wind-driven rain.

Durability (BS 3921)	Frost resistance	Soluble salts content
FL FN	Frost resistant durable in all uses	Limits of soluble salts are defined by tests Low (L) Normal (N)
ML MN	Moderately frost resistant, durable except when saturated and subject to repeated freezing and thawing	
OL ON	Not frost resistant. Bricks liable to be damaged by repeating freezing and thawing. For internal use only	

Note:
Calcium silicate and concrete bricks contain no soluble salts.

Table 4: Durability of brickwork

Use	Brick type			Notes on mortar
	Clay	Calcium silicate	Concrete	
Foundation to DPC	FL,FN,ML, MN	Class 3	Strength >20N/mm^2	
Foundation to DPC (sulphates in soils)	FL,FN,ML,MN	Class 3	Strength >20N/mm^2, all Class 1 sulphates and in some Class 2, consult manufacturers. Engineering quality concrete bricks up to Class 3 sulphates	Where sulphates are Class 3 or higher use sulphate resisting Portland cement
Un-rendered external walls (protected from saturation)	FL,FN,ML,MN	Class 3	Strength >7 N/mm^2	
Un-rendered external walls (not protected from saturation)	FL,FN	Class 3	Strength >15 N/mm^2	Use sulphate resisting cement in mortar with type N clay bricks
Rendered external walls	FL,FN,ML,MN	Class 3	Strength >7 N/mm^2	Use sulphate resisting cement in mortar and base coat of render with type N bricks
Copings, cappings and sills	FL,FN	Class 4	Strength >30 N/mm^2	
Internal	FL, FN,ML,MN,OL,ON	Class 3	All	

Table 5: Suitability of brickwork in masonry

Use	Designation (BS EN 998-3)	Proportion by volume			Minimum compressive strength (N/mm²)(a)
		Portland cement: lime: sand	Air-entrained Portland cement: Sand	Masonry cement: sand	
Mortar for internal and external use above DPC	iii	1:1:5-6	1:5-6	1:4-5	2.5
General purpose to BRE Digest 362		Air-entrained with plasticiser Portland cement: lime: sand 1:1:5.5 by volume			2.5
High durability Mortar for: A) Use below or near external ground level B) In parapets and chimneys C) External walls with high risk of saturation due to severe weather exposure	ii (b)	1:0.5:4-4.5 (c)	1:3-4 (c)	1:2.5-3.5 (c)	5.0
	If type N clay bricks are to be used, or for all chimneys use sulphate resisting cement				
Low permeability jointing mortar including copings, cappings and sills	i (d)	1:0.25:3 Use a type S sand to BS 1200	N/A	N/A	10.0
Loadbearing masonry designed to BS 5628:1		Air entrained with plasticiser, Portland cement: lime: sand 1:1:5.5 by volume			As specified

Notes:
(a) Minimum compressive strength1 of site mixed mortars at 28 days (N/mm²)
(b) For concrete or calcium silicate brick use a designation (iii) mortar
(c) Where soil or ground-water sulphate levels are appreciable (Class 3 or higher) use sulphate resisting Portland cement.
(d) For concrete or calcium silicate bricks use designation (ii) mortar

Table 6: Suitability of mortar

2.3.3 Standards referred to:

- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 187: 1978 Specification for calcium silicate (sand lime and flint lime) bricks
- BS 3921:1985
- BS 5628 Parts 1, 2 and 3 Code of Practice for use of masonry
- BS EN 771-1:2011
- BS EN 998 Specification for mortar for masonry

2.3.4 Developments within coastal locations

Developments in coastal environments will be subject to exposure from wind-blown salt spray, which could adversely affect the durability of components and claddings. This is in addition to the typical higher exposure environment encountered due to wind-driven rain (particularly on the Western seaboard; see Figure 2 in Chapter 7.1).

Where developments are within 3km of the coastal shoreline, structures and protective coatings/ claddings and detailing should be subject to scrutiny for a potentially enhanced risk of the effects of corrosion and reduced durability.

The design team should provide a detailed assessment of the protection and maintenance arrangements required for a project that falls within these locations, and identify suitably approved materials that are appropriate for use in the construction.

Shoreline/sea front developments will be designated as having a 'very severe' exposure risk, and the design team must provide specific proposals to demonstrate the durability, suitability and weather tightness of the construction, particularly for window and door openings, cladding and roof fixings, together with planned maintenance programmes to ensure the construction meets the requirements of this Manual.

2.3.4.1 Further reference

- BS 5628 – 3: 2005 Code of Practice for the use of masonry (superseded by BS EN 1996).
- BS 8104 Code of Practice for assessing exposure of walls to wind-driven rain
- BS 7543 Guide to durability of buildings and building elements, products and components
- BS 5493 Code of Practice for protective coating of iron and steel structures against corrosion
- BS 5427 Code of Practice for the use of profiled sheet for roof and wall cladding on buildings.

2.3.5 Suitability of materials

It is important to ensure materials used in construction:

- Meet the requirements of British Standards or Codes of Practice or equivalent European Standards current at the time of application
- Are materials/products or systems covered by a current approval from an independent third-party technical approval body accepted bythe Warranty provider .This would either be a UKAS or European equivalent accredited organisation, such as ILAC (International Laboratory Accreditation Co-operation). Details of the testing body accreditation will need to be supplied, as well as the certification document

In addition:

- The independent third-party testing information must recognise UK Building Regulation requirements and additional Warranty standards. Details of the performance and the limitations of use of the material/ product or system tested must be provided
- Where bearing a CE marking in accordance with the Construction Products Directive, this shall be supported by evidence of the testing carried out on the product

Construction products that do not meet the requirements of this Technical Manual may not be acceptable for Warranty approval. It is advised that the design team must approach the Warranty provider early in the design stage to discuss the viability of the use of such a material, and determine what further independent third-party testing may be required in advance of the final design proposal.

CHAPTER 3: MODERN METHODS OF CONSTRUCTION (MMC)

CONTENTS

3.1.1 INTRODUCTION

3.1.2 SUITABILITY OF SYSTEMS AND COMPONENTS

3.1.3 TYPES OF MODERN METHODS OF CONSTRUCTION (MMC)

3.1.4 SUITABILITY OF SYSTEMS TO MEET WARRANTY REQUIREMENTS

FUNCTIONAL REQUIREMENTS

3.1 MODERN METHODS OF CONSTRUCTION (MMC)

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
iv. All MMC systems must be assessed and approved by a recognised third-party assessment body.

CHAPTER 3: MODERN METHODS OF CONSTRUCTION (MMC)

3.1.1 Introduction

Modern methods of construction (MMC) are being used in the construction industry, particularly for housing, as they potentially represent savings in time and materials, and provide higher standards of quality than more conventional methods of construction.

Key points to note are:

- Off-site assembly means quick erection times on-site and a quick, weather tight construction achieved.
- The accurate setting out of foundations, etc. needs to be managed.
- MMC, particularly modular systems and large panel systems, will require advanced planning of the site for access, off-loading, installation and possibly storage of systems.
- The construction, design and layout of a typical system is planned in advance, so last-minute changes have to be avoided by good project management and what is known as a 'design freeze', imposed in advance of production commencing in the factory.
- The quality of the final product will rely on accurate assembly on-site by factory-trained or authorised Specialist Contractors.
- MMC take advantage of standardised construction, and may not be adaptable for complex architectural or planning design requirements. Additional testing may be necessary to ensure standards for durability and weather tightness can be achieved, e.g. incorporating flat roof drainage outlets through closed panel parapet extensions.

3.1.2 Suitability of systems and components

It is important to ensure that MMC, products or systems:

- Meet the requirements of British Standards or Codes of Practice or equivalent European Standards current at the time of application.
- Are materials/products or systems covered by a current approval from an independent third-party technical approval body which is accepted by MDIS. This would be either a UKAS accredited or a European equivalent accredited organisation, such as ILAC (International Laboratory Accreditation Co-operation). Details of the testing body accreditation will need to be supplied, together with the certification document.
- Carry independent third-party testing that recognises UK Building Regulation requirements and additional Warranty standards. Details of the performance and the limitations of use of the material/product or system tested must be provided.
- Bear a CE marking in accordance with the Construction Products Directive. This shall be supported by evidence of testing carried out on the product.

Construction methods that cannot meet the requirements of this Technical Manual must be approved in advance by the Warranty provider at the design stage, well before commencement on-site.

MMC, products or systems that have third-party approval will still need to be structurally approved on a site-by-site basis depending on the layout and loading of the component. Thermal properties and measures to prevent condensation will also require specific assessment depending on exposure, orientation, etc.

3.1.3 Types of modern methods of construction (MMC)

MMC (this applies to systems and components) usually fall into the following categories:

- Volumetric or modular construction
- Panelised
- Hybrid (semi-volumetric)
- Site-based systems

Most MMC components are usually site-based, e.g. Insulated Concrete Formwork Systems.

3.1.3.1 Volumetric

Volumetric construction (also known as modular construction) involves the 'off-site' production of three-dimensional units. Quality controlled systems of production in the factory should be in place and expected as part of any third-party approval.

Modules may be brought to site in a variety of different forms, ranging from a basic structural shell to one where all the internal and external finishes and services are already installed.

Volumetric construction can consist of timber frame, light gauge steel and concrete or composite constructions. External cladding may form part of the prefabricated system, with only localised on-site specialist sealing required.

Alternatively, traditional masonry cladding may need to be constructed; in this case, specific detailing for the support of claddings, cavity barriers and DPCs must be pre-agreed and checked by Site Managers.

3.1.3.2 Panelised

The panel units are produced 'off-site' in a factory under a quality controlled process, and assembled on-site to produce a three-dimensional structure. The panels may consist of wall, floor or roof units, sometimes referred to as cassettes.

3.1.3.3 Closed panels

These involve the factory installation of lining materials and insulation, and may be constructed of timber, steel frame or concrete panels. Panels can often include services, windows, doors and finishes.

3.1.3.4 Open panel systems

Open panel systems do not include insulation, lining boards, Vapour Control Layers, etc. These are applied to the frame system on-site, together with the external cladding and internal finishing. Therefore, careful control of on-site finishing will be required, and the panels must be protected against the elements until weather tight.

'Conventional' timber frame panels are typically classed as 'open panel systems', and would normally arrive on-site with the sheathing board fixed but without insulation or internal boards. For Warranty purposes, these types of open panel systems can normally be classified as established or traditional construction, providing that such open panel systems have quality assured systems in place and are registered either with the Structural Timber Association or TRADA BM (See Chapter 7 of this Technical Manual for general guidance on conventional timber frame construction).

Note: Bespoke timber frame open panel systems that do not have such QA procedures will need either third-party accreditation or independent Structural Engineer supervision to be provided to monitor the installation, erection and completion (sign off) of the system.

Structurally Insulated Panels (SIPs) are a form of composite panel. Only systems with independent third-party approval will meet the requirements of the Technical Manual.

Rain screen systems should have third-party certification confirming satisfactory assessment, and comply with the requirements of the CWCT Standard for Systemised Building Envelopes, including the following sections:

- Part 1: Scope, terminology, testing and classification
- Part 2: Loadings, fixings and movement
- Part 3: Air, water and wind resistance
- Part 4: Operable components, additional elements and means of access
- Part 5: Thermal, moisture and acoustic performance
- Part 6: Fire performance
- Part 7: Robustness, durability, tolerances and workmanship
- Part 8: Testing

3.1.3.5 Hybrid

Again off-site manufactured, this combines both panelised and volumetric approaches, and typically volumetric units, e.g. student accommodation or hotel pods.

3.1.3.6 Sub-assemblies and components

This category covers factory-built sub-assemblies or components in an otherwise traditionally built structural form, typically schemes incorporating the use of floor or roof cassettes, precast concrete foundation assemblies, preformed service installations and cladding systems, etc.

3.1.3.7 Site-based systems

These are structural systems that fall outside the 'off-site manufactured' categories, such as Insulated Concrete Formwork (ICF). Only systems with independent third-party approval will meet the requirements of the Technical Manual. The acceptability of these systems relies heavily on the quality procedures in place for the installation of the system on-site, in accordance with third-party approval.

3.1.4 Suitability of systems to meet Warranty requirements

(Please also refer to the requirements in Chapter 2 of this Manual.)

An independent third-party assessment of the system/product must recognise UK Building Regulation requirements and our additional Warranty standards.

Details of the performance and the limitations of use of the material/product or system testing must be provided to determine if the requirements of this Manual are met.

The Independent Assessment, e.g. a European Technical Assessment, must provide details of performance and testing carried out in the following areas to demonstrate acceptability to the Warranty provider:

- Structural integrity
- Performance in fire situations
- Resistance to water penetration (consider exposure rating of location), vapour permeability and dangerous substances
- Safety in use
- Acoustic characteristics
- Thermal and movement characteristics
- Compatibility of materials (interaction between components, structural or otherwise)
- Durability and longevity of materials (60-year lifespan in accordance with CML requirements)
- Maintenance issues

Structural performance must be identified against appropriate BS EN standards. The Developer must provide actual structural calculations for each project on a case-by-case basis, and the design shall allow for robustness to disproportionate collapse.

Where the independent certification does not recognise our Warranty requirements, additional checks may be required to confirm the system is acceptable, e.g. the need to provide a drained cavity behind some insulated cladding systems and to external cladding systems on timber and steel-framed systems. Supporting evidence of testing undertaken to prove the system may be asked for.

Durability and weather tightness are key aspects of the Technical Manual requirements, and the track record of the MMC will need to be established.

Evidence of experience gained elsewhere, where environmental conditions may be significantly different, will need to be assessed, in comparison with conditions here in the UK.

Treatment of timber components will need to be assessed with regard to the species of timber used. The natural durability and the need for preservative treatment are dependent on the component's location in the construction and the Warranty requirement for durability. Treatment for insect attack in certain parts of the country will also be required.

Detailing is critical in providing integrity to the building, e.g. connections between a wall panel and a window unit. Supporting documentation must show the make-up of the tested system. When assessing projects, a particular design detail may not have been covered by the MMC certification, e.g. a balcony junction. This information must be made known at an early stage.

Certain components of a building have particular functions and may not be replaced by components that look similar but might structurally behave in a different manner. Similarly, a product with a third-party assessment for a particular use may not be acceptable in a different form of construction.

The continuation of Quality Management Systems from manufacture to erection on-site must be demonstrated. The level of supervision of the systems on-site is critical to meet the requirements of this Technical Manual.

CHAPTER 4: SITE INVESTIGATION REPORTS, GEOLOGY AND CONTAMINATION

CONTENTS

4.1 INTRODUCTION

4.2 ROLES AND RESPONSIBILITIES

4.3 FLOW CHART OF SITE INVESTIGATION PROCESS

4.4 PHASE 1: GEOENVIRONMENTAL ASSESSMENT (DESK STUDY)

4.5 PHASE 2: GEOENVIRONMENTAL ASSESSMENT (GROUND INVESTIGATION)

4.6 MAIN REFERENCES

APPENDIX A CHECKLIST FOR GEOENVIRONMENTAL ASSESSMENT (PHASE 1 AND 2)

APPENDIX B SOIL AND ROCK CLASSIFICATION

APPENDIX C LABORATORY TESTING

FUNCTIONAL REQUIREMENTS

4. SITE INVESTIGATION REPORTS, GEOLOGY AND CONTAMINATION

Workmanship

i. All work is to be carried out by a qualified and technically competent person in a workmanlike manner.

Materials

i. All samples to be stored and kept in such a way that will not cause inaccuracy when soils are tested.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The site investigation should be completed at an appropriate level for the risk in accordance with the relevant British Standard.
iii. Site investigation and remedial measures must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements (refer to Appendix 2a for a list of standards referred to).

These Functional Requirements apply to the following sections of this chapter:

4.1 Introduction
4.2 Roles and Responsibilities
4.3 Flow Chart of Site Investigation Process
4.4 Phase 1: Geoenvironmental Assessment (Desk Study)
4.5 Phase 2: Geoenvironmental Assessment (Ground Investigation)

CHAPTER 4: SITE INVESTIGATION REPORTS, GEOLOGY AND CONTAMINATION

4.1 INTRODUCTION

This Chapter sets out the requirements for an acceptable site investigation. It is intended to be flexible and user-friendly, and includes simple checklists aimed at ensuring compliance. The aim is to raise standards in the interests of both the Warranty provider and the builder or Developer. This will lead to a safe and economic design that will minimise the risk to all those involved in the project.

Where projects run over time and over budget, this is usually as a direct result of problems within the ground. It is therefore vitally important to reduce the risk of unforeseen conditions that can directly affect the overall cost of the project. It is believed that builders and developers will view this work as an important safeguard, rather than unnecessary expenditure.

To ensure a consistently high standard, all stages of the work should be carried out by a Chartered Engineer or Chartered Geologist with at least five years' experience of this type of work. Specifying properly qualified personnel will considerably increase the overall industry standard.

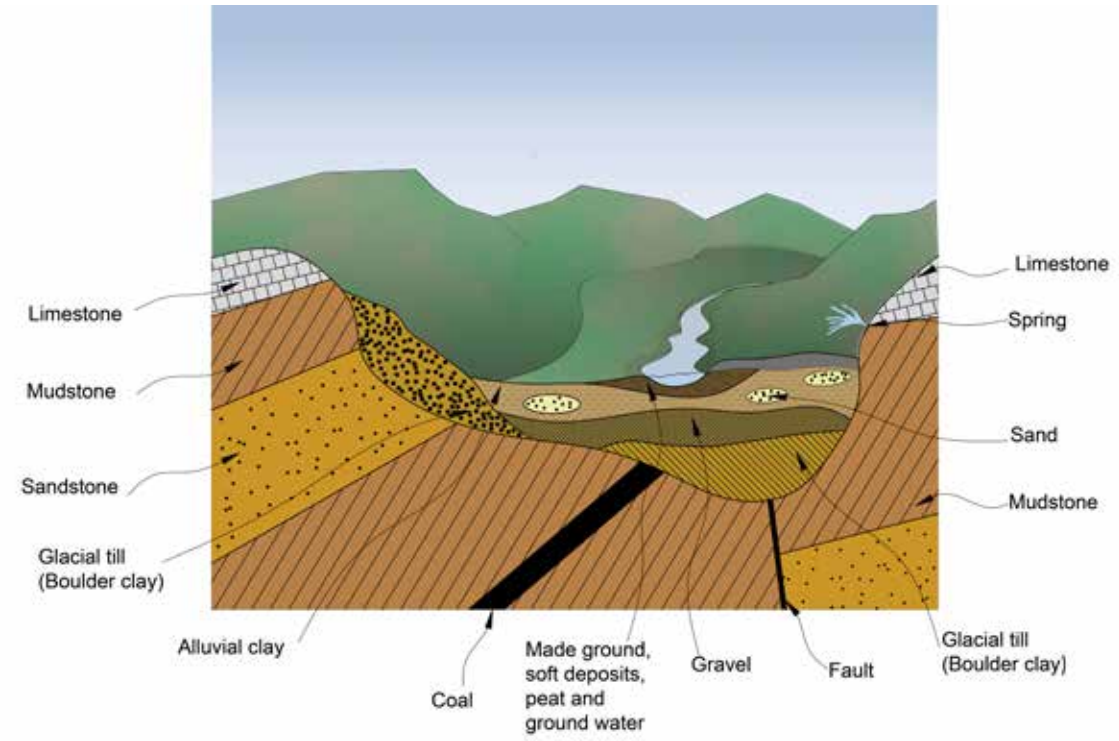


Figure 1: The geological environment: cross section of a river valley

4.2 ROLES AND RESPONSIBILITIES

The roles and responsibilities of those parties involved in the development are the Owner, Developer, Builder and Self-Builder.

4.2.1 Owner/Developer/Builder/Self Builder

The provision of clear development proposals for the site, and the implementation of a competent site investigation using appropriately qualified personnel, is now a priority for Regulators. These demonstrate that any geotechnical and contaminated land risks can be safely dealt with. Specific Health and Safety responsibilities, in particular the CDM Regulations, also require compliance.

4.2.2 Environmental Health/Contaminated Land Officer

The provision of advice to the local Planning Department on technical matters and planning conditions requires a competent and comprehensive site investigation and associated risk assessment.

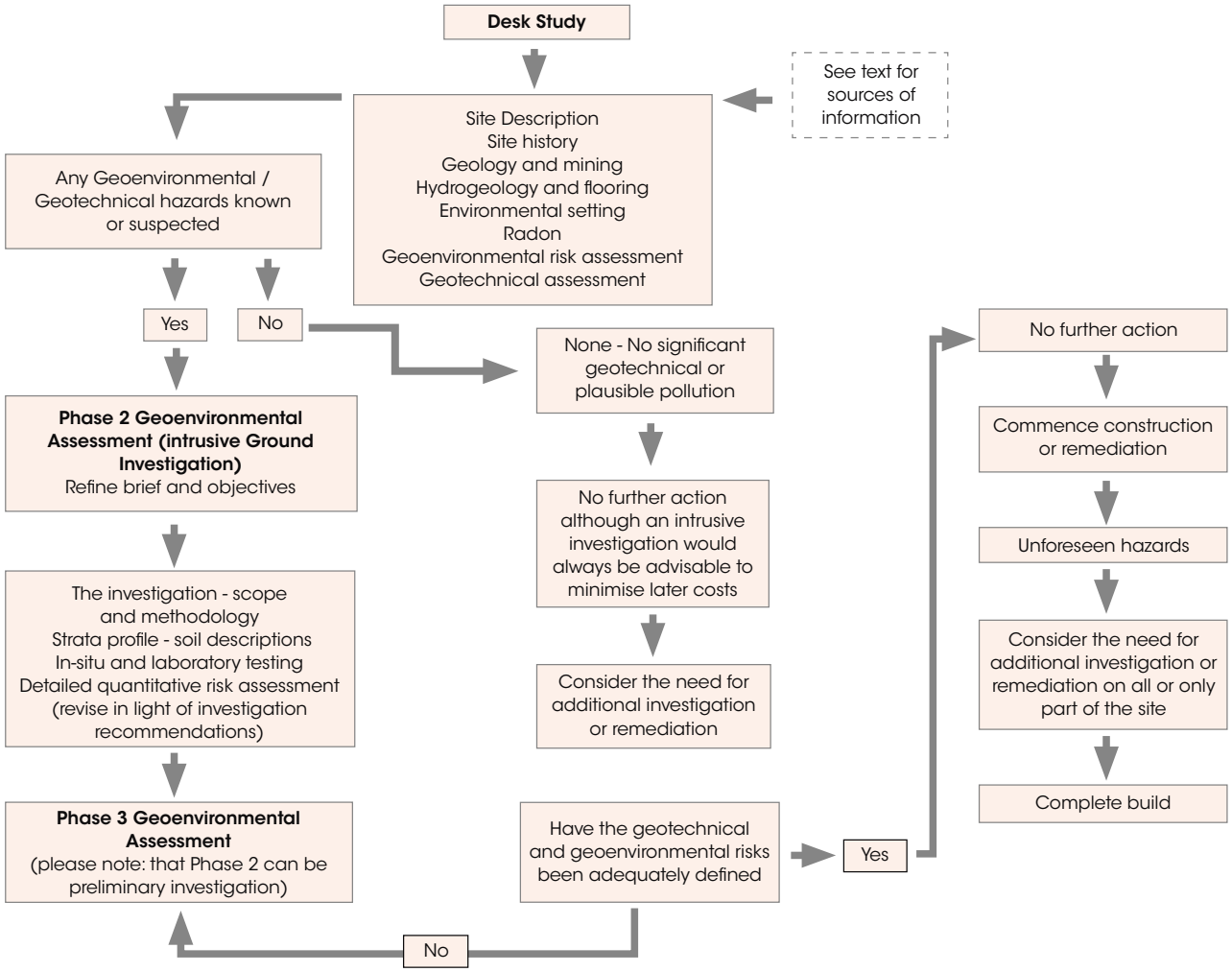
4.2.3 Local Authority Building Control

Building Control is responsible for enforcing the Building Regulations, which also requires a competent and comprehensive site investigation.

4.2.4 Health and Safety Executive

The HSE are responsible for health and safety at work, including the CDM Regulations.

4.3 FLOW CHART OF SITE INVESTIGATION PROCEDURES



4.4 PHASE 1: GEOENVIRONMENTAL ASSESSMENT (DESK STUDY)

4.4.1 Introduction

The aim of the Phase 1 Geoenvironmental Assessment is to identify and assess the potential geotechnical and geoenvironmental (contamination) hazards on the site. Since all sites are different, it is important to identify the scope and purpose of the desk study. This will include who commissioned the work, the development proposals, the relevant procedures followed and the objectives. Any issues specifically excluded should also be noted if these might normally be expected as part of the desk study.

4.4.2 Site description

The site description should define the exact extent of the site, and should include a site address, grid reference and elevation. The boundaries and topography of the site should be defined.

A site inspection should always be carried out not only of the site itself, but also the immediate surrounding area. This should include any information not apparent from the maps and describe what currently occupies the site, such as buildings, hard standing, watercourses, vegetation, trees and any particular features.

The type and distribution of vegetation can indicate soil and ground water conditions, and note should be made of any invasive plants, such as Japanese Knotweed and Giant Hogweed. Adjacent features and land use should be reported if there is likely to be an impact on the development. It is not uncommon for features such as tanks to be known about but unrecorded.

The walkover should note any potential sources of contamination and geotechnical hazards, such as slopes, excavations, land slipping, ground subsidence, soft ground or desiccated/shrinkable soils.

All structures on the site should be inspected both internally and externally for any evidence of structural damage, such as tilting, cracking or chemical attack. Any evidence of underground features should be noted. Where practical, the local residents can often give valuable information, although caution should be used in respect of their 'memories'. Local place names can give useful indications of former uses, e.g. Gas Works Lane, Water Lane, Tannery Road, etc. Aerial photographs and their interpretation can also prove helpful.

A photographic record of the site, and any specific features of the site, should be included with the report.

4.4.3 Site history

The history of the site and the surrounding areas is extremely important when assessing the likelihood of contamination or geotechnical hazards. Historical Ordnance Survey maps date back to the mid-19th Century and often specify the actual industrial use of particular sites or buildings. They may show areas of quarrying or infilling, and indicate where buried obstructions, such as underground tanks or old foundations, can be expected.

The influence or impact of off-site past industrial use will depend upon the type of industry, the underlying geology and the topography. However, consideration should normally be given to any such features within a 250m radius of the site (or further where appropriate) with the potential to affect it.

Historical maps are available from libraries and commercial providers, such as GroundSure or Envirocheck. The latter provide a cost-effective method of obtaining maps, and include the ability to superimpose current site boundaries on older maps. Issues regarding possible breaches of copyright are also avoided by using licensed products.

It should be remembered that historical maps only provide a snapshot in time, and care must be

taken when interpreting what may have occurred in the intervening years. For example, a quarry may be shown on one map and infilled on the next. However, in the intervening period, it could have expanded prior to infilling; similarly, industrial uses may not always be recorded, while many military or sensitive uses may have been omitted. Other sources of information may include the ubiquitous internet search and historical aerial photographs. Additionally, it may be necessary to search the libraries of Local Authorities and Local History departments.

4.4.4 Geology and mining

The geology of the site should be recorded by reference to published geological maps, which most commonly exist at 1:50,000 (1 inch to 1 mile) and 1:10,000 (6 inch to 1 mile). The British Geological Survey Geo-Index also provides existing ground investigation records, including logs and reports. It should be noted that these records can relate not only to the surrounding areas but may also include previous investigation of the site itself. The information on the geological maps can also be supplemented with British Geological Survey technical reports, flood risk appraisals and memoirs.

The bedrock geology, any overlying superficial deposits and the effects of weathering should all be described, together with any geological faults that may affect the site. An explanation of the likely ground conditions should be given, together with reference to any other mapped geological features, particularly if there are likely to be any natural cavities or solution features.

4.4.4.1 Mining areas

In former coalfields, or other areas of mineral extraction, the maps may not always record the presence of old or active workings. The likelihood of shallow coal workings affecting surface stability should be established in conjunction with a Coal Authority report. Such reports also record areas that have been affected by the extraction of brine, which is particularly prevalent in the Cheshire area. Other forms of mineral extraction will require site-specific research.

The potential for mine workings and mine entries within an influencing distance of the proposed development should be addressed by a suitably qualified and experienced engineer prior to commencement of works, and in accordance with CIRIA SP 32: Construction Over Abandoned Mine Workings, 2002.

Reference should be made to reports on geological hazards, such as Envirocheck or GroundSure reports, both on-site and locally.

4.4.4.2 Solution features in chalk

Solution features (such as pipes, swallow holes and solution cavities, sometimes loosely infilled with drift deposits) are commonly found in chalk, caused by water draining through the chalk and dissolving it. The risk of solution features should be addressed in the Site Investigation Report (commonly from an Envirocheck or GroundSure report on geological hazards, both on site and locally).

Hazard maps are available with different coloured areas representing different levels of risk. Where the risk is moderate or high, special precautions should be taken, which for strip foundations would include careful inspection of the excavation, probing and use of reinforcement to span potential voids.

Where piled foundations are used, CIRIA PR 86 recommends "that a CPT (Cone Penetration Test) is undertaken at each pile location at sites identified during desk studies to be prone to dissolution". Alternatively, in some instances it can be appropriate to design the pile for shaft friction alone, assuming that the pile has no end bearing due to a solution feature below it. In extreme circumstances where a site investigation borehole has encountered an extensive solution feature, the shaft friction may also be reduced to take account of this.

The potential effects of soakaways, leaking drains, run off, etc. on the chalk will need to be considered and addressed in the design.

CIRIA C574: Engineering in Chalk, 2002 gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low-density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent, soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations
- Where the chalk is of low density, or its density is not known, soakaways should be sited at least 10m away from any foundations.
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipe work.
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits.

4.4.5 Hydrogeology and flooding

The assessment should include the flood risk and hydrogeology of the site, particularly whether the site lies on a Principle Aquifer and/or Source Protection Zone, which are both susceptible to pollution of ground water. The presence of surface water features and drainage should be described, and the overall risks of flooding to the site should be determined, primarily with reference to the Environment Agency flood map data and Local Authority-commissioned Strategic Flood Risk Assessments. Flood risk data is continually being updated by the Environment Agency and Local Authority.

Any ground water or surface water abstraction points 'downstream' of the site, particularly any potable (drinking water) abstraction points, should be recorded, as this may have liability implications should the development cause any pollution.

4.4.6 Environmental setting

The question as to whether a site poses an actual or potential environmental risk, or is at some external risk from pollution, will be determined by its environmental setting. This will in turn depend upon the site's topography, geology, hydrogeology and hydrology, amongst other site-specific considerations.

It is necessary to consider other potential sources of contamination, such as pollution control licenses, discharge consents, hazardous sites (COMAH, NIHHIS), pollution incidents, landfills, waste treatment sites and past and current industrial sites.

Current industrial operations rarely provide a risk of pollution to a site. Pollution is most likely to have been caused by historical activities and processes that were often deemed normal practice in the past, but which are considered unacceptable today. In this regard, the past history is invariably highly significant in respect of possible ground pollution.

The site should be considered in relation to any designated environmentally sensitive sites, such as Special Areas of Conservation, Special Protection Areas, Nature Reserves and Sites of Special Scientific Interest. In particular, could contamination on the site be affecting such sensitive areas, whether these are on or adjacent to the study site?

Data relating to current industrial licensing, consents and the like, together with information relating to environmentally sensitive sites, is typically available through commercial data suppliers. As with the historical maps, this is usually a cost-effective method of obtaining data.

For both the historical maps and datasets, there is usually little or no interpretation of the information, and it is essential that this interpretation is carried out by an experienced and qualified individual. Automated Risk Assessments do not include appraisal by qualified staff, and should therefore be viewed with caution and are not usually

acceptable to Regulators. An example of this was a contaminated former petrol filling station site recorded as having no past industrial use. The historical maps never recorded the site as a filling station, nor did the environmental data. However, the walkover quickly identified former bases for pumps and filling points for underground storage tanks (USTs).

4.4.7 Radon

The need to incorporate Radon Protection Measures should be determined by reference to risk maps produced by the Health Protection Agency. Such information is also usually included within commercially available datasets.

4.4.8 Geoenvironmental Risk Assessment and conceptual site model

A quantitative health and environmental Risk Assessment should be carried out as part of the assessment. The process of Risk Assessment is set out in Part IIA of the Environment Protection Act 1990 and amended in subsequent legislation.

This Act introduces the concept of a pollution linkage; the linkage consists of a pollution (contaminative) source or hazard and a receptor, together with an established pathway between the two. For land to be contaminated, a pollution linkage (hazard-pathway-receptor) must exist - this forms a so-called 'conceptual model' of the site.

SOURCE → **PATHWAY** → **RECEPTOR**

Examples of pathways and the effects of land contamination (after PPS 23) are shown on Figure 2: Pathways of potential contaminants.



Figure 2: Pathways of potential contaminants

4.4.8.1 Human health (pathways 1 - 5, receptors A - C)

There is an uptake of contaminants by food plants grown in contaminated soil. The uptake will depend on their concentration in the soil, their chemical form, soil pH, plant species and prominence in diet.

Ingestion and inhalation

Substances may be ingested directly by young children playing on contaminated soil if they eat plants that have absorbed metals or are contaminated with soil or dust. Ingestion may also occur via contaminated water supplies. Metals, some organic materials and radioactive substances may be inhaled from dusts and soils.

Skin contact

Soil containing tars, oils and corrosive substances may cause irritation to the skin through direct contact. Some substances, e.g. phenols, may be absorbed into the body through the skin or through cuts and abrasions.

Irradiation

As well as being inhaled and absorbed through the skin, radioactive materials emitting gamma rays can cause a radiation response.

Fire and explosion

Materials such as coal, coke particles, oil, tar, pitch, rubber, plastic and domestic waste are all combustible. Both underground fires and biodegradation of organic materials may produce toxic or flammable gases. Methane and other gases may explode if allowed to accumulate in confined spaces.

4.4.8.2 Buildings (pathways 7 and 8)

Fire and explosion

Underground fires may damage services and cause ground subsidence and structural damage. Accumulations of flammable gases in confined spaces leads to a risk of explosion.

Chemical attack on building materials and services

Sulphates may attack concrete structures. Acids, oils and tarry substances may accelerate the corrosion of metals or attack plastics, rubber and other polymeric materials used in pipework and service conduits or as jointing seals and protective coatings to concrete and metals.

Physical

Blast-furnace and steel-making slag (and some natural materials) may expand. Degradation of fills may cause settlement and voids in buried tanks, and drums may collapse as corrosion occurs or under loading.

4.4.8.3 Natural environment (pathway 6, receptors D - E)

Phytotoxicity (prevention / inhibition of plant growth)

Some metals essential for plant growth at low levels are phytotoxic at higher concentrations. Methane and other gases may give rise to phytotoxic effects.

Contamination of water resources

Soil has a limited capacity to absorb, degrade or attenuate the effects of pollutants. If this is exceeded, polluting substances may enter surface and ground waters.

Ecotoxological effects

Contaminants in soil may affect microbial, animal and plant populations. Ecosystems or individual species on the site, in surface waters or areas affected by migration from the site may be affected.

For any contaminant source identified, judgement is required to assess the probability of a pollution linkage occurring and the potential consequences of that linkage. Based on the probability and likely consequences, the overall risk (significance) can be established. The definitions that are used for this purpose should be clearly stated. The probability of a hazard, combined with its consequences, can be used to assess risk, and this forms the so-called Conceptual Site Model. This is in accordance with the Statutory Guidance for Contaminated Land (Defra 2006).

The following tables may be used to explain the decision-making process:

Severe	Damage to human health Substantial pollution of controlled waters Significant change in ecosystem population Irreparable damage to property
Moderate	Non-permanent damage to human health Minor pollution of controlled waters Change in ecosystem Damage to property
Mild	Short term health effects Slight pollution of controlled waters Slight effect on ecosystem Minor repairable damage to property
Near zero	No noticeable effect on human health No significant pollution to controlled waters No measurable effect on ecosystem densities. Non-structural cosmetic damage to property

Table 1: Consequences of pollution linkage

Probability of a hazard and an associated linkage	**Consequences of a pollution linkage (hazard-pathway-target)**			
	Severe	**Moderate**	**Mild**	**Near zero**
High	Very High	High	Medium / Low	Low / Negligible
Medium	High	Medium	Low	Low / Negligible
Low	High / Medium	Medium / Low	Low	Negligible
Unlikely	High / Medium / Low	Medium / Low	Low	Negligible

Table 2: Decision making

Final overall risk is based on an assessment of probability of a hazard and its consequences. Risk categories are shown shaded in the table above and defined below:

Risk	**Description of risk levels**
High	Site probably or certainly unsuitable for present use or environmental setting. Contamination probably or certainly present and likely to have an unacceptable impact on key targets. Urgent action needed.
Medium / Moderate	Site may not be suitable for present use or environmental setting. Contamination may be present, and likely to have unacceptable impact on key targets. Action may be needed in the medium term.
Low	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impact on key targets. Action unlikely to be needed in present use.
Negligible	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impact on key targets. No action needed while site remains in present use.

Table 3: Overall risk

4.4.9 Geotechnical assessment

Although no intrusive investigation may have been carried out on the site at the desk study stage, it should be possible to give preliminary indications in respect of the geotechnical matters set out below:

Foundations	Are normal to deep strip footings likely to be suitable or may piling or ground improvement be necessary? Will made ground, old foundations, cellars or services be encountered?
Mining and quarrying	Will the possibility of shallow mine workings or quarrying on the site need to be addressed?
Soakaways	Are soakaways likely to be suitable based on the mapped geology? (Actual on-site permeability tests would need to be carried out to determine suitability or not.)
Roads	hat is the sub-grade strength (CBR) likely to be? (The actual design will be dependent on the CBR measured on-site.)
Excavations	Will soft ground plant be suitable or will rock breakers be needed for deeper excavation?
Groundwater	Is shallow groundwater expected?
Earthworks	Are any significant earthworks anticipated?
Gas protection	Will gas protection measures be required or would they be prudent in accordance with good practice?

Table 4: Geotechnical assessment – preliminary indicators

The above can only be provided on the basis of limited site data, and it is recommended that the scope of any intrusive ground investigation is set out here if the desk study is to be presented as a stand-alone document.

4.5 PHASE 2: GEOENVIRONMENTAL ASSESSMENT (GROUND INVESTIGATION)

4.5.1 Pre-ground investigation

The initial investigation should comprise a desk study as described in Section 4.3 of this Chapter.

4.5.2 The investigation

After the desk study has been carried out, the objective of the intrusive investigation is to provide detailed information for the safe and economic development of the site at minimum cost. Clearly, no guarantee can be given that all relevant conditions will necessarily be identified, but the work carried out should be aimed at reducing risk to acceptable levels.

Increasing expenditure on the site investigation will reduce the risk of unforeseen conditions, but professional judgement and experience is also required. Not all forms of investigation will be needed, and that which is necessary in the best interests of the client should be carefully assessed for each individual project.

The investigation must be designed to provide the appropriate level of information on ground and ground water conditions on the site, together with identifying potential areas of contamination. The investigation should be undertaken in accordance with the principles of:

- BS EN 1997-1: 2004 Eurocode 7 – Geotechnical design – Part 1: General rules
- BS EN 1997-2: 2007 Eurocode 7 – Geotechnical design – Part 2: Ground investigation and testing
- BS 5930: 1999 and BS 10175: 2001

It will also require the full-time supervision of a Chartered Geologist or Chartered Engineer.

The dates of the investigation and the methods used should be stated, with the exploratory hole positions being shown on a drawing.

An intrusive investigation may comprise the following:

4.5.2.1 Trial pitting

Normally, these should be at least three times the foundation depth where possible, or sufficient to prove competent bedrock. They should be excavated outside proposed foundation positions where possible. On completion, the excavations are normally backfilled with the arisings.

This method enables soil conditions to be closely examined at any specific point and samples to be taken. It also gives useful information on the stability of excavations and water ingress. In-situ gas, strength and California Bearing Ratio (CBR) tests can also be carried out.

4.5.2.2 Window sampling

Window sampling consists of driving a series of 1m and 2m long tubes into the ground using a dropping weight. On completion of each run, the tube is withdrawn. The next tube is then inserted and the process repeated to provide a continuous profile of the ground. On each run, the tube diameter is reduced in order to assist in its recovery. When complete, the borehole is normally backfilled with arisings. It is also possible to carry out Standard Penetration Tests (SPT) using the window sampling equipment.

4.5.2.3 Shell and auger boring

This technique uses a tripod winch and a percussive effect with a variety of boring tools, where disturbed and undisturbed samples can be taken. This is the most suitable method for soft ground investigation as it enables the maximum amount of information to be obtained. However, minor changes in lithology may be overlooked unless continuous undisturbed sampling is used.

Disturbed samples of soils can be taken for identification and classification purposes. In cohesive soils, 'undisturbed' samples 100mm in diameter can be taken by an open drive sampler for laboratory testing of strength, permeability and consolidation characteristics.

SPT are used in granular and cohesive materials and in soft or weathered rocks. The resulting 'N' value can be compared to empirical data on strength and relative density. Difficulties in obtaining true 'N' values mean they should only be used as a guide, and not as an absolute value in foundation design.

4.5.2.4 Rotary drilling

Two main types of rotary drilling can be carried out in rock. Rock coring using a diamond or tungsten carbide-tipped core bit provides samples and information on rock types, fissuring and weathering. Open-hole drilling only produces small particles for identification purposes, and the information gained is therefore limited. The latter is, however, useful as a quick method of detecting major strata changes and the location of coal seams and old workings. Water, air, foam or drilling muds may be used as the flushing medium in either case.

Rotary open-hole drilling is carried out to determine the existence of any voids or broken ground that could affect surface stability. Due to the risk of combustion, the drilling is normally done using a water flush. On completion, the boreholes are backfilled with bentonite cement. A Coal Authority Licence is required in advance of any exploratory work intended to investigate possible coal workings.

4.5.2.5 Geophysics

Geophysics can be used in certain situations and is useful where significant anomalies exist in the ground. Ground-penetrating radar is probably the most common for defining near-surface features. The results from geophysics can be variable and, combined with the relative high cost, should be used advisedly.

4.5.3 Strata profile

Full strata descriptions should be given based on visual identification and in accordance with the requirements of:

- BS EN ISO 14688-1: 2002 Geotechnical investigation and testing – Identification and classification of soil – Part 1
- BS EN ISO 14688-2: 2004 Geotechnical investigation and testing – Identification and classification of soil – Part 2
- BS EN ISO 14689-1: 2003 Geotechnical investigation and testing – Identification and classification of rock – Part 1

4.5.4 Soil description

Samples from boreholes or trial pits should be fully described in accordance with the latest guidance from the British Standards and Eurocodes. They should include colour, consistency, structure, weathering, lithological type, inclusions and origin. All descriptions should be based on visual and manual identification as per recognised descriptive methods. The methodology for soil and rock description is given in more detail in Appendix B.

4.5.5 In-situ and laboratory testing

4.5.5.1 In-situ gas monitoring

Methane is the dominant constituent of landfill gas, and can form an explosive mixture in air at concentrations of between 5% and 15%. Thus, 5% methane in air is known as the Lower Explosive Limit (LEL). Concentrations less than this do not normally ignite. Carbon dioxide can also be a potential problem, especially where it occurs in concentrations greater than 1.5%.

In-situ gas tests should be carried out in the boreholes on completion, and in probe holes made in the sides of the trial pits. Testing is with a portable meter that measures the methane content as its percentage volume in air. The corresponding oxygen and carbon dioxide concentrations are also measured. Care is needed with this, since the rapid mixing and dilution of any gases within the atmosphere can occur very quickly.

A more accurate method used to monitor over the longer term consists of gas monitoring standpipes installed in boreholes. These typically comprise slotted UPVC pipework surrounded by single sized gravel. The top 0.5m to 1m of pipework is usually

not slotted and is surrounded by bentonite pellets to seal the borehole. Valves are fitted and the installations protected by lockable stopcock covers normally fitted flush with the ground. Monitoring is again with a portable meter and is usually done on a fortnightly or monthly basis, with at least six visits being appropriate for most sites.

The risks associated with the gases should be considered in accordance with documents such as:

- BS 8485: 2007 Code of Practice for the characterisation and remediation from ground gas in affected developments
- CIRIA Report C665 Assessing risks posed by hazardous ground gases to buildings
- NHBC Report No. 4 Guidance on evaluation of development proposals on sites here methane and carbon dioxide are present

4.5.5.2 In-situ strength testing

Hand vane and MEXE cone penetrometer tests can be carried out in trial pits in order to assess the strengths and CBR values of made ground, soils and heavily weathered bedrock materials.

4.5.5.3 Soakaway testing

If sustainable drainage is being considered, soakaway testing should be carried out. This is preferably done in trial pits, with the aim of intersecting permeable soils or naturally occurring fissures within bedrock.

Soakaway testing involves filling the trial pits with water from a bowser or such like, and measuring the fall in water over time. Where possible, two tests should be carried out to allow the immediate surrounding ground to become saturated. By knowing the dimensions of the trial pit, the permeability and/or rate of dissipation can be calculated.

Soakaway test results obtained from small hand-dug pits or shallow boreholes should be treated with caution.

4.5.5.4 Geotechnical laboratory testing

Soil testing should be carried out to BS 1377: 1990 Methods of test for soils for civil engineering purposes, and the laboratory used should be recorded and conducted by an approved UKAS laboratory. Normally, the results are summarised and the full results appended; a summary of the main types of test is presented in Appendix C.

4.5.5.5 Contamination laboratory testing

As with the investigation, the sampling should be under the full-time direction of either a Chartered Engineer or Chartered Geologist. All the recovered soil samples should be screened on-site for any visual or olfactory evidence of contamination, including the presence of Volatile Organic Compounds (VOCs). Samples should be selected from the trial pits and boreholes based on those most likely to be contaminated, and those that will give the most appropriate indication of the spread of any contaminants. The samples should be stored in either glass or plastic containers and where necessary kept in cooled conditions. Testing should be carried out by a UKAS accredited laboratory, in accordance with the Environment Agency's Monitoring Certification Scheme; MCERTS performance standards.

The aim of this is to make a preliminary assessment of the level of any contamination on the site, in order to determine if there are any significant risks associated with contaminants in respect of both human health and the environment, including controlled waters. In addition to the soil, ground water samples should be tested where appropriate.

4.5.6 Geoenvironmental Risk Assessment (conceptual site model)

The qualitative health and environmental risk assessment carried out as part of the desk study should be revised, based on the findings of the ground investigation and the results of the contamination testing, to produce a Detailed Quantitative Risk Assessment (DQRA).

The DQRA is again based on the conceptual site model, and might look similar to the following example summary of hazards, pathways and receptors. On sites with known contamination, further investigation and testing may be necessary, together with recommendations for remediation and its validation.

4.5.7 Construction

During construction, if unforeseen conditions are encountered then the Builder/Developer should seek additional advice from the consultant as to whether the new conditions will affect the continued development of the site, and whether any additional investigation or testing is necessary.

4.5.8 Recommendations

The report must include a site location plan and a plan showing any special features plus borehole and trial pit locations (factual reports will describe the work carried out, and will include borehole/trial pit logs and the results of all in-situ and laboratory testing, but there will be no interpretation of the data and no recommendations).

Source	Potential pollutant	Pathways	Receptor	Risk
Potentially contaminated made ground Possible past minor spillages and metals	Oils, fuels, grease, hydraulic fluid, metals, asbestos	1 - 5	A. Present occupants	Site unoccupied
			B. Ground workers	Low risk involved with excavation work, provided personnel adopt suitable precautions, together with washing facilities
			C. Future residents / occupants	Low risk for residential use, provided made ground is capped by clean subsoil and topsoil
		6	D. Controlled waters	Low to moderate risk at present. Provided on-site monitoring undertaken throughout the piling and ground work phases of development shows no adverse effects, the risk will be low
			E. Ecosystems	Low risk as leaching is not a problem
		7	F. Building materials and services	Low to moderate. Install pipes in clean bedding materials. Adequate precautions to be taken in respect of buried concrete
Organic material	Landfill gases, radon, VOCs, SVOCs	8	A - F	Low to moderate. Low values of ground gases present during the investigation, although basic gas protection measures are recommended
Waste materials	Fly-tipping			All waste materials to be removed from site

Table 5: Example detailed quantitative risk assessment

The interpretative report should make recommendations in respect of the main points or issues related to design and construction:

- Normal strip or deep trench footings
- Piling
- Vibro replacement
- Raft foundation
- Building near trees
- Landfill and radon gas
- Existing drains and services
- Road construction
- Sustainable surface water drainage (soakaways)
- Excavations and ground water
- Reuse of materials
- Contamination
- Capping mine shafts
- Site soil reuse
- Slope stability and retaining walls
- Further geotechnical considerations
- Change of use

Advice in respect of specific recommendations is given in Appendix A.

4.6 MAIN REFERENCES

British Standards Institution	BS 1377: Methods of Test for Soils for Civil Engineering Purposes 1990 (Parts 1 to 8) BS 3882: British Standard Specification for Topsoil BS 5930: British Standard Code of Practice for Site Investigations, 1999 BS 8485: British Standard Code of Practice for the characterisation and remediation from ground gas in affected developments, 2007 BS 10175: British Standard Code of Practice for the Investigation of Potentially Contaminated Sites, 2001 BS EN 1997-1: 2004 'Euro-Code 7 – Geotechnical Design – Part 1: General Rules' BS EN 1997-2: 2007 'Euro-Code 7 – Geotechnical Design – Part 2: Ground Investigation and Testing' BS ISO 14688-1: 2002 'Geotechnical Investigation and Testing – Identification and Classification of Soil – Part 1' BS ISO 14688-2: 2004 'Geotechnical Investigation and Testing – Identification and Classification of Soil – Part 2' BS ISO 14689-1: 2003 'Geotechnical Investigation and Testing – Identification and Classification of Rock – Part 1'
BRE	Radon: Guidance on protective measures for new dwellings, BR 211 Protective measures for housing on gas-contaminated land, BR 414, 2001 Cover systems for land regeneration, 2004 Concrete in aggressive ground. Special Digest SD1, 3rd Edition, 2005
CIEH	The LQM / CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)
CIRIA	Assessing risks posed by hazardous ground gases to buildings, CIRIA C665 Shaft friction of CFA piles in chalk 2003, CIRIA PR 86 Engineering in chalk 2002, CIRIA C574 Construction over abandoned mine workings 2002, CIRIA SP 32
DoE	CLR reports 1 - 4 Waste Management Paper No. 26A 'Landfill completion: A technical memorandum…' Waste Management Paper No. 27 'Landfill Gas: A technical memorandum…'

DEFRA	Contaminated Land Report CLR 11, 2002 (7 - 10 withdrawn) R & D Publications TOX 1 – 12, 14, 16 – 25 R & D Publications SGV 1, 3, 4, 5, 7, 8, 9, 10, 15 and 16 (withdrawn) Improvements to Contaminated Land Guidance - 'Outcome of the Way Forward', 2008 Exercise on Soil Guideline Values. July 2008 Guidance on the Legal Definition of Contaminated Land. July 2008
DETR	Circular 02/2000. Contaminated Land, 2000 Guidelines for Environmental Risk Assessment and Management, 2000
Environment Agency	Guidance for the Safe Development of Housing on Land Affected by Contamination, 2000 Guidance for waste destined for disposal in landfills, Version 2, June 2006 Protective measures for housing on gas-contaminated land Remediation Position Statements, May 2006 Guidance and monitoring of landfill leachate, groundwater and surface water Human health toxicological assessment of contaminants in soil (Science Report SC050021/SR2), 2008 Updated technical background in the CLEA model (Science Report SC0520021/SR3) Using Soil Guideline Values, 2009
HMSO	Environmental Protection Act 1990 Environment Act 1995 UK Water Supply (Water Quality) Regulations 2000 The Water Act 2003
Institution of Civil Engineers	Contaminated Land: Investigation, Assessment and Remediation, 2nd Edition
Joyce M D	Site Investigation Practice, 1982
OPDM	Planning Policy Statement 23: Planning and Pollution Control Annex 2: Development on Land Affected by Contamination

APPENDIX A

Checklist for Phase 1: Geoenvironmental Assessment (Desk Study)

Site description
(and surrounding area of relevance)

- Location, o.S. Grid reference and plans
- Topography, levels
- Site layout and main features
- Site infrastructure
- Site description and topography
- Made ground, erosion, cuttings or quarries
- Slope stability
- Evidence of faulting or mining
- Watercourses, seepages or sinks
- Marshy or waterlogged ground
- Type and health of vegetation
- Existing structures and condition
- Existing on-site processes
- Demolished structures/old foundations
- Visual evidence of contamination
- Existing site operations
- Underground and overhead services
- Trees

Mining

- Past, present and future mining
- Reference to geological sources
- Coal Authority Mining Report

- Register of abandoned mine plans and opencasts
- Shaft register
- Other mining, e.G. Sand, sandstone, limestone, brine, etc.

Geology
- Geological maps (1:50,000 and 1:10,000 scale)
- Memoirs
- Technical reports
- Engineering geological maps
- Existing trial pit or borehole logs and reports
- Subsidence features

Hydrogeology and hydrology
- Ground water vulnerability
- Aquifer status
- Abstraction licences (within 1km)
- Flood risk, drainage and watercourses (within 1km)

Local Authority consultation
- Building Control, Planning and Environmental Health/Contaminated Land Officer
- Petroleum Officer

Archival research
- Past o.S. Mapping and previous on-site and Off-site usage
- Possible contaminants associated with Former use(s)
- Town plans
- Local history records, books and photographs (where relevant and practicable)
- Aerial photographs (where relevant)
- Archaeological register (where relevant)

Contamination
- Likely contaminants based on past history
- Hazard-Pathway-Receptor scenario
- Preliminary Conceptual Site Model

Environmental database
- Operational and former landfill sites, scrapyards and waste processing sites
- Radon protection measures

Checklist for Phase 2: Geoenvironmental Assessment (Ground Investigation)

Trial pits
- Strata profile and description
- In-situ gas testing for methane, carbon dioxide and oxygen
- Landfill gas, marsh gas and mine gas
- In-situ shear strength testing
- In-situ MEXE cone penetrometer for CBR/in-situ shear strength
- Full description of ground and ground water conditions
- Soakaway testing
- Geotechnical contamination laboratory testing

Boreholes
- Cable percussive, window sampling, dynamic probing or rotary drilling to BS 5930
- Use of British Drilling Association accredited drillers
- Full description of ground and ground water to BS 5930
- Installations for long-term gas and water monitoring (if required)
- Geotechnical laboratory testing (BS 1377) and contamination testing if suspected by accredited laboratories

Other methods of investigation
- Geophysics
- Cone penetrometer

Recommendations for reports

Foundations and retaining walls
- Foundation type, depth, bearing capacity and settlement
- Ease of excavation
- Sulphate/acidity/concrete class
- Shrinkage/heave
- Effect of vegetation, including building near trees
- Buoyancy or flotation effects
- Ground improvement options, e.g. piling, vibro, compaction, etc.

Mining
- Precautions for foundations in respect of past or future mining
- Treatment of shallow mine workings
- Capping of shafts and adits

Landfill/mine gas/radon
- Requirements for long-term monitoring
- Protection measures for structure
- Venting measures

Road construction
- CBR of subgrade and its preparation
- Sub-base type and thickness
- Excavation of unsuitable material
- Soil stabilisation
- Frost susceptibility

Drainage and excavations
- Ground water regime, including dewatering
- Use of soakaways
- Support and ease of excavation
- rock levels
- Use of sheet piling, diaphragm, bored piles and ground anchors

Earthworks
- Compaction characteristics
- Surcharging and self-settlement
- CBR at formation level
- Slope stability and slope stabilisation
- Suitability of excavated material for re-use

Contamination
- Full assessment of contamination testing
- Hazard-Pathway-Target scenarios/conceptual model
- Risk assessment and liability
- Precautions or remediation of contamination

Further investigation
- Is further investigation needed?
- Nature of further investigation

APPENDIX B

Soil and rock descriptions

Fine soils (cohesive soils)

The following field terms are used:

Soil Type	Description
Very soft	Exudes between fingers
Soft	Moulded by light finger pressure
Firm	Cannot be moulded by the fingers but can be rolled in hand to 3mm threads
Stiff	Crumbles and breaks when rolled to 3mm threads but can be remoulded to a lump
Very stiff	No longer moulded but crumbles under pressure. Can be indented with thumbs

The following terms may be used in accordance with the results of laboratory and field tests:

Description	Undrained shear strength Cu (kPa)
Extremely low	<10
Very low	10 - 20
Low	20 - 40
Medium	40 - 75
High	75 - 150
Very high	150 - 300
Extremely high	>300

Fine soils can also be classified according to their sensitivity, which is the ratio between undisturbed and remoulded undrained shear strength:

Sensitivity	Ratio
Low	8
Medium	8 - 30
High	>30
Quick	>50

Granular soils (non-cohesive)

The following descriptions are used for granular soils:

Description	Normalised blow count (N1) 60
Very loose	0 - 3
Loose	4 - 8
Medium	9 - 25
Dense	26 - 42
Very dense	43 - 58

Rock description

This is based on:

i. Colour (minor then principal colour)
ii. Grain size

Description	Predominant grain size (mm)
Very coarse – grained	>63
Coarse - grained	63 - 2
Medium - grained	2 - 0.063
Fine - grained	0.063 - 0.002
Very fine - grained	<0.002

iii. Matrix
iv. Weathering

Term	Description
Fresh	No visible sign of weathering / alteration of the rock material.
Discoloured	The colour of the original fresh rock material is changed with evidence of weathering / alteration. The degree of change from the original colour should be indicated. If the colour change is confined to particular mineral constituents, this should be mentioned.
Disintegrated	The rock material is broken up by physical weathering, so that bonding between grains is lost and the rock is weathered / altered towards the condition of a soil, in which the original material fabric is still intact. The rock material is friable but the grains are not decomposed.
Decomposed	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a soil in which the original material fabric is still intact; some or all of the grains are decomposed.

v. Carbonate content
vi. Stability of rock material

Stable indicates no changes when a sample is left in water for 24 hours. Fairly stable indicates fissuring and crumbling of surfaces. Unstable indicates complete disintegration of the sample.

vii. Unconfined compressive strength

Term	Field Identification	Unconfined Compressive Strength (MPa)
Extremely weak [a]	Indented by thumbnail	Less than 1
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	2 - 5
Weak	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	6 - 25
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	26 - 50
Strong	Specimen required more than one blow of geological hammer to fracture it	51 - 100
Very strong	Specimen requires many blows of geological hammer to fracture it	101 - 250
Extremely strong	Specimen can only be chipped with geological hammer	Greater than 250

Note:

(a) Some extremely weak rocks will behave as soils and should be described as soils.

viii. Structure

Sedimentary	Metamorphic	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flowbanded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	
Graded	Gneissose	
	Folded	

ix. Discontinuities

x. Discontinuity spacing, persistence and roughness, infilling and seepage

xi. Weathering of the rock mass

xii. Rock mass permeability

In addition to the description of the soils and rocks and their associated depth, ground water should be noted in terms of both where it was struck and changes over time. Any unusual colouration or odours of any of the soils encountered during the investigation should be recorded.

It should be noted that lateral and vertical changes can occur between exploratory points, and care is needed when extrapolation is used. This is particularly true of the 'made ground', which, by its nature, can be highly variable in its physical and chemical composition.

Term	Description	Grades
Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces	0
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces	1
Moderately weathered	Less than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones	2
Highly weathered	More than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones	3
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact	4
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soils have not been significantly transported	5

APPENDIX C

Laboratory testing

Natural or in-situ moisture content
The natural or in-situ moisture content of a soil is defined as the weight of water contained in the pore space, expressed as a percentage of the dry weight of solid matter present in the soil. Soil properties are greatly affected by the moisture content, and the test can help provide an indication of likely engineering behaviour.

Liquid and plastic limits
Two simple classification tests are known as the liquid and plastic limits. If a cohesive soil is remoulded with increasing amounts of water, a point will be reached at which it ceases to behave as a plastic material and becomes essentially a viscous fluid. The moisture content corresponding to this change is arbitrarily determined by the liquid limit test. 'Fat' clays, which have a high content of colloidal particles, have high liquid limits; 'lean' clays, having a low colloidal particle content, have correspondingly low liquid limits. An increase in the organic content of clay is reflected by an increase in the liquid and plastic limits.

If a cohesive soil is allowed to dry progressively, a point is reached at which it ceases to behave as a plastic material, which can be moulded in the fingers, and becomes friable. The moisture content of the soil at this point is known as the 'plastic limit' of the soil.

The water content range over which a cohesive soil behaves plastically, i.e. the range between the liquid and plastic limits, is defined as the plasticity index.

A cohesive soil with natural water content towards its liquid limit will, in general, be an extremely soft material, whereas a cohesive soil with natural water content below its plastic limit will tend to be a firm or stiff material.

Particle size distribution
Knowledge of particle size distribution is used to classify soils and indicate likely engineering behaviour.

British Standards define soils in relation to their particle size, as shown below:

Boulders >200mm Cobbles 200mm - 63mm	Coarse sand 2mm - 0.63mm Medium sand 0.63mm - 0.2mm Fine sand 0.2mm - 0.063mm
Coarse gravel 63mm - 20mm Medium gravel 20mm - 6.3mm Fine gravel 6.3mm - 2m	Coarse silt 0.063mm - 0.02mm Medium silt 0.02mm - 0.0063mm Fine silt - 0.0063mm - 0.002mm
	Clay <0.002mm

Bulk density
The bulk density of a material is the weight of that material per unit volume, and includes the effects of voids whether filled with air or water. The 'dry density' of a soil is defined as the weight of the solids contained in a unit volume of the soil.

Permeability
The permeability of a material is defined as the rate at which water flows through it per unit area of soil under a unit hydraulic gradient.

Consolidation characteristics
When subjected to pressure, a soil tends to consolidate as the air or water in the pore space is forced out and the grains assume a more densely packed state. The decrease in volume per unit of pressure is defined as the 'compressibility' of the soil, and a measure of the rate at which consolidation proceeds is given by the 'coefficient of consolidation' of the soil. These two characteristics, Mv and Cv, are determined in the consolidation test, and the results used to calculate settlement of structures or earthworks by a qualified person.

Strength characteristics

The strength of geological materials is generally expressed as the maximum resistance that they offer to deformation or fracture by applied shear or compressive stress. The strength characteristics of geological materials depend to an important degree on their previous history and on the conditions under which they will be stressed in practice. Consequently, it is necessary to simulate in the laboratory tests the conditions under which the material will be stressed in the field.

In general, the only test carried out on hard rocks is the determination of their compressive strength, but consideration must also be given to fissuring, jointing and bedding planes.

The tests currently used for soils and soft rocks fall into two main categories. First, those in which the material is stressed under conditions of no moisture content change, and second, those in which full opportunity is permitted for moisture content changes under the applied stresses.

Tests in the first category are known as undrained (immediate or quick) tests, while those in the second category are known as drained (slow or equilibrium) tests. The tests are normally carried out in the triaxial compression apparatus, but granular materials may be tested in the shear box apparatus.

The undrained triaxial test gives the apparent (cohesion) C_u and the angle of shearing (resistance) $\emptyset_u$. In dry sands, $C_u = 0$ and $\emptyset_u$ is equal to the angle of internal friction, whereas with saturated non-fissured clays $\emptyset_u$ tends to 0 and the apparent cohesion C_u is equal to one-half the unconfined compression strength qu. On-site, the vane test gives an approximate measure of shear strength.

For some stability problems, use is made of a variant of the undrained triaxial test in which the specimen is allowed to consolidate fully under the hydrostatic pressure, and is then tested to failure under conditions of no moisture content change. This is known as the consolidated undrained triaxial test. Pore water pressures may be measured during this test, or alternatively a fully drained test may be carried out. In either case, the effective shear strength parameters C′ and Ø′ can be obtained, which can be used to calculate shear strength at any given pore water pressure.

Compaction

The density at which any soil can be placed in an earth dam, embankment or road depends on its moisture content and on the amount of work used in compaction. The influence of these two factors can be studied in compaction tests, which can determine the maximum dry density (MDD) achievable at a certain optimum moisture content (OMC).

California Bearing Ratio (CBR) test

In flexible pavement design, knowledge of the bearing capacity of the sub-grade is necessary to determine the thickness of pavement for any particular combination of traffic and site conditions. The quality of the subgrade can be assessed by means of the CBR test, or approximately by the MEXE cone penetrometer.

Chemical tests

Knowledge of the total soluble sulphate content and pH of soils and ground water is important in determining the protection required for concrete or steel in contact with the ground. Other specialist tests may be carried out on sites suspected of being contaminated by toxic materials.

CHAPTER 5: FOUNDATIONS

CONTENTS

5.1 GROUND IMPROVEMENT

5.2 FOUNDATIONS, TREES AND CLAY

5.3 STRIP AND MASS FILLED FOUNDATIONS

5.4 PILED FOUNDATIONS

5.5 RAFT FOUNDATIONS

FUNCTIONAL REQUIREMENTS

5.1 GROUND IMPROVEMENT

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Ground improvement schemes should be appropriately tested to confirm that the completed works meet design specifications. The testing regime must be agreed with the Warranty Surveyor prior to commencement of work.
iv. The Developer shall ensure that adequate quality control procedures are in place. The quality control must identify that site work meets the design intention. All procedures should be auditable and available for inspection.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Site investigation by an appropriately qualified person should be supplied and provide the following information:
    a. Depth of original soil types below the structure.
    b. Details of any filled ground and its suitability to accept ground improvements techniques.
    c. Gas generation or spontaneous combustion from ground conditions.

    The investigation must be endorsed by the Specialist Foundations Contractor.
iii. Structural elements outside the parameters of Approved Document A (England and Wales) must be supported by structural calculations provided by a suitably qualified expert.
iv. The ground improvement works must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

5.1.1 Introduction

Ground improvement enables sites with poor load-bearing capacity to be strengthened, meaning the loadings of the proposed building can be adequately supported off suitable foundations. The guidance detailed in this Chapter will be accepted as a satisfactory method of meeting the Functional Requirements.

5.1.2 Limitations of guidance

The following situations are beyond the scope of the guidance in this Chapter:

- Where the original ground or sub-strata is unstable or will continue to settle.
- Sites with soft clays with a low bearing capacity (30kN/m^2 undrained).
- Filled ground where high levels of voids are anticipated.
- Clay fill, where the water will influence the foundation or where collapse may occur.

Each development site has its own specific characteristics, and where conditions do not clearly fall within the guidance given, clarification should be sought from the Warranty Surveyor or a suitably qualified and experienced expert.

5.1.3 Vibratory ground improvement

5.1.3.1 Introduction

Vibro displacement using vibro stone columns is a method of enhancing ground bearing capacity and limiting settlement. Typical applications include the support of foundations, slabs, hard standings, pavements, tanks or embankments. Soft soils can be reinforced to achieve improved specification requirements, whilst slopes can be treated to prevent slip failure. Both natural soils and made ground can be improved.

Vibro treatment should be carried out in accordance with Institute of Civil Engineers: 1987 Specification for ground treatment: Notes for guidance, and to a depth sufficient to reach an adequate bearing stratum.

5.1.3.2 Vibratory techniques

The vibratory process is applied to weak natural soils and filled ground with a view to improving the load-bearing capacity and providing an adequate bearing stratum for the building's foundations.

There are two vibratory techniques commonly used in the UK. These are known as the 'dry bottom feed' and 'dry top feed' methods; a third technique, less frequently used in the UK, is known as the 'wet bottom feed' method.

Dry bottom feed method

The dry bottom feed method is used in weaker soil conditions or where there is a high water table and the borehole is liable to collapse between vibroflot insertions. The vibroflot penetrates using its mass, air flush and vibration, but at design depth, the stone is introduced via a hopper into a pipe fixed to the side of the vibroflot. The stone, usually 40mm in size, exits the pipe at the tip of the vibroflot and reaches the bottom of the borehole. The stone is then compacted into the surrounding soil by repeated withdrawal and insertion of the vibroflot.

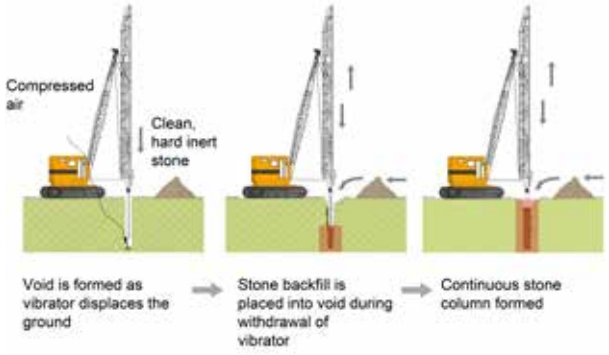


Figure 1: Vibratory techniques: dry bottom feed method

Dry top feed method

In the dry top feed method the vibroflot penetrates the weak soil or fill again using its mass, air flush and vibration to form a borehole. Once refusal or design depth is reached, the vibroflot is removed and stone fill is introduced into the bore, the 'charge' is typically 500mm - 800mm deep.

The vibroflot is re-inserted and 'packs' the stone into the surrounding strata. Successive charges of stone are added and compacted bringing the column up to working level. Typically the stone grading is 40mm - 75mm.

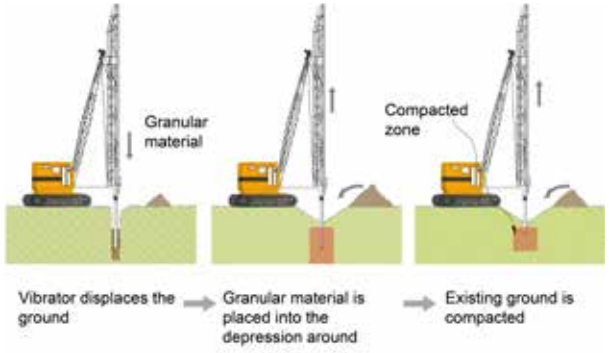


Figure 2: Vibratory techniques: dry top feed method

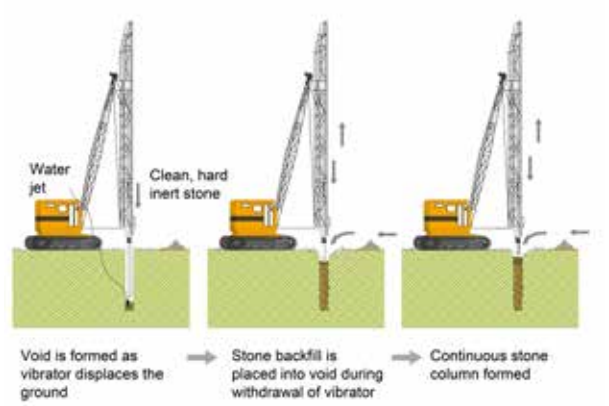


Figure 3: Vibratory techniques: wet bottom feed method

Wet bottom feed method

Where the ground contains fines and silts, water jetting from the tip of the vibroflot is used to remove loose materials and form a cavity for charges of stone to be added to replace and densify the soft ground. The carbon footprint of this activity is generally less than for comparable piling solutions.

5.1.3.3 Suitability of ground conditions

Through the process of a site investigation, it should first be established by the appointed Engineer or suitably qualified specialist that the ground is capable of being improved by a vibratory ground improvement technique. The site investigation should determine the depths and properties of the natural materials under the site, including the presence of cavities, mines, rocks or soils that may dissolve or erode when water passes over them. It should also be established at an early stage whether the site has previously contained any buildings or structures, and whether they have been completely removed, including basement walls, floor slabs, etc. The presence and extent of any existing or redundant services and drains should be investigated, and the associated backfill to the excavations. In addition, the effect that any proposed sustainable drainage system (SuDS) might have on the ground conditions should be identified.

The Engineer should supervise the site investigation, taking account of the findings of the desk study, and first establish whether there are any contaminated substances or gases present. Data should be gathered using a suitable method for comparison with the site post treatment. Investigations should be made into the presence, level and nature of any ground water, and if it is likely to rise and cause heave or collapse by saturation.

The extent of any areas of made-up ground on the site should be established, including:

- The proportions, compaction and distribution of constituent materials throughout its depth.
- The grading and particle size distribution of fill materials.
- The potential for gas generation from fill materials, and the risk of combustion of natural deposits.

The appointed Specialist Contractor should be satisfied that the site investigation report provides adequate and representative information in order to design the ground improvement. The results of the investigation should be presented to the Warranty Surveyor prior to the commencement of the work.

The Developer shall obtain written confirmation from the Engineer and Specialist Contractor that the site is suitable for the proposed ground improvement system, and that all detrimental factors associated with the site and the proposed development have been taken into account. This is

to be made available to the Warranty Surveyor prior to the commencement of any work on the site.

Site workmanship

The Specialist Contractor should appoint an Engineer to supervise the vibratory foundation works at all times and ensure that:

- The required depth and bearing capacity of stone columns are achieved.
- The stone columns are correctly located beneath the proposed foundation and in accordance with design drawings.

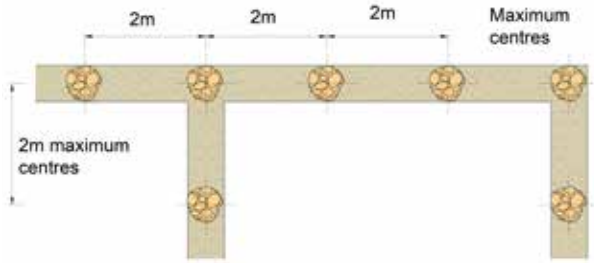


Figure 4: The intersection of adjacent reinforced concrete strips

5.1.4 Engineered Fill

5.1.4.1 Design of Engineered fill

Careful selection of the material and controlled placement should ensure that the engineered fill forms an adequate foundation material; however, in some circumstances, significant ground movements can occur. Engineered fill should be designed and placed in accordance with recognised good practice, as noted in references at the end of this section.

Engineered fills used to produce suitably shaped landforms for structures should be constructed to high standards to minimise the risk of ground movements causing damage to property built on shallow foundations.

In designing and specifying a fill to form a foundation for buildings, the following technical requirements should be established:

- A well-constructed excavation, safely executed, with all soft and hard spots removed, and made reasonably dry and well drained.
- Sound fill without undesirable material and capable of compaction as specified, provided with starter and capping layers as necessary.
- Placement and compaction to ensure that the performance of the fill will meet required criteria as a foundation fill.
- Appropriate monitoring; the Designer must ensure that all work can be carried out safely as required by the Health and Safety Executive Construction Design and Management Regulations.

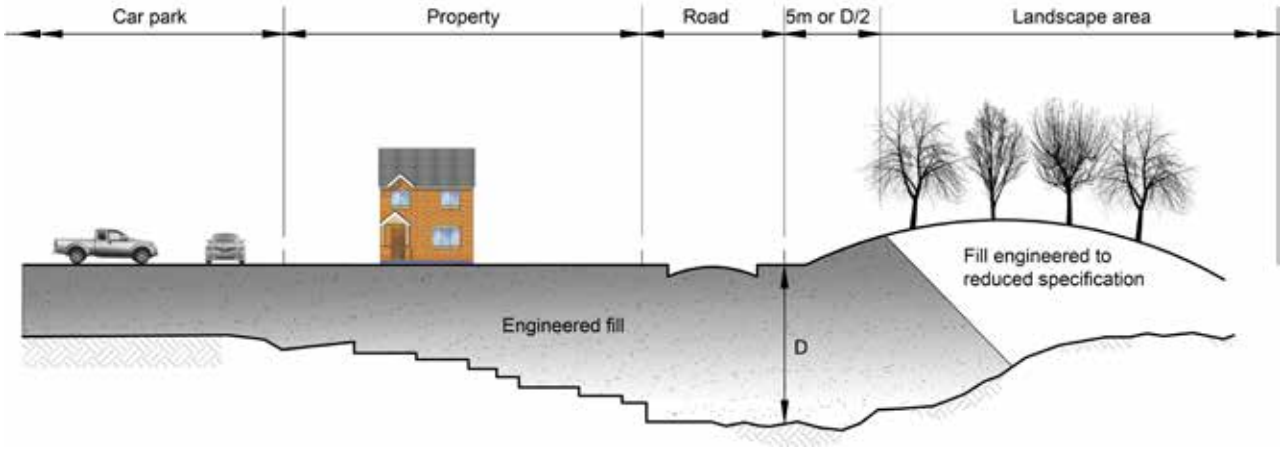


Figure 5: Typical engineered fill construction

5.1.4.2 Fill selection

Fill should be clearly categorised into material that may and may not be used: unsuitable fill, general fill, restricted fill and special fill. Fill materials must not present an environmental or health hazard.

Unsuitable fill should not be used at any location on the site.

General fill is all material except that which is unsuitable, restricted or special, and is normally the majority of the material used. It may include natural soils as well as some waste products.

Restricted fill is material that would be general fill except that it contains minerals hostile to the built environment. It can include natural materials such as pyritic shales, sulfate-bearing clays and waste materials, including burnt colliery discard and steel slag. Its use is precluded where ground water could rise to the underside of the deepest foundation, or where it is rejected for pollution reasons. For some developments, such as housing with gardens, restricted fills would include fills that are harmful to people.

Special fill is high-quality material, such as well-graded natural sands and gravels, crushed rock or clean demolition rubble. Its use will often have to be reserved for specifically defined purposes, such as a capping layer or backfill to retaining walls. Where possible though, granular soils should be used as general fill since these materials drain readily and consolidate quickly. The smaller the predominant particle size, the longer the potential time required for consolidation under the self-weight of the fill.

5.1.4.3 End product criteria

The greatest threats to successful in-service performance are:

- Collapse settlement due to inundation of dry or inadequately compacted fills.
- Excessive consolidation settlement of wet compressible fill.
- Heave or settlement of clay fills due to climatic changes or vegetation.

These ground movements depend on moisture movement, so by reducing the voids in a fill, the opportunities for excessive in-service movements should be restricted. A maximum allowable air-voids content of 5% is a suitable criterion for most clay fills. However, specifying a 5% air-voids content is insufficient, as this value may easily be achieved by adding water to the fill without increasing compactive effort. A suitable alternative control method is to specify a minimum acceptable density as a proportion of the maximum dry density measured in a standard laboratory compaction test. Limits on moisture content are required also. If the fill is too wet, there could be excessive consolidation settlement, and if the fill is too dry, it might be vulnerable to collapse compression.

5.1.4.4 Placing engineered fill

A successful engineered fill requires not only an appropriate specification but also adequate control during placement. All the work must be carried out with due regard to safety, as required by the Construction Design and Management Regulations.

5.1.4.5 Site preparation and disposition of fill

The site should be cleared of all topsoil and other unsuitable material.

Soft spots and hard spots, such as derelict foundations, should be removed, together with ponds and surface water from depressions. Removing water by pumping may be necessary when filling some excavations below the ground water level.

When a variety of material types are used as fill, they should be deposited in horizontal layers across the site. If there is only a limited amount of good granular material, it will be best to use it in layers interspersed between layers of poorer cohesive fill.

The fill thicknesses should be reasonably constant beneath a structure to minimise differential settlement.

Feather-edges, resulting in foundations set partly on fill and partly on natural ground, should be avoided, and the site worked in such a way that structures are located either directly on natural ground or directly over fill of a consistent thickness.

If fill is to be placed over sloping natural ground, some stepping of the ground may be necessary. Construction over the face of a quarry or an opencast mining high wall should be avoided.

Special measures may have to be taken by providing flexible connections for services at the location of high walls and by thickening construction for service and estate roads.

If the natural ground on which the fill rests is soft and compressible (for example, layers of peat or soft clay), the surface of the fill may settle appreciably and unevenly as a result of the weight of the fill consolidating the soft layers below. This settlement will, of course, be additional to that resulting from the compression of the fill itself.

Sensitive structures may warrant a surface (or capping) layer formed from special fill compacted to more onerous standards than the underlying fill. This should help minimise the differential settlement suffered by the structure.

Where landscaped or other non load-bearing areas form part of a development, they need less compaction than the load-bearing areas. There should be a transition zone around the load-bearing area, as shown in Figure 5.

5.1.4.6 Fill placement

Fill should be placed in horizontal layers, with each layer separately compacted. For a given item of plant, compaction performance will be determined by fill layer thickness, fill moisture content and the number of passes of the compaction equipment. There are, however, other factors such as the need to avoid excessive handling.

Whenever possible, site trials should be undertaken to determine the correct criteria. Some general information about placing fills is given in BS 6031. Each layer should be of a thickness that allows the compactive energy to spread throughout the layer, producing the specified fill density and low air-voids content. Loose layers with a thickness greater than 250mm are unlikely to be satisfactory for earth fills compacted to support low rise structures.

It may be necessary to use layers of 200mm or less. Moisture content at the time of placing a fill is fundamental to subsequent performance, particularly where the fill contains a large proportion of fine grained cohesive material. If the fill is too dry, there is the possibility of heave or collapse settlement; if it is too wet, there is the possibility of insufficient strength and high compressibility. It will be difficult to achieve an air-voids content of 5% or less when the moisture content is low. In the same way that the addition of too much water can detract from the performance of engineered fill, soil can be over-compacted.

Granular soils and cohesive soils drier than optimum, when rolled excessively, become over-stressed, and what should have been a firm compacted surface becomes a loose tilth. This should be avoided whenever possible. Where a fill containing a large proportion of fine grained cohesive material (for example, clay) is used, filling during wet weather should be avoided.

5.1.4.7 Quality control

Quality control procedures should be implemented to ensure compliance with the specification. The nature of the control procedure will depend on the type of specification adopted. The end product specification requires an appropriate type and quantity of testing of the fill during placement to ensure that the desired end product is being achieved. Depending upon the type of contract, quality control may be the responsibility of the Engineer or of the Contractor working under the supervision of the Engineer. Control parameters should be the same as those determined during the site investigation stage. Both design and control parameters must be reproducible, a term that

denotes the range within which measurements made on the same fill by different operators using different equipment should agree.

The following are the most significant control parameters:

- Moisture content, in respect of an optimum moisture content established at the site investigation stage.
- Dry density, in respect of the already established maximum dry density.
- Air-voids content, which depends on moisture content and dry density.
- Undrained shear strength, which is an alternative to monitoring moisture content and dry density for clay fills.

The laboratory compaction tests and the associated field control tests are suitable for a wide range of fill types, and form the most generally applicable approach. For cohesive soils, undrained shear strength forms an alternative basis for specification and control testing.

However, different methods of measuring the undrained shear strength, such as the unconfined compression test and the vane test, can give significantly different values. The measured value of cohesion can be sensitive to a detailed test procedure, such as the rate of shearing.

It is important for the method of testing to be strictly specified. Where a cohesive fill contains gravel, it may not be possible to obtain sufficiently undisturbed samples for strength tests. On larger sites, employing in-situ methods, such as the cone penetrometer (BS 1377: Part 9), could be considered.

Small sites are generally more difficult to work than large sites, as finished work may be damaged more easily in confined working areas and deficiencies in site preparation usually reflect more readily in poorer quality compaction than on larger sites. Consequently, it is necessary to test more frequently on a small site than on a large one.

A suggested minimum test frequency is presented in Figure 6. However, each site should be judged on its own merits, with careful note taken of any problems revealed during site investigation. In very variable or difficult conditions, more frequent testing may be required. Tests in visually doubtful areas, and re-tests of failed areas, should be carried out in addition to those recommended in Figure 6.

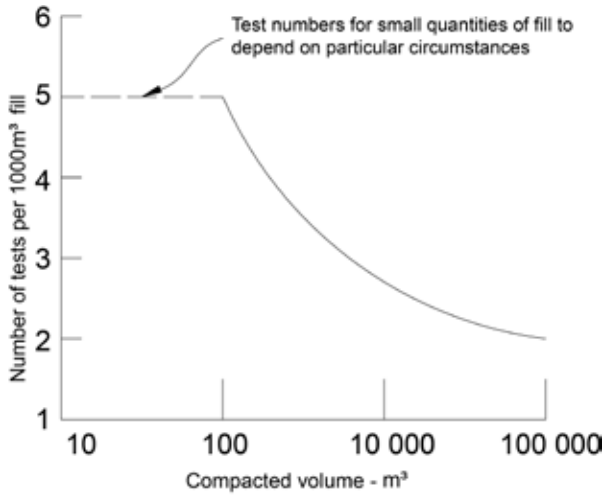


Figure 6: Number of tests

Modern compaction control requires laboratory and field testing during the site investigation, and during, and possibly following, the earthworks. The results of this work must be recorded, collated and presented to demonstrate the quality of the operation. The required documentation includes:

- Summary of the specification requirements and the end product in terms of the selected geotechnical parameters for the various fills (based on-site investigation information).
- List of the required suitability tests; one form to be completed for each borrow pit under investigation.

- Suitability test results for each borrow pit.
- List of the required control tests.
- Results of the control tests on each fill type, layer or area, as appropriate.
- A list of post-compaction monitoring requirements.
- The results of post-compaction monitoring; all completed forms should be signed and dated by the person responsible, and a list prepared of any required action or remedial work to be carried out.

5.1.4.8 Monitoring of fill performance

Monitoring provides a check on the performance of the fill after compaction, and is particularly important where vulnerable structures are to be built or foundation loading is unusually large. It is also required where the fill is relatively deep or substantial ground water rise within the fill is expected.

Monitoring techniques include:

- Surface levelling stations to measure the settlement of the fill surface.
- Magnet extensometers to measure the settlement of incremental depths of fill.
- Standpipe piezometers to measure the rise in the ground water table in the fill after placement.
- Load tests for direct estimation of settlement of surface layers produced by loadings.

Surface levelling stations are easy to install and very effective. By optical levelling of the stations, measurement can be made of the total vertical movement of the fill upon which they rest, together with any movement of the underlying natural ground, although this is unlikely to be large if all soft material has been removed prior to compaction.

Levelling stations should be sufficiently robust to resist damage due to construction traffic. A round headed bolt cast into a 1m concrete cube set 300mm into the fill has been found to be effective. Magnet extensometers are unlikely to be necessary in shallow-depth fill. Standpipes or piezometers will be of advantage if there is reason to suspect that ground water will rise into the fill at any time in the future, with consequent settlement.

5.1.5 Testing

Testing is carried out to confirm that the ground improvement works meet the design criteria. The tests are usually completed to determine the ground bearing capacity.

The Engineer shall require the Specialist Contractor to verify that the ground treatment has been completed to a satisfactory standard. This will usually include carrying out suitable testing to establish the degree of ground improvement, its load-bearing characteristics and settlement potential. These tests may include:

5.1.5.1 Plate tests

This test will not determine the design but will allow for an assessment of the workmanship on the stone columns. Plate tests should be carried out on stone columns or treated ground at a frequency of at least one test per day per rig.

The plate tests should be carried out with a 600mm diameter plate and minimum test load of 11 tonnes.

5.1.5.2 Mini zone tests

A mini zone test (dummy footing) can be used as a limited substitute for zone tests. The test should be applied to at least two stone columns and the area of foundation they support. To be useful, mini zone tests should be continued for long enough to establish the presence of creep behaviour.

Mini zone tests (dummy footing) should be carried out at a rate of one test per 1000m^2–3000m^2 of treated ground, along with penetration tests at a rate of one test for 20–50 stone columns, or one test for not more than 500m^2 of treated ground, with a minimum of one test per structural unit.

Alternatively, in the absence of penetration tests, one test per ten houses (with a minimum of two tests per site) would suffice.

5.1.5.3 Zone tests

An isolated pad or strip footing is used to test up to eight stone columns and the intervening ground. Loadings, which should simulate the dwelling loads, are held for 24 hours at predetermined stages to examine creep behaviour.

5.1.5.4 In-situ tests

Where vibration will improve the ground itself, e.g. granular materials, then in-situ testing is appropriate. The improvement can be assessed when the test results are compared with the in-situ test results recorded during the pre-treatment investigation.

5.1.5.5 Trial pits

Trial pits can be excavated around trial stone columns to prove that they are fully formed and to the required depth and diameter. This is a destructive test, and allowance should be made accordingly.

On completion of the treatment, the Engineer should satisfy himself that the treated ground has achieved the anticipated condition assumed in the design, and provide evidence in writing to the Warranty Surveyor.

5.1.6 Fill materials

The following materials require testing to ensure their suitability for use as fill to support structural foundations and slabs, or as backfill to associated trenches:

- Acid wastes
- Reactive materials
- Materials that include sulphates (e.g. gypsum)
- Organic materials
- Toxic materials
- Materials that cause noxious fumes, rot, undue settlement or damage to surrounding materials

The sample tests should be carried out by a suitably qualified person, and it may be necessary to take a number of samples to identify the material characteristics of the fill accurately.

5.1.7 Sources of fill material

Where the material is of a stable and uniform type from one source, the testing regime may be reduced. However, if the material is variable or from a number of sources, regular inspections and/or testing may be required. Recycled aggregate or other building materials, such as crushed brick, should only be used following an inspection by the Warranty Surveyor Colliery shale and any other residue from mineral extraction or industrial process bi-products should only be used with specialist approval.

5.1.8 Suitable foundations for sites with improved ground

Foundations on sites with improved ground should either be of a reinforced strip or raft type. Both foundations will require a full design by a Structural Engineer.

For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded. In relation to differential settlement, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

Functional Requirement 5.2 must be met where the foundations are bearing on cohesive soils or cohesive fill materials and trees nearby.

5.1.9 Relevant British Standards and guidance documents

Relevant British Standards, Codes of Practice and authoritative documents include:

- BS 6031 Code of Practice for earthworks
- BS 1377: Part 9 Methods of tests for soils for civil engineering purposes. In-situ tests
- BS 10175 Investigation of potentially contaminated sites – Code of Practice
- BS EN 1991 Actions on structures

CHAPTER 5: FOUNDATIONS

- BS EN 14731 Execution of special geotechnical works. Ground treatment by deep vibration
- BS EN 1997-1 General rules
- BS EN 1997-2 Ground investigation and testing
- BS EN ISO 14688 Geotechnical investigation and testing – Identification and classification of soil
- BS EN ISO 14689 Geotechnical investigation and testing – Identification and classification of rock
- BS EN ISO 22476 Geotechnical investigation and testing – Field testing
- BR 391 Specifying vibro stone columns
- Institute of Civil Engineers (ICE) Specification for ground treatment: Notes for guidance, 1987
- CIRIA C572: Treated ground: Engineering properties and performance, 2002
- CIRIA C573: A guide to ground treatment, 2002
- BRE 424: Building on fill: Geotechnical aspects
- BRE Information Paper 5/97: Collapse compression on inundation

FUNCTIONAL REQUIREMENTS

5.2 FOUNDATIONS, TREES AND CLAY

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Strip foundations should be of a suitable depth in order to achieve a satisfactory level of performance.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance;
ii. Foundation type and depth must be suitable to resist movement due to the influence of nearby trees.
iii. Structural elements outside the parameters of Approved Document A (England and Wales) must be supported by structural calculations provided by a suitably qualified expert.
iv. The design and construction of the foundations must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

CHAPTER 5: FOUNDATIONS

5.2.1 Introduction

This Chapter gives guidance on foundation design when building near trees. The details described in Chapter 5 will be accepted as a satisfactory method of meeting the Functional Requirements.

5.2.2 Limitations of guidance

The following situations are beyond the scope of the guidance in this Chapter, and will require a site-specific assessment by a suitably qualified and experienced expert:

- Foundations with depths greater than 2.5m within the influence of trees
- Ground with a slope greater than 1:7
- Manmade slopes, such as embankments and cuttings
- Underpinning
- Engineered foundation designs

Each development site has its own specific characteristics, and where conditions do not clearly fall within the guidance given, clarification should be sought from the Warranty Surveyor or a suitably qualified expert.

5.2.3 The nature of the problem

The roots of all vegetation take water from the soil to make good the water lost from the leaves. If the soil contains clay, it will shrink as it is dried, or swell if it is allowed to rehydrate. If the shrinking or swelling extends below the foundations, they will subside or heave respectively. If the movements are in excess of those that can be tolerated by the building, damage is likely to occur.

Although all vegetation can cause soil drying, the roots of trees extend deeper and further and are thus particularly prone to causing damage. Large shrubs can also root to considerable depths, but their influence is more localised. Herbaceous plants and grass can also cause soil drying down to 1.5m, and require some precautions.

Damage is best avoided by increasing foundation depth to below the level where significant changes in moisture content are likely to occur. This Chapter defines the depths that are required, and the most suitable types of foundations. The extent of soil drying can be variable and unpredictable. If all risk of damage is to be avoided, the required depths would be punitive; instead, the guidance seeks to minimise the risk by striking a balance between the extent of risk and the costs of increasing foundation depth.

The extent of risk depends on:

- The soil
- The potential for the tree species to cause soil drying
- The size of the tree
- the proximity of the tree to the foundations
- the likely climatic conditions in the locality

These factors are considered in greater detail in the following sections.

5.2.4 The soil

Soils may be broadly classified into two types:

- Cohesive soils comprise mainly of clay or fine silt particles. When moist they are plastic and can be moulded, and will remain intact if placed into water. As they dry, they will become stiffer, and will eventually crumble if dried beyond a certain point. These soils can potentially cause problems.
- Non-cohesive soils, comprised mainly of sand or with only a proportion of clay or silt, cannot be moulded and will break up if placed in water. They are not subject to significant swelling or shrinkage.

The clay component of cohesive soils can vary widely; very few soils are pure clay, but they contain varying quantities of sand or silt. Clay soils are defined by their particle size (less than two microns), and it is only these clay particles that will shrink or swell. The particles are made-up of a complex molecular lattice structure that is capable of absorbing water, and as it absorbs water the particles will swell, and vice versa. There are many

different types of clay with different molecular structures, and all of which have different swelling characteristics. The extent of swelling and shrinkage that can occur will therefore depend on the type of clay particles and the proportion of clay, as opposed to silt or sand, within the soil.

The potential of soil to swell or shrink can be determined by simple tests to determine its plastic limit (the moisture content below which it changes from being plastic and mouldable, and starts to crumble) and liquid limit (the moisture content above which it changes from being plastic, and starts to flow like a liquid). The plastic and liquid limits can be determined by simple laboratory tests in accordance with BS 1377. The difference between the plastic and liquid limits is the plasticity index; the higher the plasticity index, the greater the potential volume changes.

5.2.5 Potential of the tree species to cause soil drying

Tree species differ in the ability of their roots to grow and exploit the available water in a cohesive soil, particularly if it has high clay content. This is commonly referred to as their 'water demand'. Species such as Oak, Poplar and Eucalyptus are deemed as high water demand as they are particularly efficient at exploiting clay soils, rooting to considerable depth. A few species only rarely cause damage and are deemed of low water demand, whilst the majority fall into the moderate category.

Hardwood species tend to have a broad spreading root system, extending considerable distances laterally as well as to depth. By contrast, the influence of most conifers is more localised, but just as deep. A few species (of both hardwoods and conifers) have intermediate characteristics. The guidance takes account of the different patterns of rooting, but it must be emphasised that the distribution of roots can be variable, meaning the guidance should not be taken as indicating a 'zone of influence' of a tree.

5.2.6 Size of tree

The amount of water taken by the roots relates to the leaf area and the vigour of the tree. With open grown trees, height is usually considered the best indicator of leaf area. The greatest water uptake occurs as the tree reaches maturity, and so 'mature height' is the determining factor. Individual trees within a group or row will have a smaller leaf area, but as they compete with each other, the mature height of the individual trees remains the relevant factor.

Although some trees are managed as pollards or are subject to periodic reduction to control their size, unless such treatment can be assured in the future, mature height should be used.

5.2.7 Proximity

The closer the tree, the deeper the potential influence, and the guidance indicates the required foundation depth at any distance. The parts of the foundations closest to the tree require the greatest depth, but if preferred can be stepped down for more distant parts.

5.2.8 Likely climatic conditions

Weather conditions play a major role in determining the extent of soil drying. Hot sunny weather will increase the rate of water uptake by the roots, whereas rainfall during the summer can restore the water that has been taken. As the hottest and driest conditions tend to be in South East England, it has the greatest risk. For other, wetter, parts of the country, the guidance allows for reducing the required foundation depth.

5.2.9 Information required for determining the foundation depth

5.2.9.1 Establishing ground conditions

The British Geological Survey website (www.bgs.ac.uk) can indicate the likely soil conditions in any locality. Enter the postcode to locate the site, and a left click on the location brings up a box that shows the bedrock geology and the superficial deposits (if present). The name of the bedrock or superficial deposits are often sufficient to indicate probable soil conditions

(e.g. London Clay or Plateau Gravel), but if not, clicking on the name will bring up further details.

Unless there is clear evidence that a cohesive soil is not present, site investigations will be required to determine the soil type to at least the depth of potential influence of adjacent trees. Usually, trial holes are an acceptable method for determining the soil strata, but specialist site investigation reports are preferred if available.

Soil samples should be taken from at least two depths, at 1.5m and 2.5m (or the base of the trial hole, whichever is the shallower), and sent to a soil laboratory for determination of plastic and liquid limit (and thus plasticity index). In addition, the moisture content of the samples is usually determined. The highest value of plasticity index should be used for determining foundation depth.

5.2.9.2 Identification of trees

Many local authorities will require a Tree Survey and Arboricultural Method Statement as part of the planning application. This will usually serve to identify all relevant trees both on and off-site. If a tree survey is not available, assistance with identification of all of the more common trees can be obtained from various websites:

Natural History Museum
www.nhm.ac.uk/nature-online/britishnatural-history/urban-tree-survey/identify-trees/tree-key/index.html

Royal Botanic Gardens, Kew
apps.kew.org/trees

Science and Plants for School (particularly useful for winter identification, using twig characteristics)
www-saps.plantsci.cam.ac.uk/trees/index.htm

If a tree cannot be identified, it must be assumed to have high water demand (deep rooting).

5.2.9.3 Mature height of tree

The mature heights of common tree species are provided in Table 4 of Appendix A.

Mature height should be used unless:

- An arboricultural report is obtained, indicating that a lesser height is appropriate for the conditions of the site.
- Assurance can be provided that the tree will be maintained at a lesser height at all times in future.

5.2.9.4 Proximity of tree

Measurement should be taken from the centre of the trunk to the nearest part of the foundations. If preferred, foundations depths can be stepped down at greater distances, in accordance with Chapter 5.5.4, by measurement to other locations around the building.

5.2.9.5 Climatic conditions

Determine from the map in Figure 7 whether the depth of foundations can be reduced for the relevant site location.

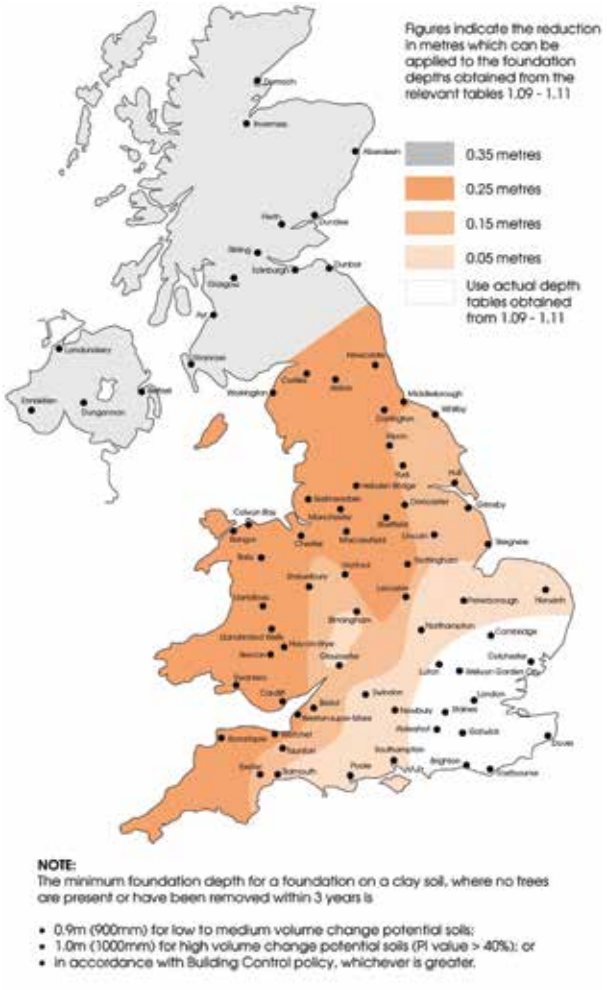


Figure 7: Allowable reductions for geographical location

5.2.10 Determining foundation depth

5.2.10.1 Foundation Depth Calculator

Foundation depth can be determined using the Foundation Depth Calculator which can be found on our website. The depth of foundation is determined by inputting the:

- Plasticity index of soil (see Chapter 5.2.1);
- Water demand of the tree (see Table 4);
- Mature height of the tree (see Table 4), or alternative values being used (see Chapter 5.2.3);
- Distance of relevant tree to nearest part of foundations, and distances elsewhere if stepping foundations (see Chapter 5.2.4);
- Allowance for climatic conditions (see Chapter 5.2.5).

5.2.10.2 Foundation depths to allow for future tree planting

Where there is a landscape plan specifying future tree planting, foundation depths should be calculated on the basis of the proposed species of tree and its proximity. If no species has been specified, they should be assumed to be moderate water demand.

Even if no tree planting has been specified, it is advisable to allow for reasonable future tree or shrub planting, or for the growth of self-seeded trees or shrubs, as shown in column 2 of Table 1.

If the building design or location is such that no tree planting is likely at any time in the future, minimum foundation depths, as shown in column 3 of Table 1, should be used.

Plasticity index	Depth to allow for reasonable future tree/shrub planting (m)	Minimum depth if no future tree/ shrub planting likely (m)
> 40	1.5	1.0
20 – 40	1.25	0.9
10 - 20	1.0	0.75

Table 1: Minimum foundation depths

5.2.11 Woodlands, groups or rows with mixed species of trees

Foundation depth should be determined on the basis of the individual tree that requires the greatest depth.

5.2.12 Foundation design

5.2.12.1 Depths in excess of 2.5m

Where the required foundation depths, as determined in Chapter 5.3, are in excess of 2.5m, foundations must be designed by a suitable expert, i.e. a Chartered Structural Engineer, taking account of the likely effect of soil movement on the foundations and substructure. Short bored piles with ground beams are recommended, and may prove to be the most economical form of construction. Short bored piles are an essential requirement for depths in excess of 3m.

5.2.12.2 Foundation depths less than 2.5m

Conventional strip foundations may be constructed practically and economically to a maximum depth of 2.5m.

Trench fill foundations are likely to be most economic at depths below 1.5m, but can be economic to depths up to 2.5m.

For foundation depths in excess of 2m, short bored piles with ground beams are recommended. All pile designs should be undertaken by a suitable expert, i.e. a Chartered Structural Engineer.

Structural raft foundations are generally not accepted as a suitable foundation on sites with a high risk of shrinkage/heave due to adjacent trees.

5.2.12.3 Heave precautions

Allowance must be made for the probability that any existing tree is likely to die sometime during the life of the building. If the tree has dried the soil prior to the foundations being laid, when it dies (or becomes over-mature) the soil will rehydrate and swell, causing upward or lateral heave movement of the foundations. Severing roots within the footprint of a building foundation will also allow the soil to rehydrate.

If foundation depth is greater than 1m, a proprietary compressible material must be placed on all inside surfaces of the peripheral foundations to allow for lateral soil swelling, as shown in Figures 8–10. Material is not required on internal foundations (as swelling pressures are likely to be similar on both sides). The material must be capable of compressing to allow for lateral swelling, in accordance with column 3 of Table 2.

Ground bearing slabs should not be used if the foundation depth is greater than 1m. Under these circumstances, a suspended floor slab should be used, incorporating either a void or a proprietary compressible material on the underside.

The thickness of the void should be in accordance with Table 2, or if a compressible material is used, it should be capable of compressing to provide a void of this thickness. The manufacturer's specifications must be checked to establish the actual thickness of compressible material required to both accommodate movement and be able to compress to the dimensions in Table 2.

Plasticity index of soil	Required foundation depth (m)	Thickness of void against side of foundation or ground beam (mm)	Thickness of void on underside of edge beam and floor slab (mm)
> 40	> 2.5	Engineer design	
	2.0 – 2.5	35	100
	1.5 – 2.0	25	75
20 – 40	> 2.5	Engineer design	
	2.0 – 2.5	25	75
	1.5 – 2.0	25	50
< 20	2.0 – 2.5	-	50
	< 2.0	No special precautions	

Table 2: Minimum void dimensions for foundations, ground beams and suspended floor slabs

Typical foundation designs to allow for heave are shown in Figures 8–10.

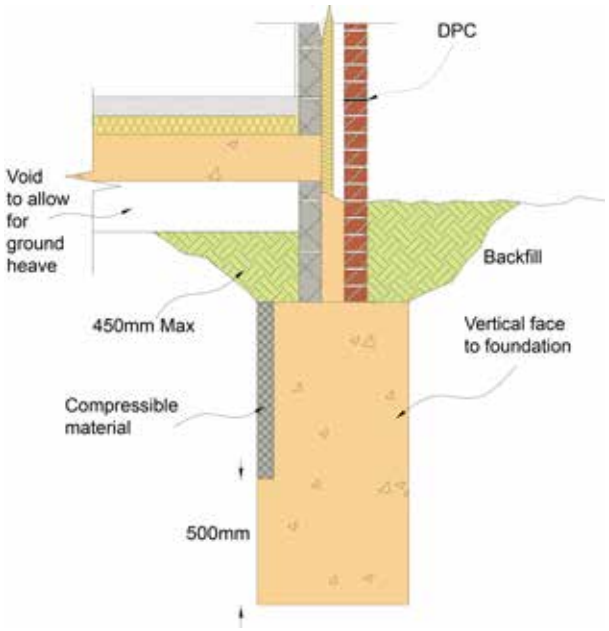


Figure 8: Heave protection: section through a typical mass filled foundation

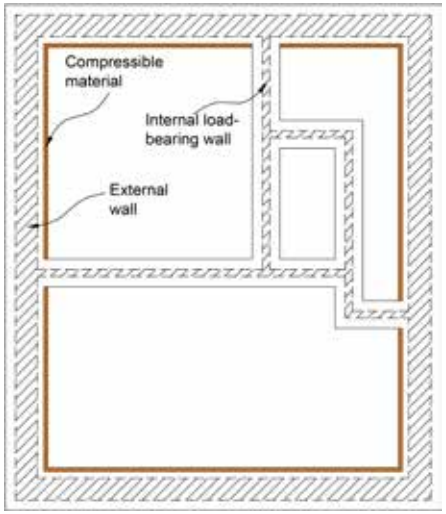


Figure 9: Plan of heave protection to a mass filled foundation

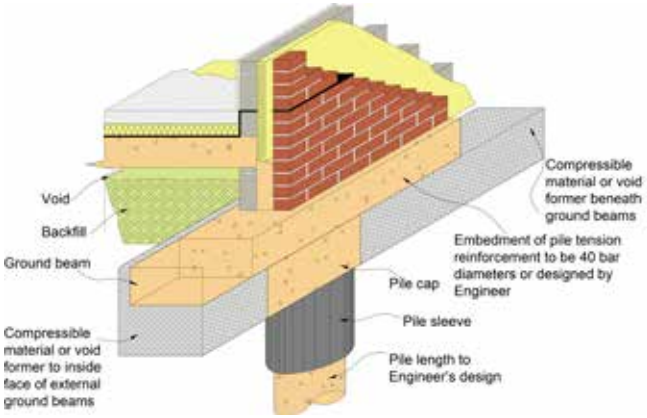


Figure 10: Heave protection: Section of pile and beam foundation

5.2.13 Special situations

5.2.13.1 Trees removed prior to construction

If trees have been removed prior to construction, precautions must be taken against potential rehydration and swelling of the soil. If they have been removed within 12 months of the foundations being laid, the design should be drawn up as if the tree was still present. If the height of the former trees is known, the depth should be determined using actual height. If the identity is not known, it should be assumed to be of high water demand, and if height is not known, it should be assumed to be 20m.

If trees have been removed more than 12 months prior to construction, precautions should be taken in accordance with Table 3.

Plasticity index	Time since tree felled (years)	Thickness of void against side of foundation or ground beam (mm)	Thickness of void below slab (mm)
>40	2-3	35	100
	4-5	25	75
20-40	2-3	25	75

Table 3: Minimum void dimensions for foundations, ground beams and suspended floor slabs where trees have been removed

5.2.13.2 Sloping sites

If the slope is greater than 1:7, foundations should be Engineer-designed (see Chapter 5.1.2). For slopes less than 1:7, distance should be measured down the angle of the slope. If there is a retaining wall, include the height of the retaining wall in the distance.

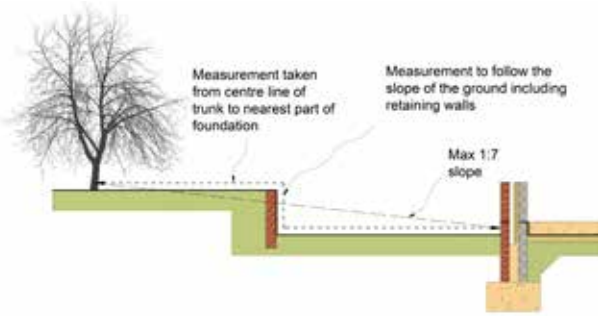


Figure 11: Measuring foundation distance on sloping sites

5.2.13.3 Changes in level

Changes in ground level (either raising or lowering soil levels) beneath the branch spread of the tree can damage the tree, and should be avoided if possible.

If ground levels are altered in proximity to existing trees that are to remain, foundation depth should be determined on the basis of the mature height of the tree and original ground level.

If ground levels are altered in proximity to trees that are to be removed, foundation depth should be determined on the basis of the existing height of the tree and original ground level.

5.2.13.4 Varying foundation depths

As foundation depth depends on the proximity of the tree, the depth can be reduced in steps with increasing distance. Steps should be in accordance with Chapter 5.2 of this Manual.

5.2.13.5 Protection for drains

In addition to the requirements of Chapter 9 of this Manual, drainage near trees should incorporate additional provisions. Where there is a volume change potential within the ground, the provisions include:

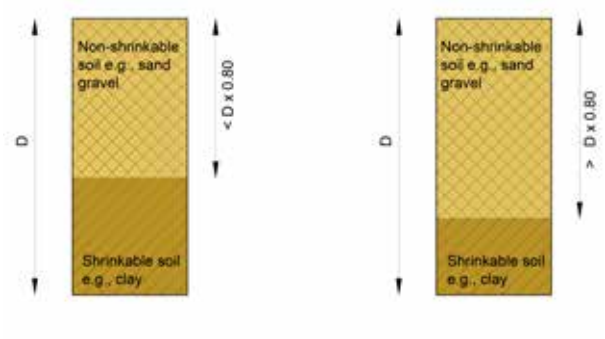
- Increased falls to cater for any ground movement.
- Deeper and wider backfill of granular material.
- A drainage system that is capable of movement should heave and shrinkage occur; drainage pipes should not be encased in concrete.
- Additional clearance is required where drains pass through the structure of a building to allow for additional movement.

5.2.14 Made-up ground

This refers to land or ground created by filling in a low area with non-original soils or other fill material. Often, such created land is not suitable for building without the use of specialist foundations. If there is high clay content within the made-up ground, specialist foundations may require additional heave protection. It is also important to establish the depth of the made-up ground, because if it is a relatively shallow depth, the original soil below may be cohesive and within the zone of influence of the tree.

5.2.15 Strip or trench fill foundations in non-shrinkable soils overlying shrinkable soils

If non-shrinkable soils, such as sand and gravels, overlie shrinkable clays, increased foundation depths are not required if the depth of the non-shrinkable soil is greater than 0.8 of the depth that would be required for the underlying shrinkable soil. See Figures 12 and 13 for further clarification.



Figures 12 and 13: Foundation depth required, using foundation calculator and plasticity index of underlying clay

APPENDIX A

Mature height of trees

Broad leafed tree		H	Conifer		H
High water demand					
Elm, English	Ulmus procera	24	Cypress, Lawson	Chamaecyparis lawsoniana	18
Elm, Wych	Ulmus glabra	18	Cypress, Leyland	X Cupressocyparis leylandii	20
Gum tree	Eucalyptus Spp.	24	Cypress, Monterey	Cupressus macrocarpa	20
Hawthorn	Crataegus monogyna	10	Cypress, Smooth	Cupressus glabra	15
Oak, English	Quercus robur	24			
Oak, Holm	Quercus ilex	16			
Oak, Red	Quercus rubra	20			
Oak, Turkey	Quercus cerris	24			
Poplar, Hybrid black	Populus x euramericana	28			
Poplar, Grey	Populus canescens	18			
Willow, Srack	Salix fragilis	24			
Willow, White	Salix alba	24			
Willow, Weeping	Salix alba 'Tristis'	16			
Whitebeam	Sorbus aria	14			
Moderate water demand					
Elm, Wheatley	Ulmus carpinifolia 'Sarniensis'	20	Cedar	Cedrus spp.	20
Lime	Tilia spp.	24	Cypress, Italian	Cupressus sempervirens	12
Oak, Fastigiate	Quercus robur 'Fastigiata'	20	Wellingtonia	Sequoiadendron giganteum	24
Poplar, Lombardy	Populus nigra 'Italica'	25	Western red cedar	Thuja plicata	18
Poplar, Aspen	Populus tremula	18			

Table 4: Water demand (rooting depth) and mature heights (metres) of common trees

Low water demand					
Acacia, False	Robinia pseudoacacia	16	Dawn redwood	Metasequoia glyptostroboides	16
Apple	Malus spp.	10	Douglas fir	Pseudotsuga menziesii	18
Ash	Fraxinus spp.	24	Fir	Abies spp.	18
Beech	Fagus sylvatica	20	Hemlock	Tsuga heterophylla	16
Cherry, Japanese	Prunus serrulata	9	Juniper	Juniperus communis	6
Cherry, Fruit	Prunus cerasus	12	Larch	Larix spp.	16
Cherry, Plum	Prunus cerasifera	10	Maidenhair tree	Ginkgo biloba	16
Cherry, Wild	Prunus avium	16	Monkey puzzle	Auracaria auracana	14
Chestnut, Horse	Aesculus hippocastanum	20	Pine	Pinus spp.	16
Chestnut, Sweet	Castanea sativa	18	Spruce	Picea spp.	16
Maple, Japanese	Acer palmatum	8	Yew	Taxus baccata	12
Maple, Norway	Acer platanoides	18			
Mountain ash	Sorbus aucuparia	10			
Pear	Pyrus spp.	12			
Plane	Platanus spp.	22			
Plum	Prunus domestica	12			
Sycamore	Acer pseudoplatanus	20			
Birch	Betula spp.	14			
Elder	Sambucus nigra	10			
Fig	Ficus carica	8			
Hazel	Corylus avellana	8			
Holly	Ilex aquifolium	12			
Honey locust	Gledistsia triacanathos	14			
Hornbeam	Carpinus betulus	16			
Indian bean tree	Catalpa bignonioides	16			
Laburnum	Laburnum spp.	12			
Magnolia	Magnolia spp.	10			
Mulberry	Morus spp.	12			
Sweet gum	Liquidambar styraciflua	14			
Tree of Heaven	Ailanthus altissima	20			
Tulip tree	Liriodendron tulipifera	18			
Walnut	Juglans regia	16			

FUNCTIONAL REQUIREMENTS

5.3 STRIP AND MASS FILLED FOUNDATIONS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Strip foundations should be of a suitable depth in order to achieve a satisfactory level of performance.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. Strip foundations must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

CHAPTER 5: FOUNDATIONS

5.3.1 Introduction

Strip and mass filled foundations are usually the most simplistic and cost-effective foundation for low rise buildings on original ground, and the guidance in Chapter 5.3 provides details of how to meet the Functional Requirements.

5.3.2 Limitations of guidance

The following situations are beyond the scope of the guidance in this Chapter:

- Traditional strip and mass filled foundations for buildings other than dwellings.
- Dwellings greater than three storeys.
- Foundations on filled ground.
- Strip and mass filled foundations where foundation depths exceed 2.5m.

5.3.3 Design

Strip and mass filled foundations shall be designed to ensure that the building is appropriately supported at all times without excessive settlement. This foundation type should only bear onto original ground if the foundation has been designed by a Structural Engineer and is appropriately reinforced. It is therefore important that site conditions are appropriately assessed prior to the building design. Further guidance on ground condition assessment can be found in Chapter 4 – Site Investigation.

For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded. In relation to differential settlements, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

5.3.4 Minimum foundation dimensions

Strip foundations should be of a 600mm minimum width for external walls. For single leaf internal walls up to 150mm thick, foundations may be reduced in width to 450mm. The minimum thickness of strip foundations should be 150mm. Foundations should be situated centrally below the wall.

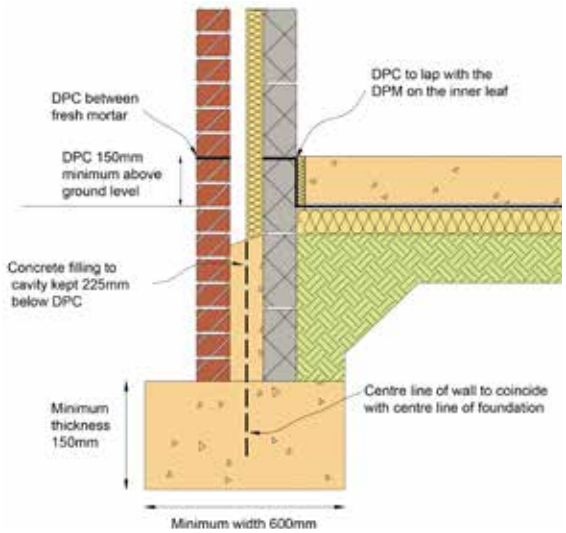


Figure 14: Typical strip foundation

5.3.5 Foundation depths

The depth of all foundations should be determined by specific site conditions. All foundations must bear onto virgin stable subsoil and, except where strip foundations are founded on rock, the strip foundations should have a minimum depth of 450mm, measured from finished ground level to their underside, to avoid the action of frost. This depth, however, will commonly need to be increased in areas subject to long periods of frost or in order that loads are transferred to suitable ground. Where trees are situated close to a proposed building founded on a clay soil, the foundation depth/design will be affected; further guidance is available in Chapter 5.2.3.

In clay soils with a plasticity index greater than or equal to 10%, strip foundations should be taken to a depth where anticipated ground movement will not impair the stability of any part of the building, taking into account the influence of vegetation and trees on or adjacent to the site. The depth to the underside of foundations on clay soils should not be less than 750mm, as measured from finished ground level, and depths may need to be increased in order that loads are transferred to suitable ground. Table 1 gives details of minimum foundation depths, which can be found in Chapter 5.2.10.2.

Modified plasticity index	Volume change potential 40% and greater	Minimum foundation depth (m)
40% and greater	High	1.0
>20% - <40%	Medium	0.9*
<20%	Low	0.75

*If the modified plasticity index is not confirmed minimum foundation depths should be 1m.

Table 5: Minimum foundation depths

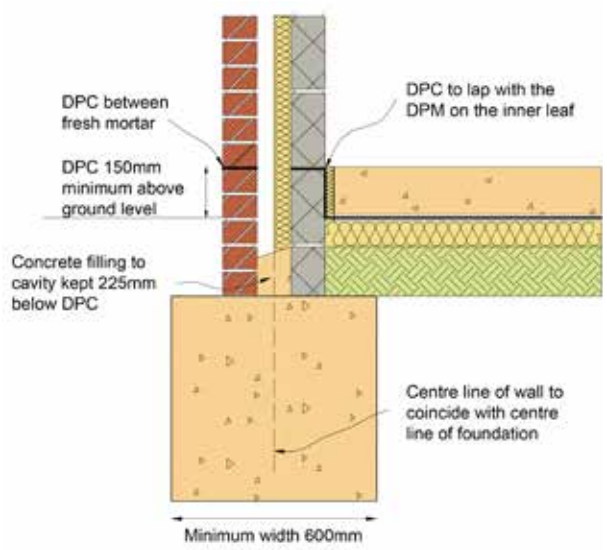


Figure 15: Typical mass fill foundation

5.3.6 Setting out foundations

The accuracy of setting out foundations should be checked by set controlled trench measurements, including their location relative to site borders and neighbouring buildings. Levels should be checked against benchmarks, where appropriate. In particular, for excavations check:

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

Walls should be located centrally upon the foundation, unless specifically designed otherwise. Any discrepancy in dimensions should be reported promptly to the Designer. Resulting variations should be distributed to all concerned with site works, including the Warranty Surveyor.

5.3.7 Excavations

Excavation should be to a depth that gives sufficient bearing and protection from frost damage. To avoid damage caused by frost, the depth of the foundation(s) in frost-susceptible ground should be at a minimum of 450mm below ground level. If the finished ground level will be above the existing ground level then, in cold conditions when freezing is expected, the foundation depth should be calculated from the existing, not finished, ground level.

Where the depth of trench fill foundations is in excess of 2.5m, they must be designed by a Chartered Structural Engineer in accordance with current British Standards and Codes of Practice. For trench fill, it is imperative to check that the finished foundation level is correct and horizontal. It will be difficult to adjust for discrepancies in the small number of brick courses between foundation and DPC level.

Prior to concreting, excavations should be 'bottomed out' to remove any debris that may have fallen into the trench; the excavations should be free from water, and if it has been left open for a long period of time, further excavation may be required to a non-weathered strata.

Note: It is important that Health and Safety obligations are met and that excavations are appropriately supported to prevent collapse.

5.3.8 Reinforcing

Strip and trench fill foundations should be reinforced where necessary to suit localised ground conditions. Reinforcement, if needed, should be clean and free from loose rust, and should also be placed correctly. Bars, of an appropriate size, should be supported to guarantee that they are 75mm above the base of the foundation, or as indicated in the design. They should be secured at laps and crossings, and, if in doubt about any soft

spots, the Engineer's advice should be taken prior to placing the concrete.

5.3.9 Foundation joints

If construction joints are necessary, they should not be positioned within 2m of a corner or junction in the foundation. All shuttering should be removed before work progresses beyond the construction joint.

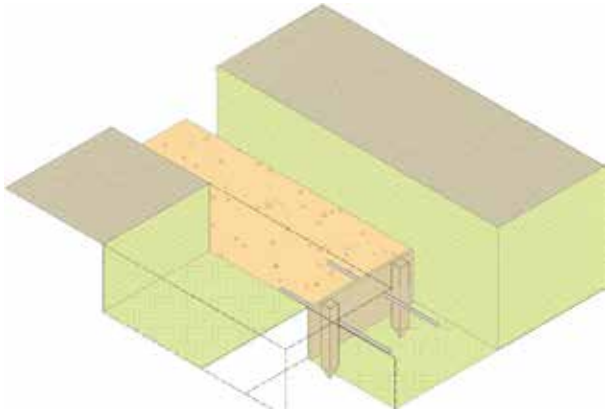


Figure 16: Using reinforcement bars across a joint

5.3.10 Steps in foundations

Steps in foundations must not be of a greater dimension than the thickness of the foundation. Where foundations are stepped (on elevation), they should overlap by twice the height of the step, by the dimension of the foundation or by 300mm, whichever is the greater, as shown in Figure 17.

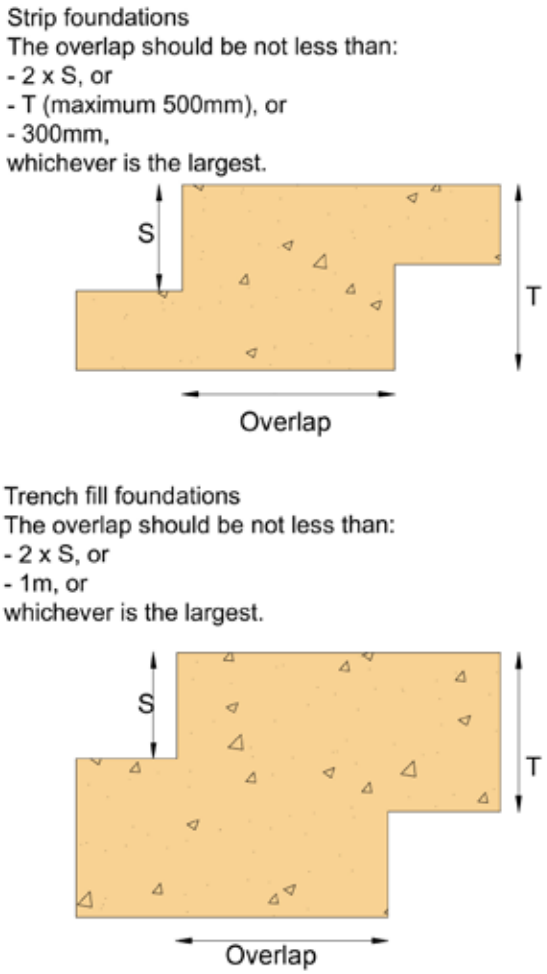


Figure 17: Steps in foundations

5.3.11 Standards referred to:

- BS 8004 Code of Practice for foundations
- BS 5950-1 Structural use of steelwork in buildings
- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 8110 Structural use of concrete

FUNCTIONAL REQUIREMENTS

5.4 PILED FOUNDATIONS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Pile foundations schemes must be tested to confirm that the installation meets the design requirements.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Piled foundation designs must be supported by structural calculations provided by a suitably qualified expert. Calculations for full piling systems must be provided by, or endorsed by, the piling manufacturer.
iii. Piled foundations must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

5.4.1 Introduction

Piles are used to transfer loads from buildings to the supporting ground, and are utilised in a wide range of applications where conventional strip footings are inappropriate. They are particularly employed where soft or loose soils overlay strong soils or rocks at depths that can be reached conveniently by driving or boring. They are often the most economical type of foundation when very heavy loads must be supported or uplift forces need to be resisted. Large piles are extremely useful for limiting the settlements of large structures on deep stiff clays; smaller versions can provide appropriate foundations for houses and other small buildings on stiff clays liable to shrinkage and swelling. The technique has been in use for many years.

5.4.2 Limitations of guidance

The following situations are beyond the scope of the guidance in this Chapter:

- Innovative foundation systems that do not have third-party approval or accreditation.
- Piling systems where the structural design is not endorsed by the Specialist Piling Contractor.

5.4.3 Pile classification

Piles of many different types and methods of installation have been developed to suit the wide variety of soils. Piles generally fall into two main types:

- Bored and dug, including short bored and secant (replacement piles).
- Driven and jacked piles, steel, concrete and timber (displacement piles).

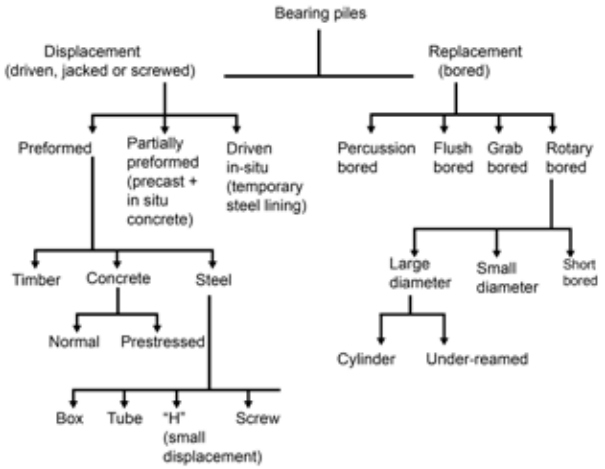


Figure 18: The range of piling types (BRE publication)

5.4.4 How piling systems work

There are basically two groupings of piles, based on the way that they transfer loads to the ground:

- End bearing piles derive the greater part of their support from bearing forces at the base. They act largely as columns transferring loads. through soft deposits, usually to dense granular soil or rock at the foot of the pile.
- Friction piles, on the other hand, develop most of their support from friction between the shaft and the soil, usually firm clay.

5.4.5 Choosing the right piled solution

The choice of piling system to support the structure will depend entirely upon the ground conditions. It is important to have the appropriate site investigation works carried out to determine depths of filled ground, the bearing capacity of soils, soil type and any existing workings or services that may clash with pile locations. Further guidance for ground condition assessment can be found in Chapter 4 – Site Investigation.

Analysis of the site investigation report should be completed by a Specialist Piling Contractor and Structural Engineer, as they are best placed to design the most economical piling system.

Piles are particularly appropriate for heave sites (trees removed), for which they are strongly recommended.

Pile layouts can be readily designed to accommodate an individual plot. A good design will seek to achieve cost savings in foundation excavation and materials through incorporation of large ground beam spans between piles and a small number of piles.

The Piling Contractor should take care to ensure that the piles are inserted vertically and pile tops are correctly aligned to support the foundation beams. An acceptable level of tolerance is for a pile to be offset in plan from the theoretical position by no more than 75mm, with vertical alignment no worse than 1m in every 75m (1:75).

5.4.6 Ground beams

Piles should be capped with an appropriate ground beam system. There should be adequate connections between the beam and the pile to ensure that the loads are transmitted effectively or that the beams are adequately restrained to the pile to resist uplift on sites that are susceptible to heave. All external, internal, partition and party walls can be accommodated using this system. The ring beam and its connections should be part of the piled foundation design, and should be supported by structural calculations provided by a Structural Engineer.

5.4.7 Pile construction records

Pile construction records should be made available for all piles installed. The records should include the following information:

- Pile type (driven tube, Continuous Flight Auger (CFA), auger bored, etc.).
- Pile dimensions (diameter or width/breadth).
- Pile depth.
- Driving records from driven piles, including hammer type, weight, drop height, sets, hammer efficiency.
- Pile verticality confirmation, which should be no more than 1:75 from vertical.

For CFA and concrete screw piles, we should be given the computer output for concrete volume and rig performance.

5.4.8 Testing

Piled foundation installation should be appropriately tested to ensure that the installed foundations meet the design requirement. A testing strategy plan should be agreed at the design stage that is representative of the complexity of the piling system. Further guidance is available from the Federation of Piling Specialists, which has produced the Handbook on Pile Load Testing.

Static load testing of preliminary and working piles should be undertaken. Working pile testing is to be carried out at a rate of not less than 1 working pile per 100 piles or part thereof (not less than 1%). However, additional tests may be required on sites with more unstable ground or where workmanship has been an issue.

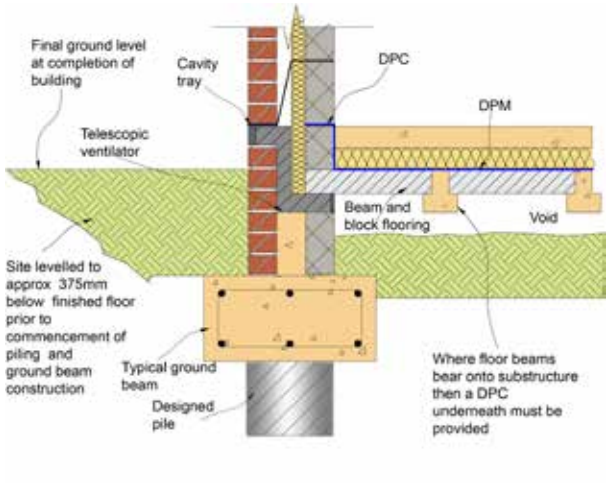


Figure 19: Pile and beam detail

5.4.9 Test methods

The Engineer shall require the Specialist Contractor to verify that the piling works have been completed to a satisfactory standard. This will usually include carrying out suitable testing to establish the degree of ground improvement, its load-bearing characteristics and settlement potential. These tests may include:

5.4.9.1 Dynamic tests

Also known as large strain testing, this technique is most commonly used for assessing the dynamic pile capacity of driven piles. Dynamic testing should be undertaken to reflect the detail of the site investigation report, the ground conditions

and the factor of safety applied to the pile design. Please submit this information at the time of the Warranty application and prior to commencement on site.

5.4.9.2 Integrity tests

Also known as low strain testing, there are two types of tests used solely for assessing pile integrity:

- Cross hole sonic logging
- Pulse echo

For integrity testing of continuous Flight Auger Piles, 100% of the piles should be tested.

5.4.9.3 Negative skin friction

Where piles pass through ground that may consolidate or change in volume (e.g. due to a change in water table or loading due to the raising of levels), the effects of negative skin friction should be taken into account. The capacity of the pile to resist the additional compressive and tensile stresses should be checked at critical cross sections.

5.4.10 Relevant Standards and Guidance Documents:

- BS 8004 Code of Practice for foundations
- BS EN 1997 – 1 Eurocode 7
- BS EN 1997 – 2 Eurocode 7
- BS 5950-1 Structural use of steelwork in buildings
- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 8110 Structural use of concrete
- Piling Good Practice Guide
  (please refer to our website for further details)

FUNCTIONAL REQUIREMENTS

5.5 RAFT FOUNDATIONS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Raft foundation designs must be supported by structural calculations provided by a suitably qualified expert.
iii. Raft foundation design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

5.5.1 Introduction

A raft foundation consists of a reinforced concrete slab, whose thickness and stiffness are designed to spread the applied wall and column loads over a large area. For domestic applications, rafts are often built with thickened perimeters to provide protection against frost heave, in which case they are effectively trench fill foundations with integral ground bearing floor slabs. Down stand edge beams also serve to stiffen the foundation's structure.

Rafts are used where it is necessary to limit the load applied to the underlying soil or to reduce the effects of differential foundation movements due to variable soil conditions or variations in loading.

5.5.2 Limitations of guidance

Rafts are not considered an accepted method of foundations where the ground conditions are susceptible to heave or shrinkage (e.g. where trees are present or have been removed).

5.5.3 Materials

Materials and workmanship should meet the requirements set out in Chapters 1 and 2 of this Manual.

5.5.4 Ground conditions

Raft foundations are usually designed for sites with ground conditions with low ground bearing capacity or where there are pockets of filled ground. It is therefore important to complete a suitable site investigation to meet the requirements of Chapter 4 of this Manual and ascertain the bearing capacity and suitability of the ground.

5.5.5 Structural design

Structural calculations should be provided by a suitably qualified Structural Engineer, confirming that the raft design is suitable for bearing onto the ground and that the ground bearing capacity safely supports the structure. For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded. In relation to differential settlement, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

The design should provide sufficient information to ensure correct installation of the raft and its reinforcing. The minimum recommended information is as follows:

- Plans and details of the proposed raft showing reinforcing positions, etc.
- Structural calculations confirming that the raft is suitable for the proposed loads applied.
- A bar schedule, to be used by the reinforcing steel supplier and installer.

5.5.6 Ducts and sleeving

Any service penetrations that pass through the raft should be appropriately sleeved to protect the service duct. Service duct positions should be planned and indicated on drawings to prevent reinforcing bars from being cut, unless the structural design has catered for this.

5.5.7 Damp Proof Membranes (DPM), Damp Proof Courses (DPC) and floor finishes

The raft foundation and the junction with the wall should be appropriately constructed to resist ground moisture penetration. A DPM can be placed beneath the raft, wrapped around the external toe and lapped into the internal DPC; however, this detail can be difficult to implement on-site, and puncturing of the membrane can commonly occur when placing reinforcing. The preferred method is to place the DPM on top of the raft slab beneath the floor insulation or screed, as indicated in Figure 20.

CHAPTER 5: FOUNDATIONS

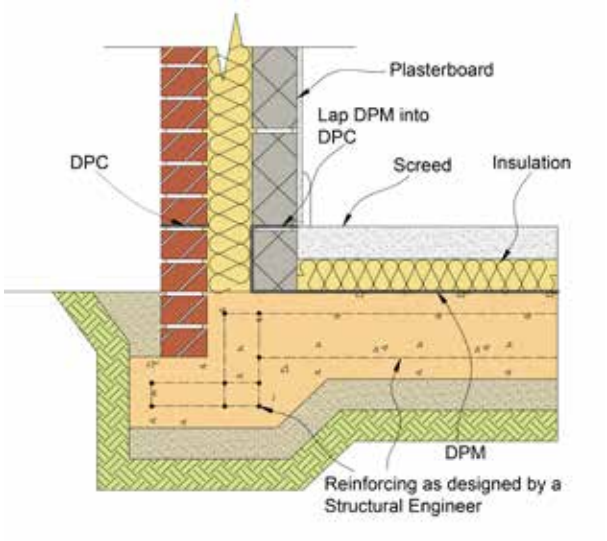


Figure 20: Typical raft foundation design

5.5.8 Standards referred to:

- BS 8004 Code of Practice for foundations
- BS 5950-1 Structural use of steelwork in buildings
- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 8110 Structural use of concrete

CHAPTER 6: SUBSTRUCTURE

CONTENTS

6.1 BASEMENTS

6.2 WALLS BELOW GROUND

6.3 DAMP PROOFING

6.4 GROUND FLOORS

FUNCTIONAL REQUIREMENTS

6.1 BASEMENTS

Definition
For the purposes of this Chapter, a basement is defined as a storey or storeys of a building that is constructed partially or entirely below ground.

Workmanship
i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials
i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design
i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Basements shall be appropriately designed to ensure that they adequately provide a suitable barrier against contaminants, ground gases and ground water.
iii. Basement design and construction must be supported by structural calculations provided by a suitably qualified expert.
iv. Design details of the basement waterproofing techniques must be provided prior to commencement onsite.
v. Basements must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
vi. All basements must be designed and constructed to a minimum of Grade 2 standard as defined in BS 8102.
vii. The basement design should be completed by a suitably qualified Waterproofing Design Specialist. The Waterproofing Specialist must take responsibility for the design liability of the waterproofing and have appropriate professional indemnity cover which covers their business activities. They must also have an understanding of hydrology and soil mechanics and hold a relevant professional qualification (i.e. Certified Surveyor in Structural Waterproofing (CSSW) or similar).

CHAPTER 6: SUBSTRUCTURE

6.1.1 Introduction

This Chapter provides guidance on the requirements associated with the design and construction of basements and other below ground structures. Principally, this concerns the process by which the risk of ground water penetration is appraised and addressed, so that problems associated with penetration do not occur, while consideration is also given to economic construction.

This process and rationale is primarily detailed within BS 8102 (2009) Code of Practice for protection of below ground structures against water from the ground (and other associated design guides). However, further practical guidance on this and compliance with Warranty requirements is included herein.

6.1.2 Limitations of guidance

This document is not intended as a standalone design guide, and does not include the full detail of what must be considered to comply with BS 8102. See 'References' for details of other associated design guides.

It must also be noted that structural waterproofing design and geotechnical investigation are specialist fields, and while general guidance is provided, advice must be sought from suitably experienced parties. Appropriate structural design must be undertaken by a Chartered Structural Engineer.

6.1.3 General principle of waterproofing design

The approach detailed within BS 8102 involves assessment of a given site to determine the characteristics that influence risk. With the benefit of knowledge gained through this investigation and assessment, suitable designs for dealing with ground water, gases and contaminants can then be devised and constructed.

6.1.4 Design responsibility

Production of a suitable design is one of the most important aspects of achieving a successful outcome, where the required standard of environment is created within the basement space and maintained in the long term. A common assumption in waterproofing is that workmanship is the most 'critical factor', and while this is undeniably important, the highest standards of workmanship will not make-up for inadequate design; hence, correct design is the first step in achieving the desired outcome.

To this end, BS 8102 includes a section on the 'design team', which states that the advice of a Geotechnical Specialist be sought for assessment of the geology and hydrogeology, and that a Waterproofing Specialist be included as part of the design team from the earliest stages, so that an integrated and practical waterproofing solution is created.

The need for a dedicated Waterproofing Specialist within the design team is intended to reduce the incidence of issues where systems are designed without following the advice and considerations detailed within BS 8102 and associated design guides.

Such scenarios may occur where Project Designers take on the role of Waterproofing Designer without sufficient reference to the stated guides, commonly relying on standard design details and without considering all appropriate factors. Please refer to BS 8102 for a list of requirements that a Designer must meet in order to fulfil the Waterproofing Designer role. Designers must also carry professional indemnity insurance cover appropriate to the project.

It must be noted that waterproofing product manufacturer 'standard details' typically disclaim design responsibility, so it is incumbent on the Waterproofing Designer to ensure that such details are correct and appropriate for the site and structure, or offer suitable variation.

The early involvement of a Waterproofing Designer is an important consideration because the

waterproofing design typically has an influence on elements of the structural and/or architectural design. Early involvement allows the waterproofing to be duly considered in association with these other aspects, and prevents situations where design fees are increased as a result of necessary redesign, or where waterproofing is compromised by working within the constraints of an ill-considered structure relative to achieving the required standard of environment.

Designers must have ongoing involvement during the build, maintaining good communication with site management and providing supervision and guidance wherever necessary.

6.1.5 Site and risk assessment

The degree of water present within the ground, and the propensity for waterlogging to occur over the lifetime of a structure, is a principal driver in assessing risk and the degree of waterproofing required. Simplistically, if a basement is constructed into a permanent high water table, then the degree of protection will necessarily be greater than a similar structure constructed into a generally dry site.

Assessment of a site must be based on the results of the site investigation and other site-specific factors. Seasonal variations in the water table must be accounted for unless long-term monitoring is undertaken. However, even where standing water levels are not noted during such pre-start site investigation, the drainage characteristics of the ground must receive particular attention. Soils with low permeability represent a risk of waterlogging or encouraging a 'perched water table', where water stands temporarily or permanently within the ground against a structure, and arguably this affects more properties with basements than the true water table level.

Other factors, such as topography and orientation, may have a bearing on the propensity for pressure to come to bear, and should also receive consideration. Further guidance on the drainage characteristics associated with different types of ground is included within the Basement Information Centre publication Basements: Waterproofing – General Guidance to BS 8102: 2009.

Ground gases and contaminants must also be considered within the risk assessment. It must be noted that while the site investigation forms part of what guides the waterproofing design, an equally important consideration is the intended use of the space and implicit consequences in the event that water penetration occurs. For example, in properties where the consequences of penetration would be severe, such as in habitable space, suitably low-risk methods must be provided.

Furthermore, whilst in theory it could be assumed that, based upon a site investigation, the risk of water pressure ever occurring is low, BS 8102 advises that consideration is given to the effects of climate change and burst water mains and sewers, as well as stating that it should be assumed that there is risk of waterlogging "even where site examination indicated dry conditions".

In summary, the site investigation guides the design, but it should never be assumed that some degree of water pressure will not occur.

Furthermore, and particularly if no site investigation has been undertaken or there is reasonable doubt as to ground water conditions, pressure to the full height of the below ground structure must be assumed at some point in the life of the structure. The Warranty Surveyor may request a copy of the Site Investigation Report, Designer's Risk Assessment and associated design rationale.

6.1.6 Water-resisting design

The principle of this is to consider and design for the pressures that the structure/waterproofing must resist based upon the site investigation and risk assessment detailed above. However, it also concerns the means by which the degree of water in the ground can be influenced by design.

6.1.6.1 Structural resistance

The ability of the structure to provide resistance to the penetration of water has a bearing upon all forms of waterproofing. Retaining walls in plain or reinforced masonry provide comparatively little resistance to the penetration of water under pressure because of the crack pattern associated with the degree of joints (mortar beds) present.

The degree of water excluded by concrete elements (walls and slab) is influenced by the nature of the design and construction. While concrete itself is relatively impermeable, the degree to which water is excluded will be greatly influenced by crack sizes and the detailing of construction joints and service penetrations.

6.1.6.2 Exclusion of surface water

Surfaces external of the basement structure at ground level can act to limit or attenuate penetration into vulnerable positions, i.e. the more permeable excavated and backfilled ground directly around the basement structure. The inclusion of surface and cut-off drains that remove standing water away from the vulnerable areas are also of benefit.

6.1.6.3 Sub-surface drainage

The use of land drainage can act to remove water from around the structure, thus alleviating pressure and reducing risk accordingly.

The use of land drainage is not viable on all sites, examples being where there is no available location to discharge collected ground water, or where high water tables and permeable ground conditions make it impractical to remove sufficiently the quantities of water present. A Geotechnical Specialist and/or Waterproofing Specialist can advise further in this respect.

Notwithstanding such conditions, the provision of effective land drains is often an economic means of greatly reducing risk, and must be included where viable.

The following considerations apply:

- Perforated land drains must be surrounded in clean graded stone and wrapped in a suitable geo-textile filter fabric to reduce the risk of clogging. This is particularly important in fine granular and clay soils where land drains are susceptible to clogging.
- Rodding points must be included (ideally at changes in direction) to facilitate maintenance, which will allow the system to function in the long term. This maintenance should be undertaken at suitable intervals (annually as a minimum), with the detail of this being written into the documentation passed to homeowners.
- Land drains must link to a reliable point of discharge. Where sump pump systems are employed, the implications of power cuts should be considered in that land drains may in such scenarios not function as intended. The effectiveness of battery back-up systems, where employed in sumps servicing land drains, should be considered in relation to assessment of the likely degree of ground water.

It is not unknown for issues of waterproofing failure to occur where land drains (that form part of the Waterproofing System) are linked into soakaways. The limitation on soakaways is that, depending on the nature of the ground, they may become saturated (similar to the ground around a basement), meaning that no more water can be accepted, with pressure subsequently coming to bear upon the structure. In such cases, the soakaway often also accepts water from rain water goods, thus providing a direct path for water from the roof to the basement. Therefore, land drains must not be directly linked to soakaways by gravity, unless it is not possible for water to surcharge, i.e. where the top of the soakaway is below the level of the actual land drains.

Land drain positioning is a critical consideration, specifically in respect of systems where there is no viable access for repair (or suitable repair strategy). Further to the advice detailed with regard to defects and remedial measures (see

Chapter 6.1.8), it is necessary in this circumstance to include land drains at a low enough position to prevent pressure from bearing upon the structure and waterproofing, so that the presence of any possible defects are mitigated.

The viability of including land drainage, and its positioning, should be considered in association with all methods of waterproofing as a means to reduce risk generally with a nominal cost implication.

The use of geo-drainage membranes applied to the external face of a retaining wall can provide a continuous drainage space external of the structure, which assists in encouraging water to drain down to the level of the land drains without pressuring the structure.

Where land drains are included, this should be in association with a permeable stone backfill compacted in layers, which also encourages water to drain down to the level of the land drains without perching and pressuring the structure.

Furthermore, the use of maintainable land drains is a necessity where employed in association with some forms of inaccessible/external tanking systems, i.e. where the structure itself provides little resistance. In such cases, if it is not feasible to include reliable land drains, alternative methods of waterproofing must be used.

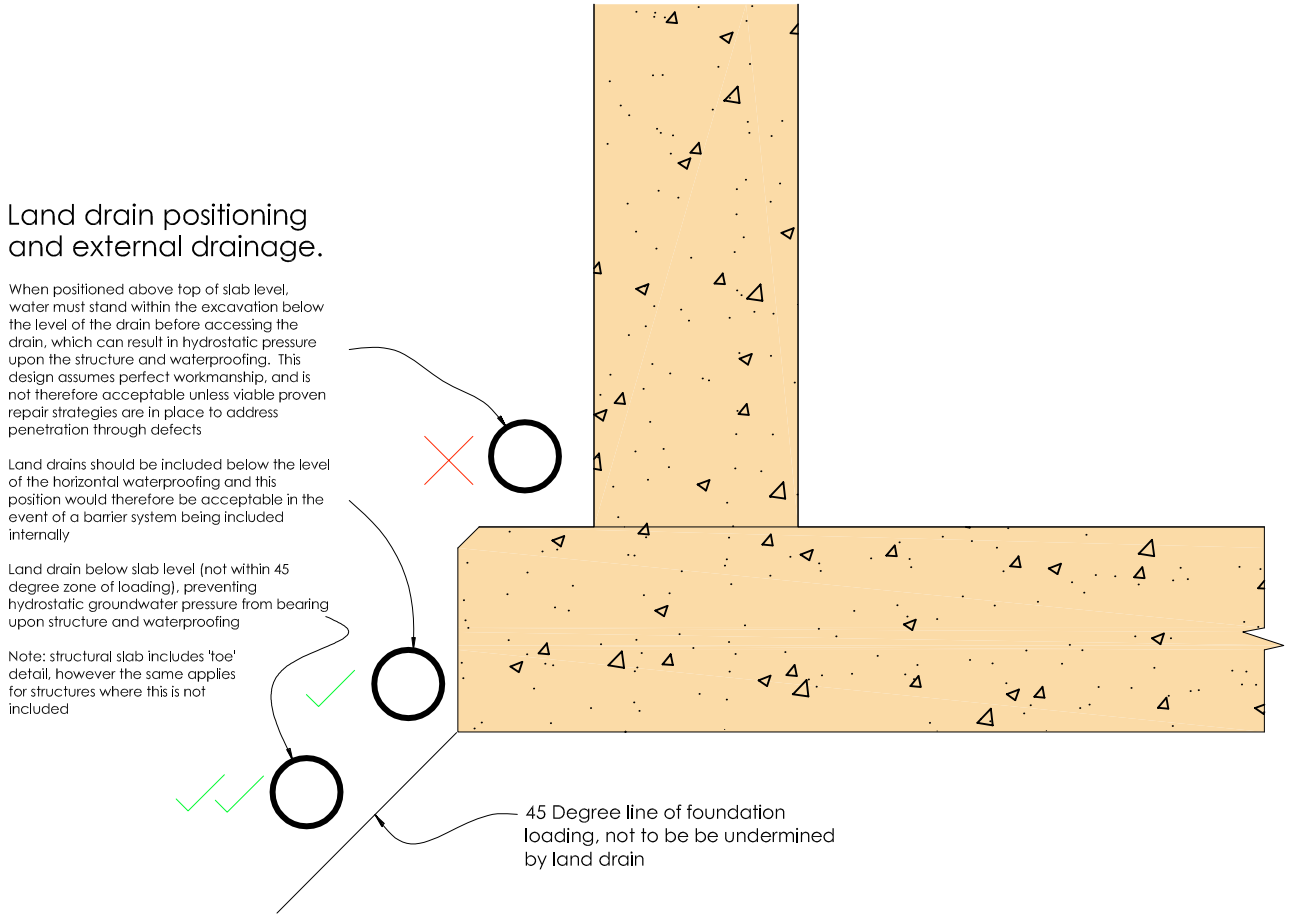


Figure 1: Suitable position of land drains

The Warranty Surveyor is to be supplied with design details where external land drainage is included.

6.1.7 Intended use and required standard of environment

Usage dictates the required 'grade' of environment, or in other words how 'dry' a given basement space must be in order to be suitable for a given usage. The Designer must therefore consider how this will be achieved in a particular site and structure; BS 8102 provides three definitions of environmental grades (Grades 1, 2 and 3).

Notably, habitable space is Grade 3, where water penetration is unacceptable. Appropriately designed environmental controls, such as vapour barriers, insulation, heating, ventilation and dehumidification, must be included to control vapour introduced via occupation sufficiently, thereby preventing problems of condensation.

Example usage for Grade 2 includes store rooms, and again water penetration is not acceptable; however, heating and ventilation is not necessarily required, albeit that some degree of ventilation is recommended even in basic storage space, which may otherwise suffer condensation-related dampness.

Grade 1 differs in that some degree of liquid water penetration is acceptable, i.e. minimal seepage as long as a space remains fit for purpose. An example of Grade 1 is basic car parking. Most basements should be constructed to allow a minimum of Grade 2, with Grade 3 being necessary for occupied space. Grade 1 is suitable for basement car parking only (excluding basement store rooms and access wells), and this should be agreed on a per scheme basis.

6.1.8 Defects and remedial measures

Within BS 8102, Designers are advised to consider the probability that systems may not be installed perfectly and that defects may occur as a result of this, or that defects may be present in supplied materials.

Designing on the assumption that a system will not be totally perfect or free of defects necessitates that consideration is given to the feasibility of repairing those defects, or ensuring that they are of no consequence, such as where systems are not accessible for repair. Different structures, Waterproofing Systems and sites have a bearing upon this consideration.

Strategies for repair of a given system must be considered as part of the design process. Further commentary is provided within each of the specific system type sections.

The detail of an appropriate repair strategy may be requested by the Warranty Surveyor in relation to a given waterproofing design.

6.1.9 Forms of waterproofing

BS 8102 defines three forms of waterproofing protection: Type A, barrier protection (commonly referred to as 'tanking'), Type B, structurally integral protection, and Type C, drained protection.

6.1.9.1 Type A, barrier protection

This form of waterproofing relies on the inclusion of a physical barrier material applied on or within the structure, often where the structure itself provides little resistance to the penetration of water. A variety of considerations apply:

- Suitability of the substrate, primarily applicable where tanking products are applied internally, in that the bond between the product and the substrate on which it is applied must be sufficient to resist hydrostatic ground water pressure.
- The requirement for preparation of substrates to accept tanking mediums.
- Movement, which in rigid tanking systems may encourage cracking through which water may penetrate, where pressure comes to bear.
- Loading, where hydrostatic pressure is applied to the structure as a result of exclusion via the tanking medium, i.e. structures must be designed to resist loads applied to them.

- Continuity, in that systems must in virtually all cases be 'continuous', as a gap in a barrier system represents a point at which water under pressure can penetrate.
- 'Buildability', namely whereby sheet membrane products are proposed, with the consideration being the practicality of wrapping a flat sheet around complex three dimensional shapes such as external corners and beneath raft slab thickened toe details.

With regard to repair strategies, internal systems have the benefit of greater accessibility, meaning that repair is more feasible. However, in being applied to the internal face of the structure, the implications of preparation, strength of substrate and bond become much more important.

External systems have greater implication, in that accessibility for repair is typically impractical post-construction, and where combined with relatively permeable wall constructions it is difficult to determine confidently the point of a defect externally because water can track within the wall construction to show itself internally at a position not local to the external defect.

On the basis that BS 8102 advises 'repairability' must be considered, the use of external adhesive membrane tanking systems on permeable constructions is precluded, unless employed in

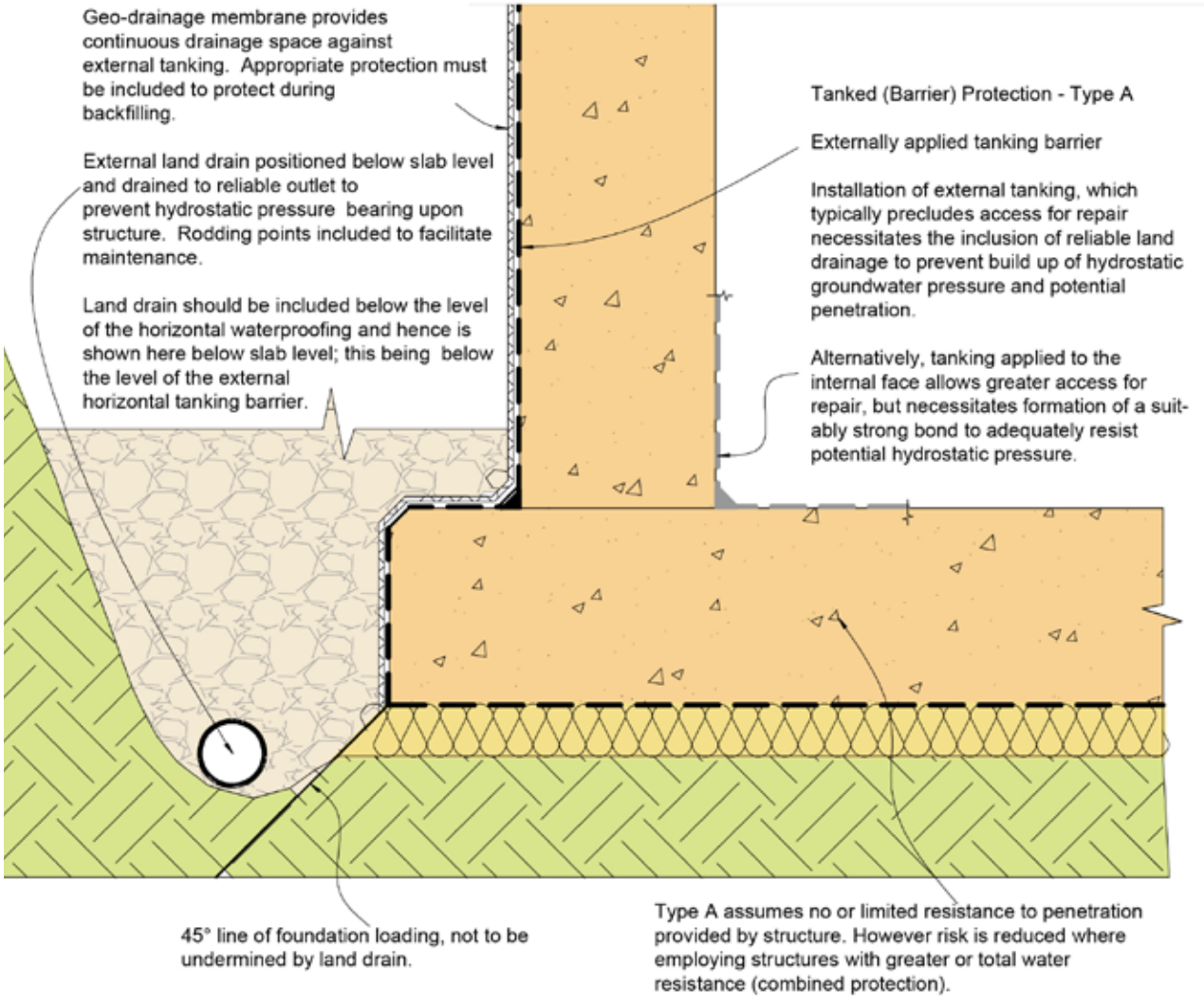


Figure 2: Type A, barrier protection

association with long-term strategies for preventing ground water from pressuring, e.g. serviceable land drains.

The use of land drains to prevent pressure coming to bear addresses the consideration that defects may occur, because if pressure is not allowed to come to bear then these defects will not allow penetration and so are of no consequence. Risk can be lessened by using a 'fully bonded' tanking system, where the bond is such that water cannot track along between the structure and tanking product, in association with a structure of lesser permeability which would allow localised repair to be undertaken.

6.1.9.2 Type B, structurally integral protection

Type B also relies on the exclusion of water, but employs the structure itself as opposed to barrier products included on or within it. In the main, Figure 3 -Type B, Structurally Integral Protection; is formed using reinforced concrete; however, this may take several forms.

Where the objective is the total exclusion of water, additional steel reinforcement can be included to limit cracking to less than 0.2mm, through which water will not pass. Alternatively, additives can be included to reduce permeability, with water being excluded without the addition of steel over and above that normally required as part of the structural design.

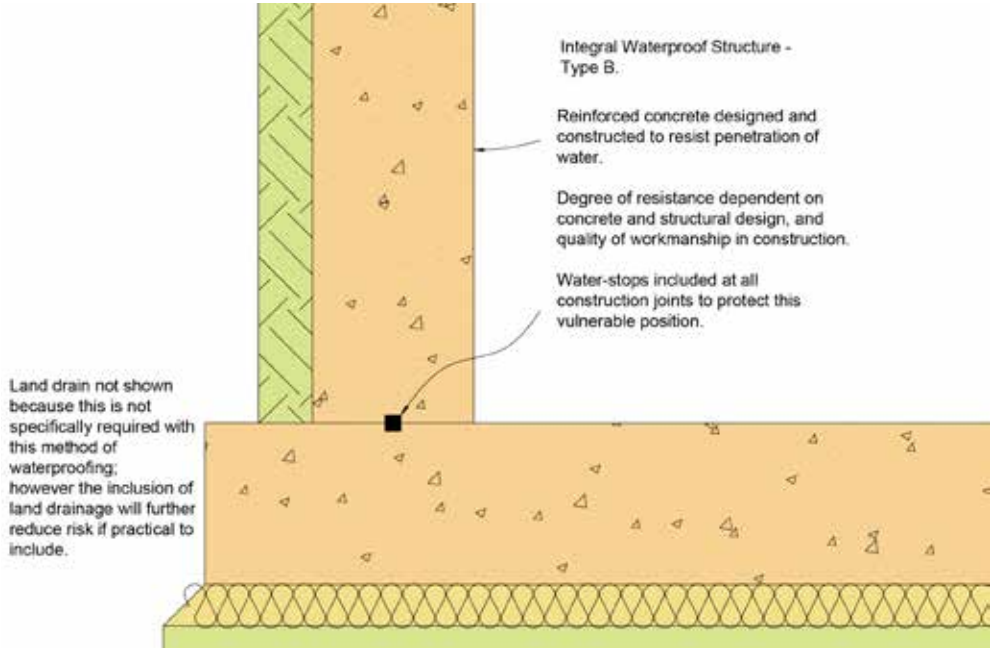


Figure 3: Type B, structurally integral protection

Concrete without additives and including more typical levels of steel reinforcement (with cracking <0.3mm), while providing good resistance to the penetration of water, will allow seepage given hydrostatic pressure, and as such is not suitable in isolation unless forming basic (non-habitable, non-storage) standards of environment.

As with any structure that aims to entirely block out water, this must be free of defects that would otherwise allow water to penetrate. In achieving this, the following must be considered:

- Structural design and specification of materials (based in part on site assessment).
- Water stop detailing at construction joints.
- Service penetration detailing.
- Appropriate specialist site supervision to ensure high standards of workmanship.
- Good placement and compaction.
- Curing.

Particular consideration must be given to the formation of construction joint details, which form a typical weak point in Type B structures. Furthermore, specialist supervision is required on site during construction.

Systems that function by excluding water may not be tested until ground water pressure comes to bear. Therefore, it is advantageous where external water pressure comes to bear prior to completion that any areas of penetration can be remedied during construction.

With regard to appraisal of repair, this method has a benefit in that the point of penetration is typically the point of the defect or pathway through which water penetration occurs. Coupled with the impermeable nature of the structure generally, this allows localised repair to be undertaken via resin injection, grouting and associated repair methods.

The main consideration is locating the point of any penetration, and it is therefore beneficial where reasonable access to the concrete structure remains viable.

6.1.9.3 Type C, drained protection

This method of waterproofing differs from Type A and Type B, in that as opposed to excluding water entirely, the structure is employed to limit penetration, while an internal drainage system collects and removes water. This isolates the internal environment from any water contained within the system.

Such systems comprise three elements:

- A drainage channel detail, typically concealed within the floor construction.
- A means of water discharge, which in a basement fully below ground requires a sump pump system, or in a sloping site may be via gravity.
- Vapour barrier drainage membranes included above or internal of the drainage system, which isolate the internal environment from the damp substrates behind.

While fully below ground basement waterproofing drainage could alternatively be linked into deeper fixed drains to drain out via gravity also, the risks associated with the surcharge of external drains are high, meaning the practice is excluded from Warranty cover.

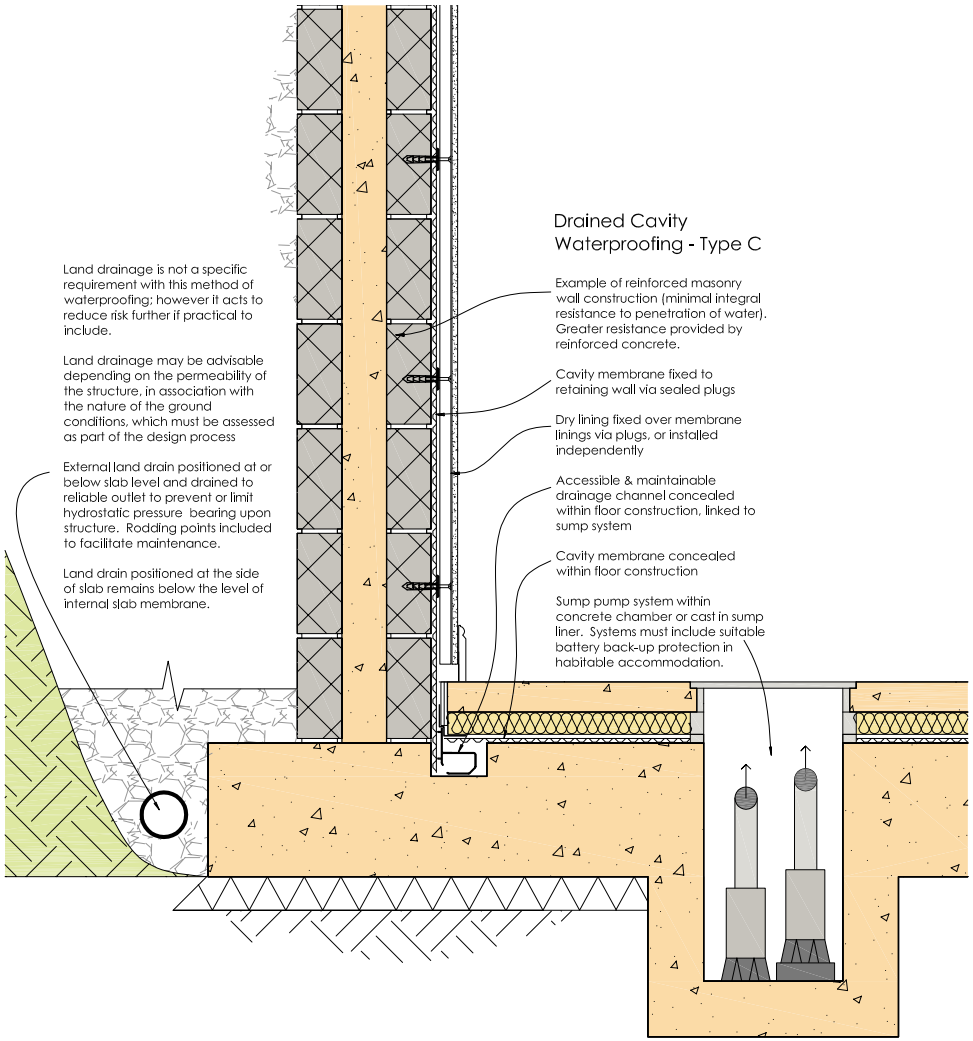


Figure 4: Type C, drained protection

Drained protection systems are reliant on their ability to remove water, and so the mechanism by which water is removed requires careful consideration. The extent of penetration also has a bearing on the capacity required, with the degree of penetration being influenced by the permeability of the structure and the ground water conditions externally.

Notwithstanding the above, the capacity of such systems to remove water must be adequate to deal with a worst-case scenario, and should be engineered with this in mind to provide a suitably low-risk system.

Sump pump systems must include mechanical redundancy (dual mains powered pumps) to protect against pump failure, and sufficient battery back-up protection to protect in the event of a power cut.

Each pump within a given system should have independent direct spur RCD/power supply, so that in the event of an issue with a pump the others will still have power. Direct spur is advised to prevent accidental turning off by homeowners.

Drainage systems typically discharge into surface water gullies at external ground floor level, and an overflow detail must be formed at the point of discharge to allow water to spill out externally in the event of drains blocking or surcharging.

CHAPTER 6: SUBSTRUCTURE

Systems can drain by gravity to low ground externally, i.e. where properties are part retaining and constructed into sloping sites. As with pumped systems, if connecting to mains drains, an overflow detail must be employed to allow water to spill externally in the event of an issue.

Internal drained protection systems must include drainage channels local to the external wall floor junctions, which facilitates maintenance and allows systems to function and protect in the long term. Where larger footprints are involved, cross floor channels must be included, ideally local to construction joints where the structure is more vulnerable to ground water penetration.

Systems must be maintained annually as a minimum. The detail of this requirement must be included in the documentation provided to the homeowner.

Water moving over and through new concrete leaches free lime within the early life of the structure, and suitable treatments should be applied to concrete to minimise this.
Substrates should be clean and free of loose or friable materials prior to the application of membrane linings.

Flood testing of a system should be undertaken during construction to check efficacy and that water flows freely to the discharge point. Testing in this manner to prove that a system functions as intended is a key benefit of this method of waterproofing, and must be part of the process.

Systems creating a habitable space require the inclusion of vapour barrier drainage membranes within the wall and floor construction.

Where elements of the drained protection system are included within cavities, cavities must be kept clear of mortar snots and debris.

Continuity of the structure must be considered because the resistance to water provided by a given structure is reduced by apertures through which water can freely move. Examples could include holes present within existing buildings, or in new construction where land drains are linked to sump pump systems, with the sumps being installed internal of the retaining shell, e.g. in light wells, thus providing a pathway for water to enter.

Temporary 110v pumps should be included during construction to address water penetration as necessary; 240v systems should be installed and commissioned as soon as viable once the 240v supply is installed.

Systems must not link directly by gravity to soakaways where any of the previously stated scenarios occur because of the danger of backflow of water through the pipes or waterlogging of the local ground above slab/DPM level. However, where such conditions are not present, sump pump systems may be employed to lift water up to ground level externally, discharging into gullies linked to soakaways. This detail should be designed by the Waterproofing Specialist.

In consideration of the repair of defects, the inclusion of drained protection systems internally generally ensures that systems can be accessed for localised repair; however, this may be lessened where systems are sandwiched within the structure, i.e. within cavities.

Part of the underlying rationale of drained protection is that water is removed continuously, so that it does not collect and place pressure upon membrane linings installed over the drainage.
If water does not place pressure upon such membranes, then the incidence of any defects within them is generally of no consequence, and so maintaining the efficacy of the drainage in the long term ensures that such defects are negated.

6.1.10 Combined protection

Combined protection via the installation of two forms of waterproofing can be employed to substantially lower the risk, and may be necessary where the consequences of failure are particularly great and/or where difficult site conditions result in an unacceptably high risk when employing a single system.

6.1.11 Ground gases and contaminants

Aggressive ground conditions may require the inclusion of a suitable ground barrier to protect the structure appropriately. Specialist advice must be sought in respect of dealing with ground gases, and Designers are advised to check current standards at the time of construction for suitable guidance.

6.1.12 Existing structures

Waterproofing existing structures differs from new construction in that Designers must work within the confines of the existing structure. However, many of the same considerations apply, in that the required standard of environment appropriate to usage must be created and maintained in the long term.

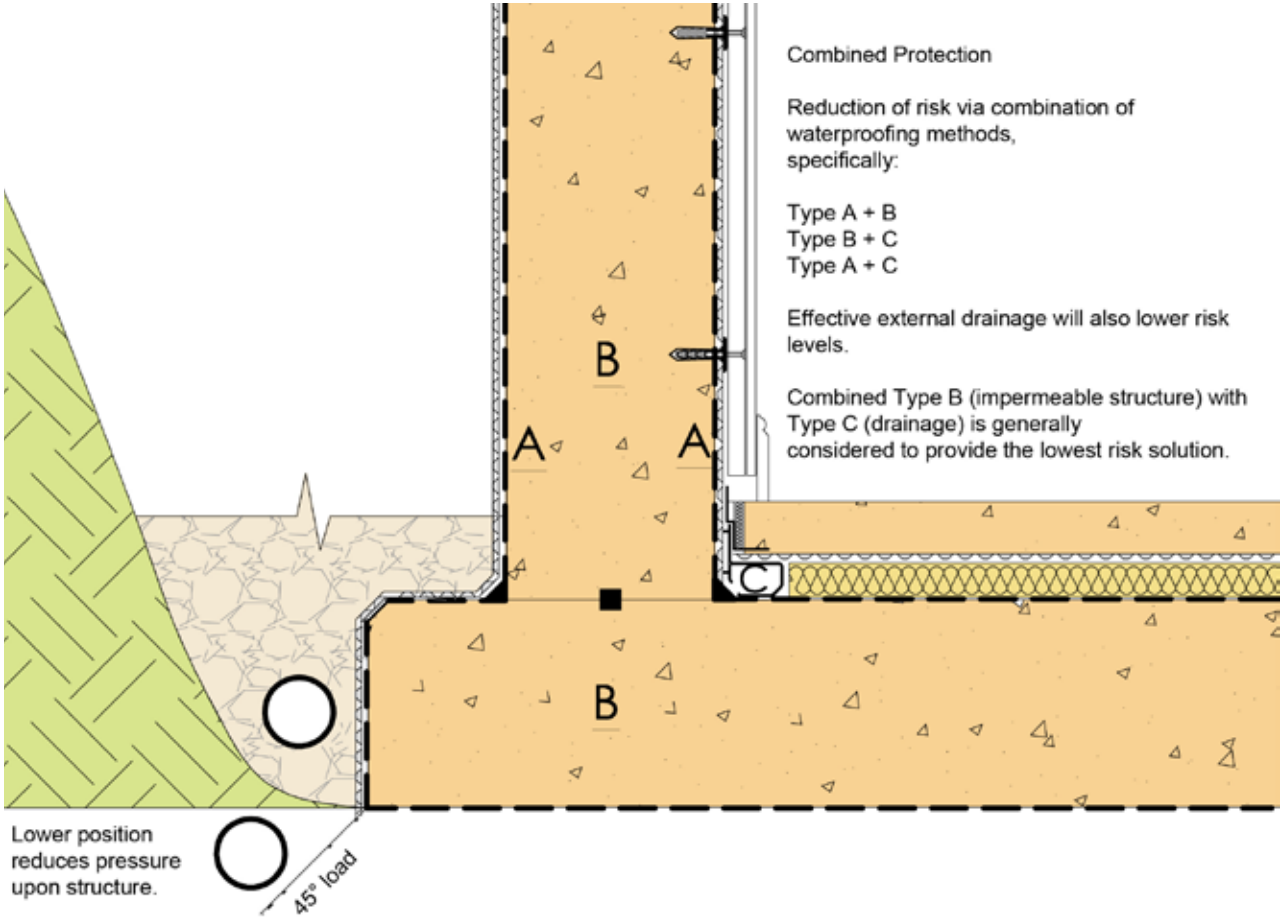


Figure 5: Combined protection

FUNCTIONAL REQUIREMENTS

6.2 WALLS BELOW GROUND

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

6.2.1 Bricks and blocks below ground

The selected bricks should be appropriately durable against saturation in accordance with BS 3921; the brick and block classifications suitable for walls up to Damp Proof Course (DPC) are shown in Table 1.

If there are sulphates in the ground and/or there is ground water present, confirmation by the manufacturer that the brick or block is suitable for use below ground should be provided.

6.2.2 Mortar mixes

Mortars below DPC are exposed to higher saturation and therefore require a higher durability, as indicated in Table 2.

Brick / block type	Use / minimum standard of brick or block	
	Walls up to DPC	**Walls up to DPC (sulphates in soils)**
Clay bricks	FL,FN,ML,MN (a)	FL,FN,ML,MN (a)
Calcium silicate bricks	Class 3 (b)	Class 3 (b)
Concrete bricks	Min strength 20N/mm² (c)	Min strength 20N/mm² (c)
Block work	Min strength 7N/mm² and density greater than 1500kg/m³ (d)	Min strength 7N/mm2 and density greater than 1500kg/m³ (d)

Notes:

(a) If the site is wet or saturated at ground level use FL or FN bricks only.
(b) Denotes a minimum standard - higher classifications may be used.
(c) For Class 1 and Class 2 sulphates, check with manufacturers to confirm suitability of brick; for Class 3 sulphates, use engineering quality concrete bricks.
(d) Autoclaved aerated blocks with independent appropriate third party certification are acceptable.

Table 1: Suitability of bricks and blocks below ground

	Proportion by volume				
High durability mortar for a use below or near external ground level	**Classification (BS EN 998-2)**	**Portland cement: lime: sand**	**Air-entrained Portland cement: sand**	**Masonry cement: sand**	**Strength**
	(ii) (a)	1:0.5:4-4.5 (b)	1:3-4 (b)	1:2.5-3.5 (b)	5.0N/mm²

Notes:

(a) For concrete or calcium silicate brick use a designation (iii) mortar.
(b) Where soil or ground water sulphate levels are appreciable (Class 3 or higher) use sulphate resisting Portland Cement.

Table 2: Typical mortar mixes for below ground masonry

6.2.3 Cavities below ground

Cavities below ground should be filled with concrete, ensuring there is a minimum gap, as indicated in Figure 6 and Figure 7, between the DPC and the top of the concrete. The concrete should be of a GEN1 grade and a consistence class of S3.

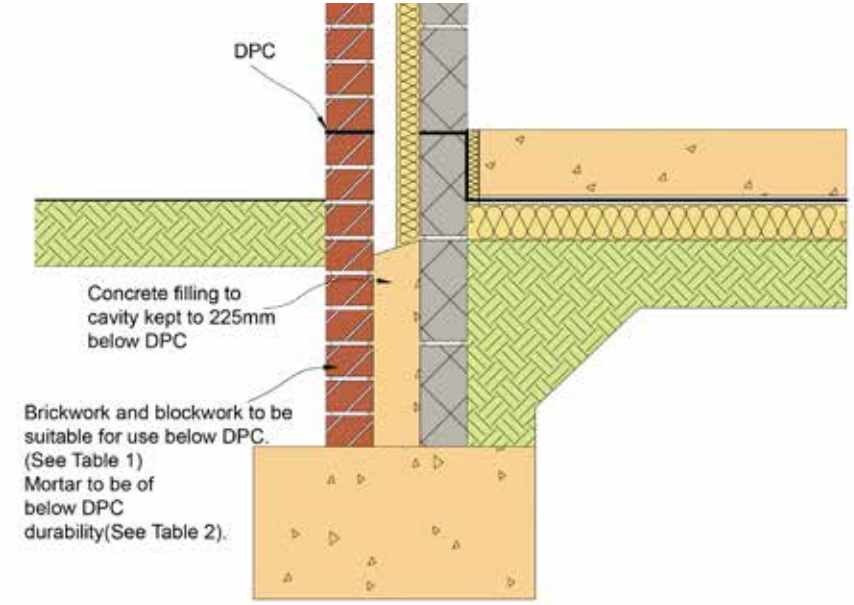


Figure 6: Concrete cavity fill: traditional ground bearing slab

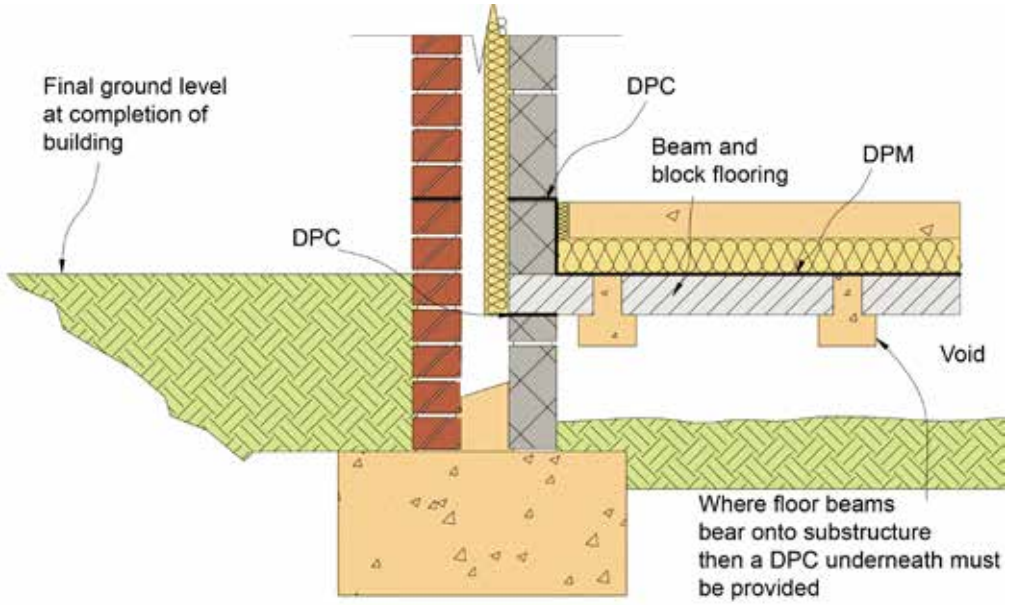


Figure 7: Concrete cavity fill: beam and block floor

FUNCTIONAL REQUIREMENTS

6.3 DAMP PROOFING

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Damp proofing works should prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

6.3.1 Damp Proof Courses (DPC)

Damp Proof Courses should be of a flexible material that is suitable for its intended use, and the DPC should have appropriate third-part certification. Generally, blue brick or slates will not be accepted as a DPC.

DPC should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required (e.g. over a telescopic floor vent) please refer to Chapter 7, section 7.1, for further guidance on cavity tray, weep holes and stop end requirements.

6.3.2 Damp Proof Membranes (DPM)

DPM should be provided beneath all ground-supported slabs or cast in-situ reinforced slabs. Membranes should be linked to the DPC and be a minimum 1200g polythene. Membranes should be laid either onto a concrete slab or onto a minimum 5mm sand blinding (if laid below a floor slab).

Other DPM may be considered if they have appropriate third-party certification and are installed in accordance with the manufacturer's instructions.

6.3.3 Stepped membranes

DPM should be continuous where floors are stepped, as illustrated in Figure 8.

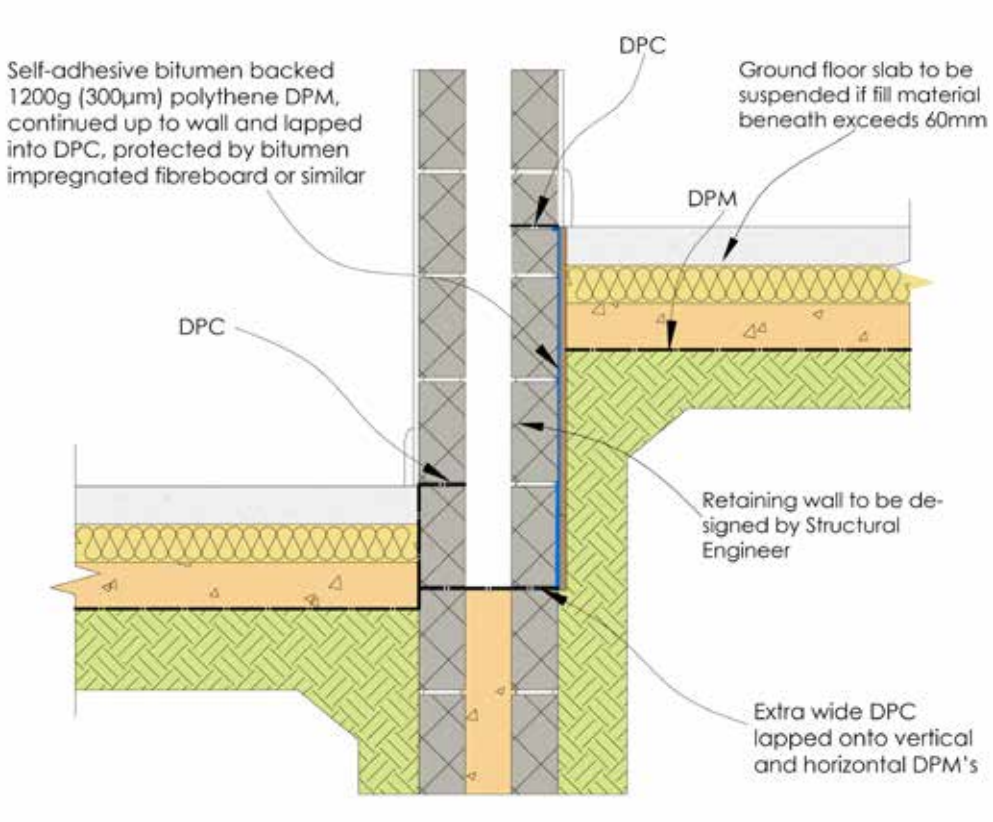


Figure 8: Stepped Damp Proof Membrane

FUNCTIONAL REQUIREMENTS

6.4 GROUND FLOORS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
iv. Precast structural elements must have structural calculations that prove their adequacy endorsed by the manufacturer.

6.4.1 Ground supported concrete floors

6.4.1.1 Site preparation

The site beneath the floor should be stripped of all topsoil, organic matter or tree roots prior to filling and compaction.

Suitable hard core would include inert quarried material such as limestone or granite. Recycled aggregates may be used, which include crushed concrete or broken brick; however, these must be completely free of contaminants and plaster and should be delivered to site from a supplier that has a quality audit process in place.

Materials available as a result of any site demolition should not be used as hard core beneath floor slabs unless specifically agreed by the Warranty Surveyor, and only then if it can be demonstrated that the material is completely free of contaminants and plaster.

Hard core should be placed and compacted in 150mm nominal layers and be fully consolidated using a mechanical compactor. A ground supported concrete floor will not be acceptable where the depth of hard core required exceeds 600mm, and an alternative ground floor solution, e.g. beam and block, should be considered.

Hard core material should not be saturated, and caution should be taken to ensure that new walls are not disturbed by compaction of the hard core.

6.4.1.2 Damp Proof Membranes (DPM)

DPM can be laid either above or below the floor slab depending on the finish of the floor. The membrane should be lapped into the DPC by at least 100mm.

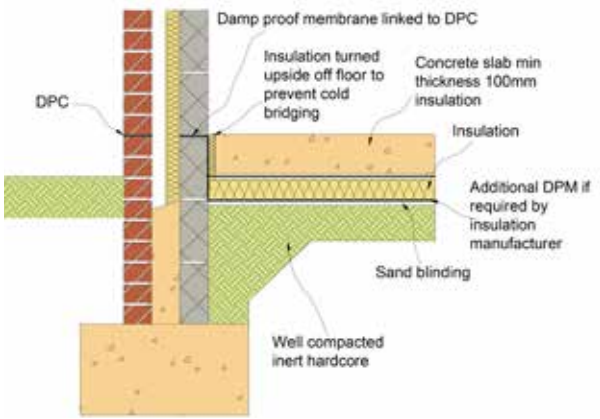


Figure 9: Typical ground bearing floor slab

6.4.1.3 Insulation

Insulation that is to be provided to ground floor can be placed either above or below the concrete slab. Insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional DPM to protect the surface of the insulation. It is important that this additional membrane is incorporated, which is shown in Figure 9.

6.4.1.4 Concreting of floors

Prior to concreting, any water or debris that may have collected on top of the DPM should be removed. Concrete should ideally be ready mixed and be of at least GEN3. Expansion joints should be provided in accordance with Chapter 2.2 of this Manual.

6.4.2 Suspended reinforced in-situ slabs

6.4.2.1 Structural design

A cast in-situ suspended concrete slab should be designed by a qualified Structural Engineer. The structural design should include the following information:

- Adequacy of walls that support the concrete slab (intermediate and perimeter walls).
- Suitable thickness, correct durability of concrete and correct provision of reinforcing.
- Provision of anti-crack reinforcing to the perimeter of floors.

6.4.2.2 Site preparation

The material below the proposed floor slab should be compacted sufficiently to support the slab during the pouring and curing stages. Any backfill material should not contain any organic matter, or contaminants that could react with the concrete or be susceptible to swelling, such as colliery waste.

6.4.2.3 Damp Proof Membranes (DPM)

DPM can be laid either above or below the floor slab depending on the finish of the floor. If the membrane is to be placed beneath the concrete, extra caution should be taken to ensure the membrane is lapped into the DPC by at least 100mm, as shown in Figure 9.

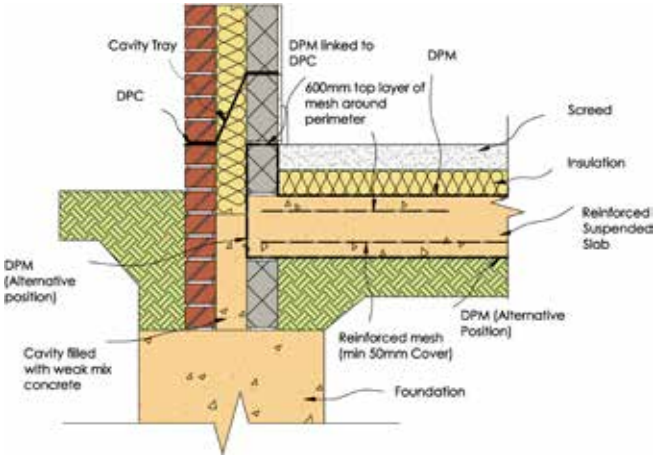


Figure 10: Typical cast in-situ concrete suspended floor

6.4.2.4 Insulation

Insulation that is to be provided to ground floor should be placed above the concrete slab. Insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional DPM to protect the surface of the insulation.

6.4.2.5 Concreting floors

The depth of concrete will vary depending upon the load conditions and the span of the floor. The overall reinforced concrete slab design should be designed by a suitably qualified Structural Engineer.

The reinforced concrete should have a minimum strength of RC30 and be ready mixed and delivered on-site in accordance with the Functional Requirements of Chapter 2.2 Materials – Concrete. Site mixing is not considered suitable for concrete suspended floors.

The poured concrete should be lightly vibrated and well tamped to ensure that no voids are left within the floor slab.

The floor slab should be appropriately shuttered around its perimeter to enable a cavity to be formed between it and the external wall. The shuttering can be expanded polystyrene (which is removed once the concrete has set) or a proprietary shuttering system.

6.4.2.6 Reinforcing

Reinforcing cover

The main reinforcing bars must have a minimum concrete cover of 40mm. Suitable spacers should be provided to support the reinforcing prior to concreting.

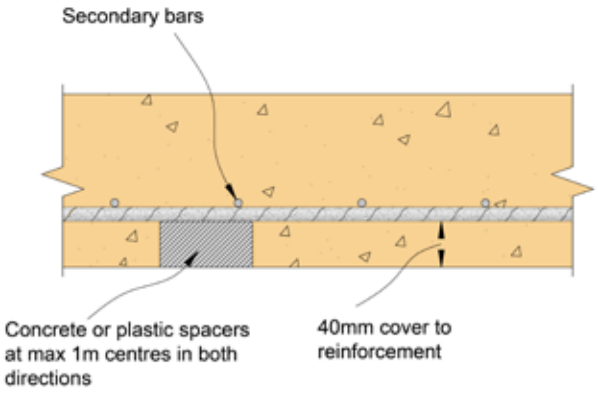


Figure 11: Cast in-situ suspended concrete floor-reinforcing cover and support

The reinforcing fabric must be laid so the main bars are in the same direction as the span.

Standard of fabric reinforcing

Reinforcing fabric should be free from loose rust, oil, grease, mud and any other contaminants that may affect the durability of the concrete. Reinforcing fabric should be of a 'B' mesh grade. This can be identified by the size of the primary and secondary bars. Primary bars are spaced at 100mm centres and secondary bars are placed at 200mm centres, as indicated in Table 3.

BS reference	Primary bar			Secondary bar		
	Size (mm)	Spacing of bars (mm)	Area mm²/m	Size (mm)	Spacing of bars (mm)	Area mm²/m
B1131	12	100	1131	8	200	252
B785	10	100	785	8	200	252
B503	8	100	503	8	200	252
B385	7	100	385	7	200	193
B283	6	100	283	7	200	193
B196	5	100	196	7	200	193

Table 3: Standard 'B' mesh reinforcing details

Lapping of reinforcing

It is accepted that reinforcing can consist of a number of sheets that can be joined together. The depth of cover will vary depending on the thickness of mesh reinforcing, and is identified in Table 4.

Minimum laps for main reinforcing bars in fabric mesh (1)	
Fabric type	Minimum lap (mm)
B1131	500
B785	400
B503	350
B385	300
B283	250
B196	200

Note:

(1) A minimum lap of 300mm is required for secondary reinforcing bars

Table 4: Minimum laps for reinforcing

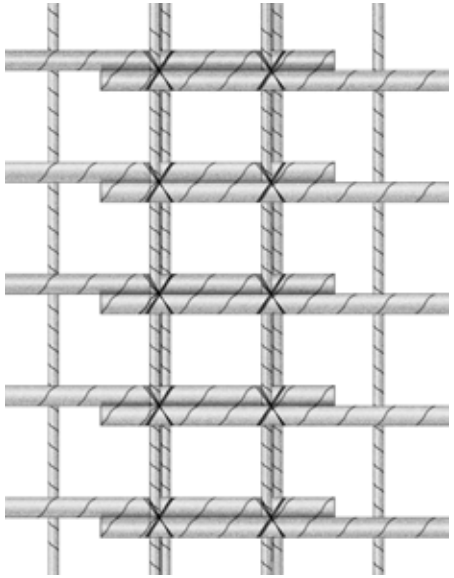


Figure 12: Typical reinforcing lap

6.4.3 Suspended timber floors

6.4.3.1 Durability of suspended timber floors

To prevent the decay of timber joists, the suspended timber floor should be constructed in such a way that:

- All joists and wall plates are above the DPC level.
- A minimum void of 150mm is provided between the joists and oversite.
- Air bricks are provided to give adequate cross ventilation to the floor void.
- Joists have adequate bearings and do not protrude into the cavity.

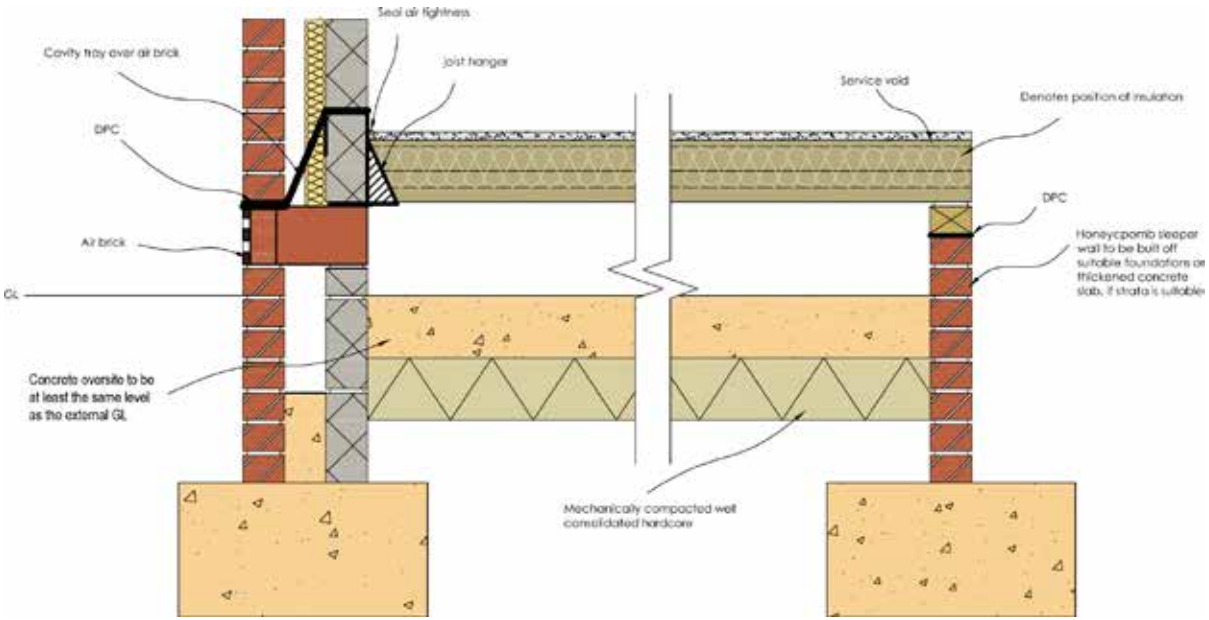


Figure 13: Typical suspended timber floor

6.4.3.2 Floor joists

All floor joists must be of a suitable durability and strength grade (minimum C16), be of the correct size and stress grade and be laid at the correct specified centres as indicated on plans and specifications. The joists should have consistent dimensions and be securely nailed to timber wall plates.

Joists at the junction with the external and party walls should be supported on suitable joist hangers and be adequately strutted at mid-span.

Floor joists can be supported internally by sleeper walls. Sleeper walls should be built of an adequate foundation if the ground is of suitable bearing strata, or can be built of a reinforced thickened slab where designed by a Chartered Structural Engineer.

6.4.3.3 Concrete oversite

A suitable oversite should be provided at least 150mm below the timber suspended floor.

The oversite should be either:

- 100mm thick concrete oversite (GEN 3) on well-compacted hard core, or
- 50mm thick concrete oversite on a 1200g DPM laid on 25mm sand blinding and well-compacted hard core

For sites that are susceptible to gas migrations, the oversite should incorporate gas protection measures designed by a suitable specialist.

6.4.3.4 Sub-floor ventilation requirements

To prevent decaying floor joists, sub-floor ventilation must be provided and give a free cross flow of air. External air bricks should be provided in two opposing walls, and must meet the provision detailed in Table 5.

Floor area of building (m^2)	Minimum ventilation provision (mm^2)
40	20,000
60	30,000
80	40,000
100	50,000
120	60,000
140	70,000
160	80,000

Table 5: Suspended timber floors: minimum cross ventilation provision

Air bricks should be evenly spaced along the two opposing walls that meet the ventilation provision. Typical ventilation areas for various types of air bricks care are identified in Table 6.

Air brick type	Dimensions W x H (mm)	Net area (mm^2)
Clay air brick square holes	225 x 75	1400
	225 x 150	4300
	225 x 225	6400
Clay air brick louvered	225 x 150	2000
	225 x 225	6400
PCV air brick	225 x 75	4645

Table 6: Typical air brick net ventilation area capacities (ventilation rates will vary between different manufacturers)

The cross flow of air must not be interrupted by internal walls or low hanging insulation. All internal walls must have air bricks to allow the free flow of air, or be built using a honeycomb technique.

6.4.3.5 Floor boarding or decking

Suitable floor boards and decking include tongue and grooved softwood flooring with a minimum moisture content at the time of fixing of between 16%–20%, in accordance with BS 1297. All boards must be double nailed or secret nailed to each joist using nails that are at least three times the depth of the board. The boards must have a minimum thickness, as indicated in Table 7.

Finished board thickness (mm)	Maximum centres of joists (mm)	Typical nail fixing (mm)
15	450	45 lost head nail
18	600	60 lost head nail

Table 7: Softwood floor boarding

6.4.3.6 Particle floor boarding

Acceptable particle boards consist of Oriented Strand Board (OSB) or chipboard.

Chipboard should be tongue and grooved and all joints glued. The boards should be laid so that the shortest length is laid parallel to the span. The OSB boards should be type 3 or 4 to BS EN 300 and should be laid with the major axis at right angles to the joists (the major axis is indicated on the OSB board by a series of arrows).

Particle boards should be either screwed or nailed to the joists at 250mm centres. Nails should be annular ring shank, which are at least three times the depth of the board.

A 10mm expansion gap should be provided around the perimeter of the floor against a wall abutment.

Thickness (mm) (chipboard)	Thickness (mm) (OSB)	Maximum span (mm)	Typical nail fixing (mm)
18 and 19	15	450	60mm annular ring shank
22	18 and 19	600	65mm annular ring shank

Table 8: Particle floor boarding

6.4.3.7 Sound insulation and air tightness

Due to the construction methods, it is more likely to be difficult to demonstrate satisfactory levels of air tightness and sound insulation for suspended timber ground floors. In ensuring that a reasonable level of air tightness and sound resistance is achieved, the following provisions should be incorporated:

- All joists to be supported off proprietary joist hangers at the junction with party walls and external perimeter walls.
- Floor boarding to be sealed against the wall using a sealant or proprietary tape.

6.4.4 Precast beam and block floors

6.4.4.1 Site preparation

All topsoil and organic matter should be removed from beneath the precast suspended floor. The ground level should be at least the same as the external ground level unless the ground below the floor is free draining. Alternatively, a DPM linked to the DPC can be provided.

6.4.4.2 Suitability of beam and block floors

All beam and block flooring systems must have appropriate third-party certification or accreditation that meets the Functional Requirements of this Chapter.

The manufacturer's details and specification for the floor must include:

- Structural calculations for the floor indicating depth and centres of the precast floor beams.
- The suitability and durability of walls supporting the beam and block floor. Recommended blocks for infilling between the beams, including compressive strength and thickness of the block.

All beam and block floors shall be installed ensuring that the following standards are met:

- Floor beams and blocks are grouted together using a cement/sand slurry with a mix ratio of 1:6 respectively.
- The beam and block floor should not be used to support load-bearing walls .
- All walls should be built off an appropriate foundation, as indicated in Chapter 5.
- A suitable mortar bed is required where block work between the floor beams bear onto load bearing walls, e.g. perimeter walls.
- Holes must not be made through the floor beams, and any service penetrations should pass through the holes made in the infill blocks. Any gaps around service penetrations should be filled with concrete (ST3) mix before screeding.

Where beam and block floors are to be installed to areas with higher potential point loads, such as garages, additional reinforcing of the screed will be required to distribute loads effectively. This reinforcing should be of at least an 'A' mesh quality, and the screed should be thick enough to give an appropriate depth of cover.

6.4.4.3 Resistance to ground moisture

The precast beam and block substructure floor shall be designed to prevent water ingress. There are two common methods of achieving this:

Method 1 – Damp Proof Membrane (DPM)

A DPM should be provided beneath the screed or insulation; the floor void beneath the beams should be appropriately vented, ensuring that a cross flow of air between two external walls is achieved. The minimum area of ventilation should equate to at least 1500mm^2 per metre run of external wall. This roughly equates to an air brick every 3m centres for a typical PVC 225mm x 75mm air brick. The ventilated void must have a minimum depth of 150mm from the underside of the floor.

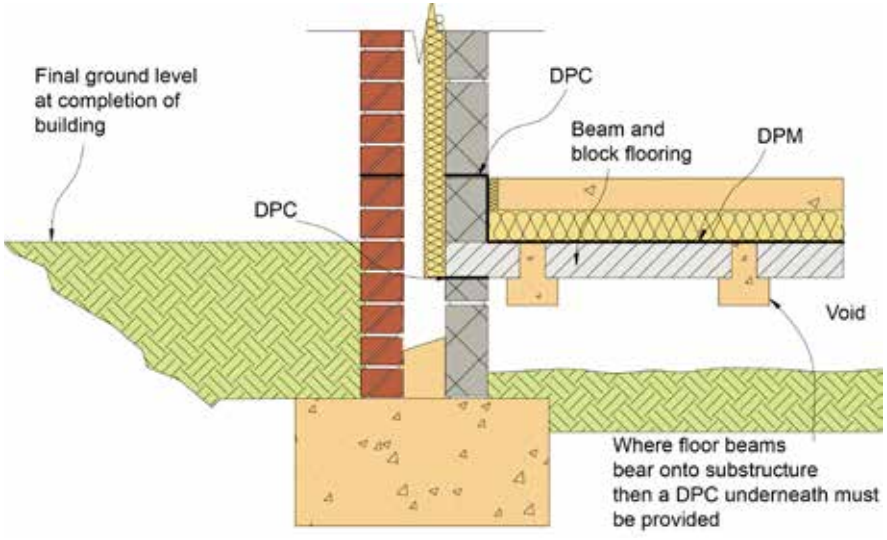


Figure 14: Typical pre-cast beam and block floor with DPM

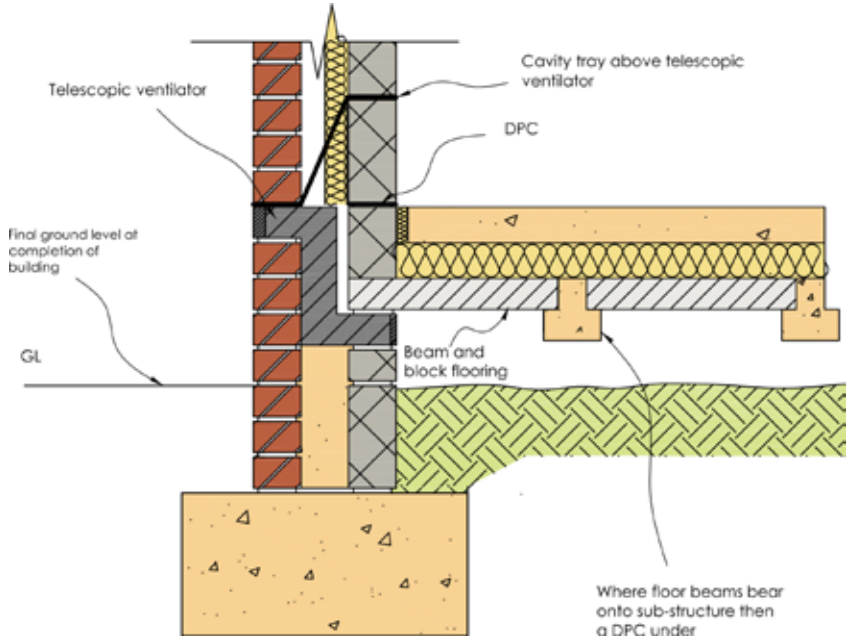


Figure 15 : Typical pre-cast beam and block floor without DPM

Method 2 – No Damp Proof Membrane (DPM)
Where no DPM is incorporated into the precast beam and block floor, the following provisions will apply:

The beam and block floor must be laid above the DPC. The floor void beneath the beams should be appropriately vented to ensure that a cross flow of air between two external walls is achieved.

The minimum area of ventilation should equate to at least 1500mm^2 per metre run of external wall. This roughly equates to an air brick every 3m centres for a typical PVC 225mm x 75mm air brick. The ventilated void must have a minimum depth of 150mm from the underside of the floor. The solum level must be at the same level as the external ground level.

6.4.4.4 Insulation

Insulation provided to ground floor should be placed above the beam and block. Insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional DPM to protect the surface of the insulation.

CHAPTER 7: SUPERSTRUCTURE

CONTENTS

7.1 EXTERNAL MASONRY WALLS

7.2 STEEL FRAME

7.3 TIMBER FRAME

7.4 WINDOWS AND DOORS

7.5 CHIMNEYS

7.6 BALCONIES

7.7 CLADDING

7.8 ROOF STRUCTURE

7.9 ROOF COVERING – TRADITIONAL SLATE AND TILES

7.10 ROOF COVERING – CONTINUOUS MEMBRANE ROOFING

7.11 ROOF COVERING – GREEN ROOFING

7.12 ROOF COVERING – METAL DECK ROOFING

FUNCTIONAL REQUIREMENTS

7.1 EXTERNAL MASONRY WALLS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Cavities should be clear from mortar droppings to prevent moisture ingress.
iv. Masonry walls should not be laid in extreme weather conditions.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. Materials should be suitable for the relative exposure of the building in accordance with the relevant British Standard.
iv. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The design and construction of masonry walls must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.1.1 Protection

All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rain water or dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

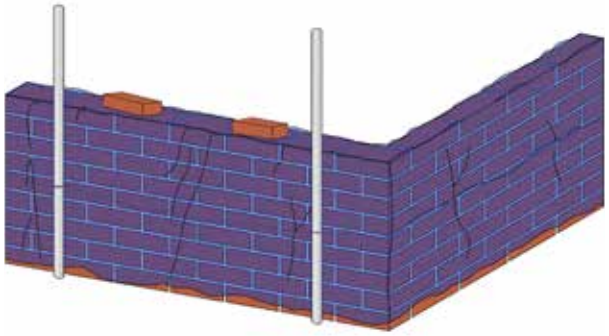


Figure 1: Protection of masonry

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

7.1.2 Brick and block suitability

Exposure

Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further guidance can be found in this Manual under Chapter 2 – Materials.

Non-rendered blockwork

All external blockwork should be rendered or otherwise finished with a cladding that is appropriately durable, unless the block manufacturer can provide third-party certification confirming that the blockwork can be left unfinished, or finished in an alternative way.

Colour variation of bricks

There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations

Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence

Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation (see Chapter 2 – Materials).

7.1.3 Mortar

General

A mortar type above DPC should be chosen in accordance with the guidance given in Chapter 2 – Materials, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/

or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching
Keep batching and mixing equipment clean to avoid contamination with materials used previously. Mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing
Mortar should be carefully and consistently proportioned, and then thoroughly mixed using a mechanical mixer, except for very small quantities.

7.1.4 Adverse weather

Working in adverse weather
Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in Chapter 2 – Materials.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Dealing with areas of high exposure to frost and wind-driven rain

Frost attack
Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.
If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Wind-driven rain
To ascertain the risk relating to wind-driven rain, the following should be determined:

- The exposure to wind-driven rain, using Figure 2.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.

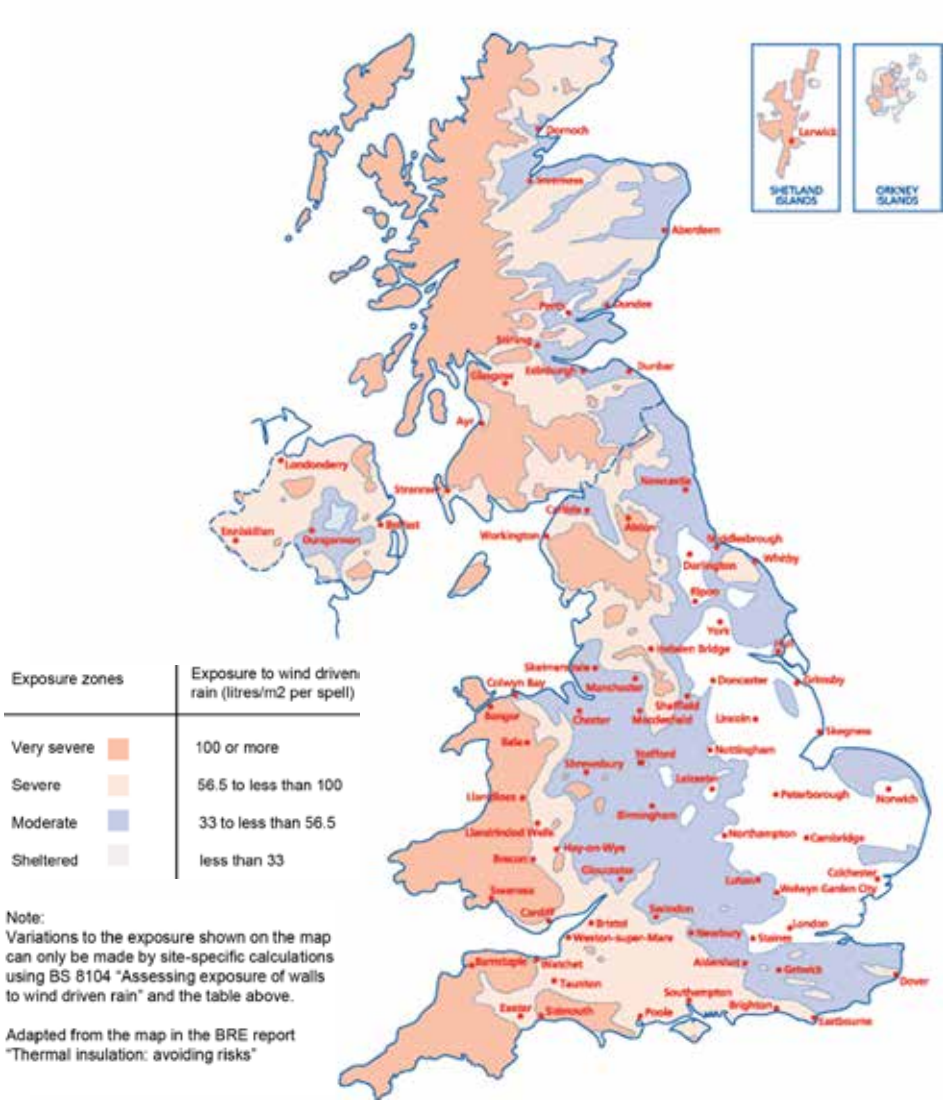


Figure 2: Map showing exposure to wind-driven rain categories

Exposure category	Suitable wall construction	Minimum insulation thickness (mm)		
		Built-in insulation	Retro-fill (other than UF foam)	UF foam
Very severe	Any wall with impervious cladding	50	50	50
	Fair-faced masonry with impervious cladding to all walls above ground storey	100	100	N/A
	Any wall fully rendered (2)	75	75	N/A
	Fair-faced masonry (1)	N/A	N/A	N/A
Severe	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	75	50
	Fair-faced masonry	75	75	N/A
Moderate	Any wall with impervious cladding or render	50	50	50
	Fair-faced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	75	75
Sheltered	Any wall with impervious cladding or render	50	50	50
	Fair-faced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	50	50

Notes:

- (1) In *very severe* exposure locations, fair-faced masonry with full cavity insulation is not permitted;
- (2) Render on an external leaf of clay bricks (F2, S1, or F1,S1 designation bricks BS EN 771) in severe or *very severe* exposures is not permitted where the cavity is to be fully filled with insulation;
- This table covers walls where the external leaf does not exceed 12m in height;
- The exposure category of the dwellings is determined by its location on the map showing categories of exposure to wind driven rain;
- Fair-faced masonry includes clay, calcium silicate and concrete bricks and blocks and dressed natural stone laid in an appropriate mortar, preferably with struck, weathered or bucket handle joints. Cavity walls of random rubble or random natural stone should not be fully filled;
- Recessed mortar joints should not be used.

Table 1: Suitable cavity wall construction depending on exposure

7.1.5 Cavities

A traditional masonry wall should be constructed using an inner and outer leaf, and a cavity should be provided between them, which meet the following provisions:

- The cavity should have a minimum width of 50mm.
- It is to be kept clear from mortar snots to ensure the cavity is not bridged.
- The two leaves should be appropriately tied, in accordance with Chapter 7.1.8.
- The cavity can be fully insulated or partially insulated, depending on exposure to wind-driven rain. For partial fill insulation, a minimum clear cavity of 50mm should always be provided. Further information can be found in BS 8104.

7.1.6 Structural design of walls

A method of meeting the requirements of the Warranty is to design and construct walls to the relevant Approved Document depending on the region. For example, in England and Wales, the masonry units should be built in accordance with Approved Document A (Structure). Alternatively, justification of design by a Chartered Structural Engineer can be used as a solution.

7.1.7 Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Restraint type joist hangers
- Lateral restraint straps
- Other forms of restraint proven by a Chartered Engineer

Restraint type hangers

It is necessary to ensure that:

- The hanger is bedded directly on the masonry and there is no gap between the hanger back-plate and the face of the masonry.
- At least 450mm of masonry is provided above the hanger.
- Hangers are spaced at centres of floor joists included in the design.
- The hanger is suitable for the loadings and masonry strength.

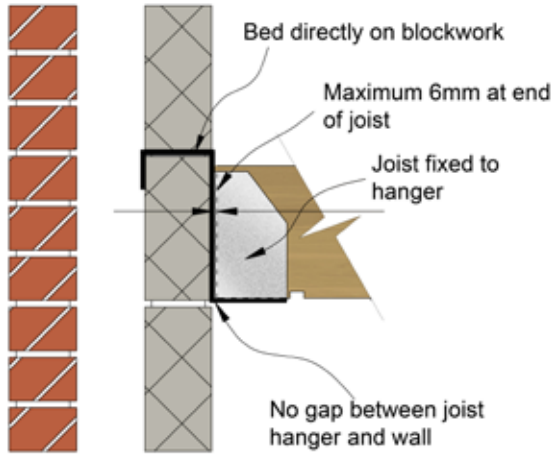


Figure 3: Typical restraint type joist hanger

Do not:

- Apply load while the mortar is still green and has not gained sufficient strength.
- Use brick courses in block walls under joist hangers; the thermal insulation of the wall may be reduced unless similar units to the blocks are used.

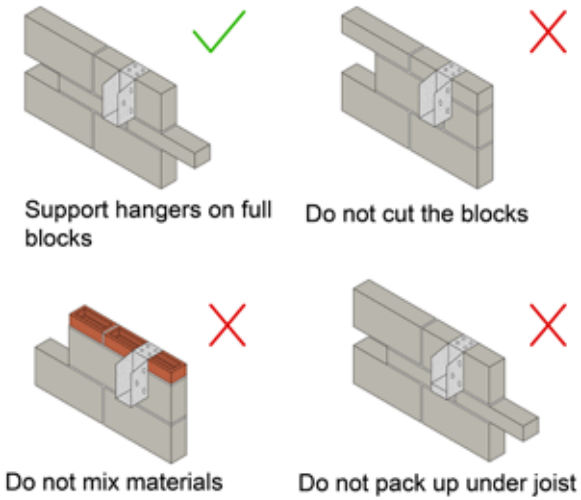


Figure 4: Correct use of hangers

Timber floors in two storey dwellings where:

- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm.
- Bearing on a timber wall plate.
- Carried by the supported wall by restraint type joist hangers as described in BS 5268: 7.1.
- Concrete floors with minimum 90mm bearing on supported wall.

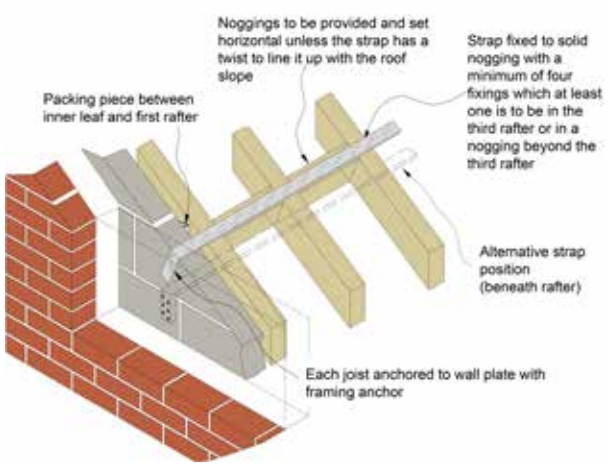


Figure 5: Lateral restraint strap to gable wall

Lateral restraint straps

Floors, including timber, block and beam, and roofs should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at 2m centres (see Figures 5, 6 and 7). Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations:

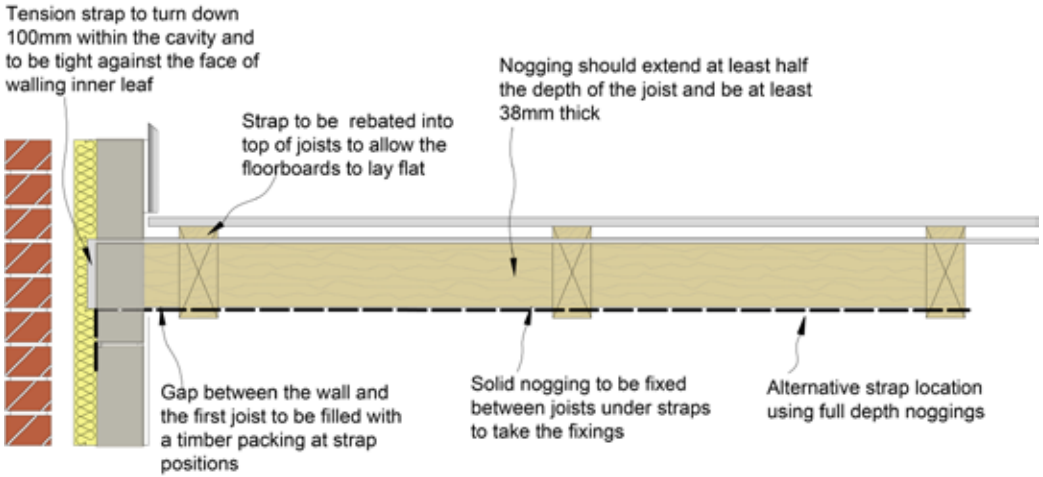


Figure 6: Lateral restraint to floors

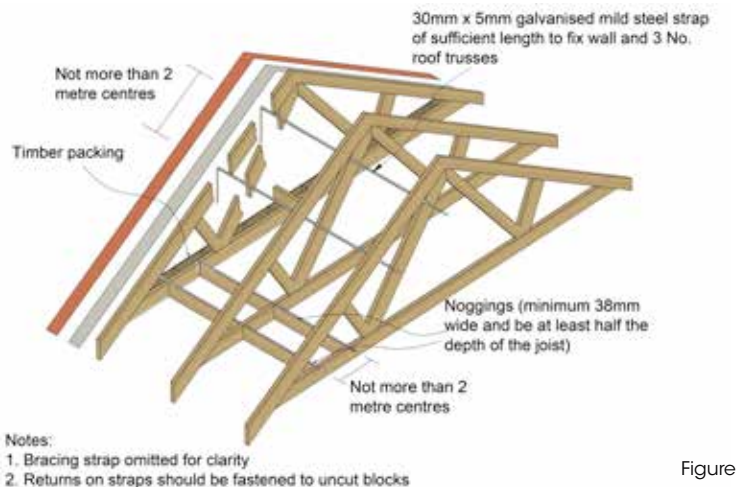


Figure 7: Lateral restraint to gable wall via roof trusses

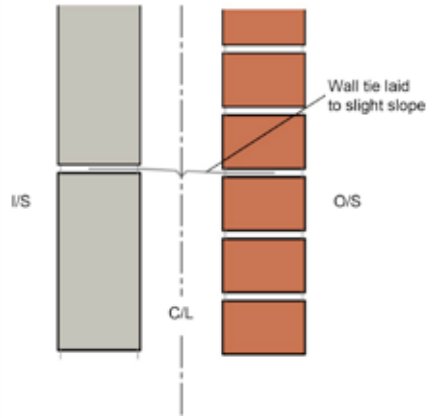


Figure 8: Wall tie provision

Stainless steel wall ties should always be used.

It is important to note that only BS EN 845-1 type wall ties or specifically manufactured (and tested) party wall ties are permitted in cavity separating walls between dwellings to reduce the transfer of sound.

7.1.8 Wall ties

Wall ties should meet the following provisions:

- Wall ties should be to BS EN 845-1 or have appropriate third-party certification.
- The overall length of the wall ties must be long enough to ensure there is at least a 62.5mm overlap onto each leaf of masonry, so that it will achieve a 50mm minimum length of bedding on the mortar.
- Wall ties should be laid to a slight fall towards the outer leaf and have the ability to hold insulation against an internal leaf for partial fill scenarios.
- Where a partial fill cavity insulation solution is proposed, a 50mm minimum residual cavity is to be provided.

Suitability and spacing of wall ties

Unfilled or fully filled cavities		Spacing of ties	
Width of cavity	**Recommended tie**	**Horizontal**	**Vertical**
50mm to 75mm wide	Butterfly Double triangle Vertical twist Proprietary ties	900mm	450mm (increased to 300mm at reveals and movement joints)
75mm to 100mm wide	Double triangle Vertical twist	900mm	450mm (increased to 300mm at reveals and movement joints)
100mm to 150mm wide	Vertical twist	750mm	450mm (increased to 300mm at reveals and movement joints)
Greater than 150mm	Wall tie specification and design to be provided by a Chartered Structural Engineer, or in accordance with appropriate third party certification. Design will be determined by location and site specific conditions.		

Table 2: Wall tie spacing

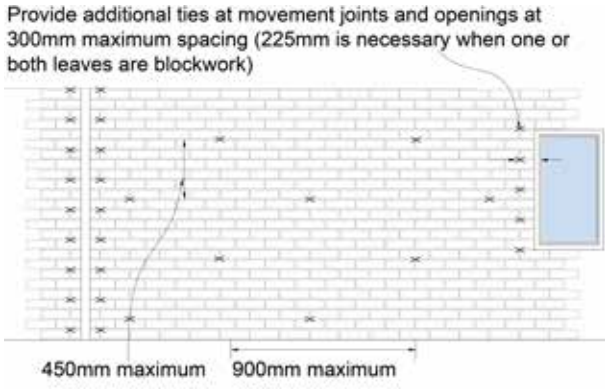


Figure 9: Provision of wall ties

Proprietary ties are to have appropriate third-party certification.

Wall ties are to have the correct thickness in accordance with BS 5628-2005.

Proprietary insulation retaining clips compatible with the tie should be used where the cavity is partially filled.

7.1.9 Bonding internal walls to external walls

Bonded walls in brickwork are comparatively easy to construct, but this can be more difficult with blockwork, so either:

- Tooth every alternative course (see Figure 10) or butt and tie (see Figure 11).
- Where blocks are of a different density, always use a butted joint; on party walls carry the separating wall through and butt up the inner leaf using a proprietary bed joint, reinforcement or suitable ties at each block course.

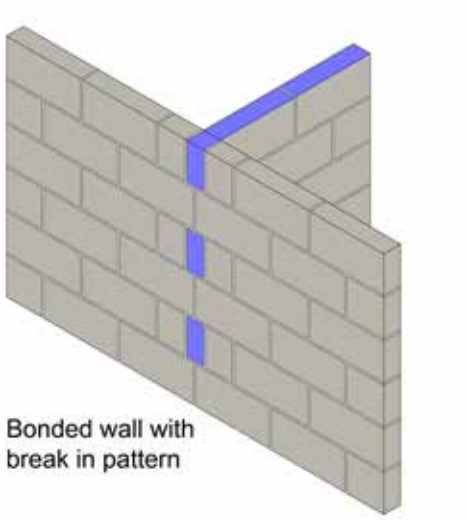


Figure 10: Block bonding internal masonry walls to inner leaf

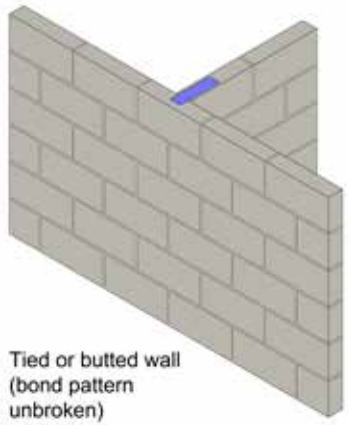


Figure 11: Bonding internal walls to inner leaf using ties

7.1.10 Corbelling

The extent of corbelling of masonry should not exceed that indicated in Figure 12 unless supported or reinforced. Reinforced corbels should be designed by a Chartered Structural Engineer.

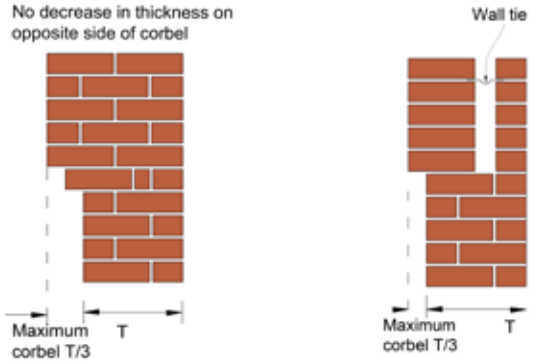


Figure 12: Typical corbelling arrangements

7.1.11 Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in Table 3. The first joint from a return should be no more than half the dimension indicated in the table.

Where the finished ground level is 600mm or greater below the horizontal DPC, the movement joint should be continued within the external leaf of the substructure. The DPC should be lapped a minimum of 100mm to accommodate any movement.

Movement joints below the DPC should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm centres should be provided on each side of movement joints. Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

Elastic sealants (Type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

The following must be considered:

- The material is compatible with the sealant
- It will not adhere to the sealant, preventing cracking within the sealant
- Provides sufficient density to allow the sealant to be applied
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness); fibreboard is not acceptable

Material	Normal spacing	Joint thickness
Clay brickwork	12m (spacing up to 15m may be possible if sufficient restraint is provided – consult Designer)	15mm
Calcium silicate and concrete brickwork	7.5m – 9m	10mm
Concrete blockwork (used in outer leaf)	6m	10mm
Stone	12m	15mm

Note:

It is not normally necessary to provide movement joints to the internal leaf of cavity walls but should be considered where rooms occur with unbroken lengths of wall in excess of 6m.

The first joint from a return should be not more than half the dimension indicated in the table. Movement joints are not acceptable in solid party or separating walls; however where cavity wall construction is adopted, offset movement joints with a solid rubber compressible strip may be acceptable.

Table 3: Spacing of expansion joints

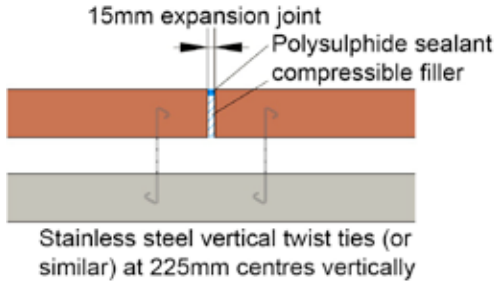


Figure 13: Typical expansion joint detail

7.1.12 Lintels

Bearing length

Use the correct length and width of lintel for the opening and cavity width; the bearing length should be at least 150mm. Do not let masonry overhang lintels by more than 25mm. Continuity of the masonry bond should be maintained at supports to beams and lintels (see Figures 14 and 15). Lintels should be insulated to prevent excessive thermal bridging.

Do not:

- Support lintels and beams on short lengths of cut block and make-up pieces.
- Apply load to the lintels or beam before the masonry supporting has hardened.

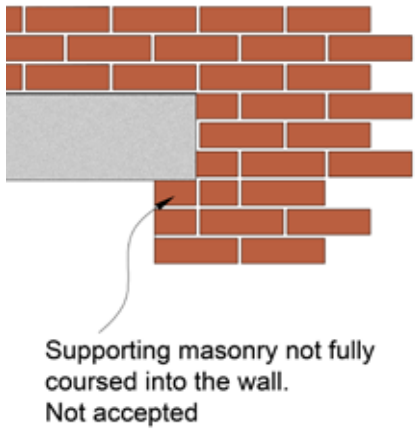


Figure 14: Incorrect method of brick bond around lintels

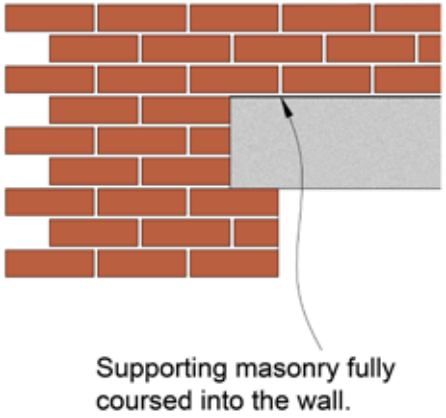


Figure 15: Correct method of brick bond around lintels

7.1.13 Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray
- Continuously above lintels where openings are separated by short piers
- Above openings where the lintel supports a brick soldier course

Cavity trays are to rise at least 150mm from the outer to the inner leaf, be self-supporting or fully supported and have joints lapped and sealed.

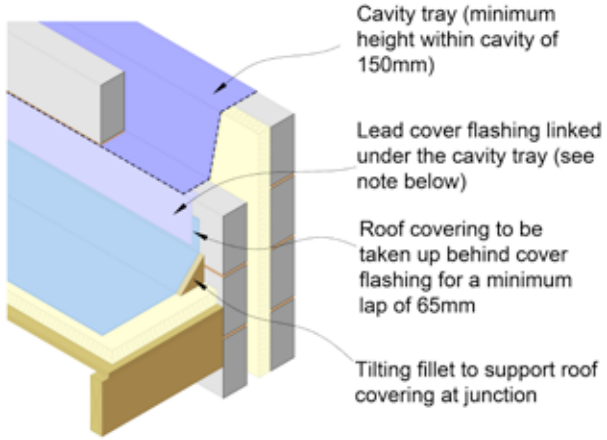


Figure 16: Cavity tray over a flat roof/wall abutment

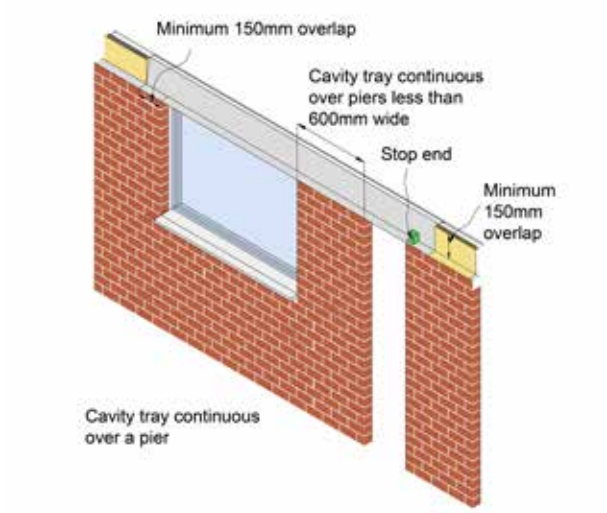


Figure 17: Continuous cavity tray over two openings and a small pier

7.1.14 Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level. When the wall is to be cavity filled, it is advisable to reduce this spacing.

At least two weep-holes must be provided to drain cavity trays above openings. Where the wall is externally rendered, the weep-holes are not deemed necessary for cavity wall construction.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

7.1.15 Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

Ring beams or floor slabs that partially bridge the cavity, e.g. when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray, especially when full cavity insulation is employed.

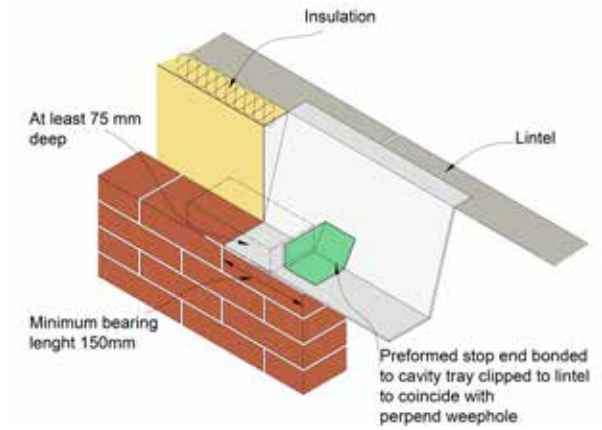


Figure 18: Stop-end to cavity tray

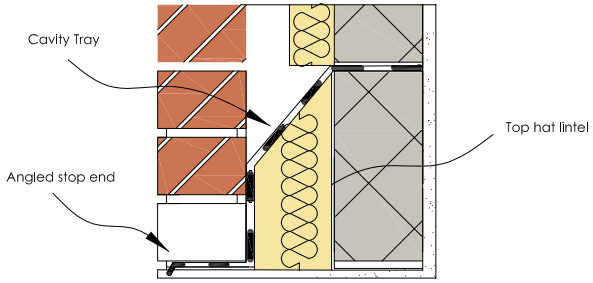


Figure 19: Stop-end in relation to cavity tray and lintel

7.1.16 Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of dwellings with steps and staggers. A proprietary cavity tray system should be used, or alternatively, a suitable tanking system. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. For brickwork, blockwork and stonework, lead cover flashings should be linked into the cavity tray (lapped in below).

Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc., which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

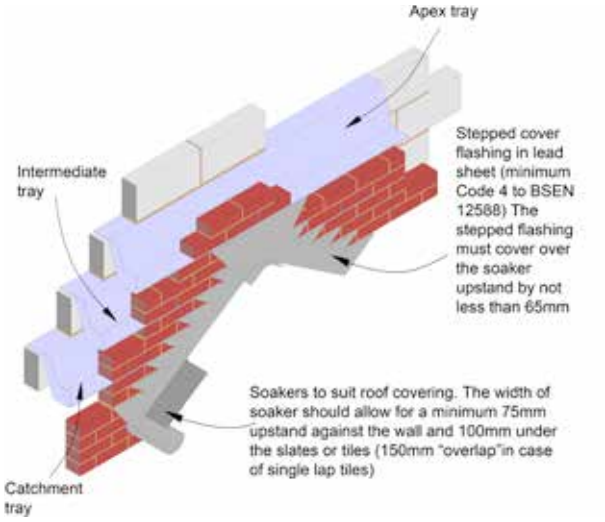


Figure 20: Stepped cavity at roof/wall abutments

7.1.17 Thermal insulation

Thermal insulation for cavity walls should be inserted to a high standard of workmanship to avoid poor insulation performance and to prevent dampness migrating to the inside of the building.

Insulation should have appropriate third-party certification and be installed in accordance with the manufacturer's instructions.

Insulation should not be cut or pierced to accommodate wall ties, unless increased centres at reveals or expansion joints are required. The wall ties should coincide with insulation joints. Partial fill insulation should be clipped or retained to the inner leaf using proprietary fixings in conjunction with wall ties.

For full fill cavities, it is recommended that mortar joints to facing brickwork are not recessed.

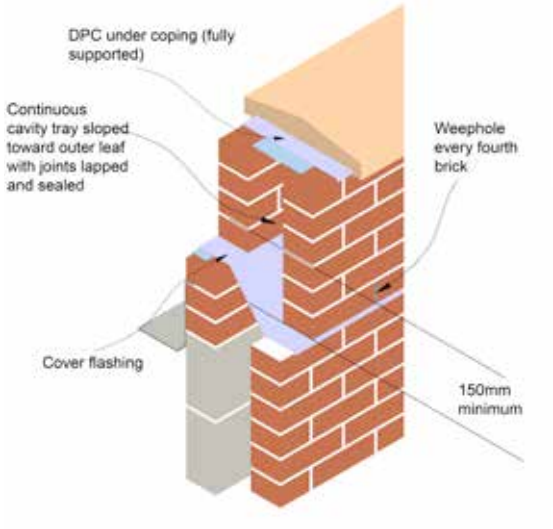


Figure 21: Parapet wall detail

7.1.18 Parapets

The minimum thickness and maximum height of parapet walls should be in accordance with Figures 21 and 22. The materials used in the construction of parapet details should be suitable for the location and exposure. Where possible, the use of raking parapets should be avoided due to the need for high standards of detailing and the workmanship required to prevent the ingress of moisture. In very severe exposure zones, it is recommended that a parapet construction is avoided altogether.

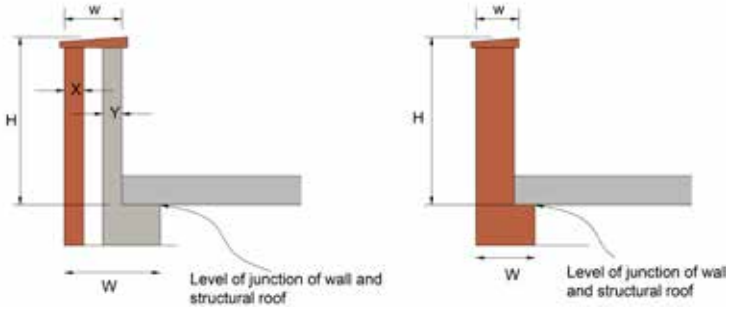


Figure 22: Maximum height of parapet walls (to be read in conjunction with Table 4)

Wall type	Thickness (mm)	Maximum parapet height (mm)
Cavity wall	x + y equal or less than 200	600
	x + y greater than 200 equal or less than 250	860
Solid wall	w = 150 w = 190 w = 215	600 760 860

Note:

w should be less than W as shown in Figure 22.

Table 4: Parapet walls/height ratios

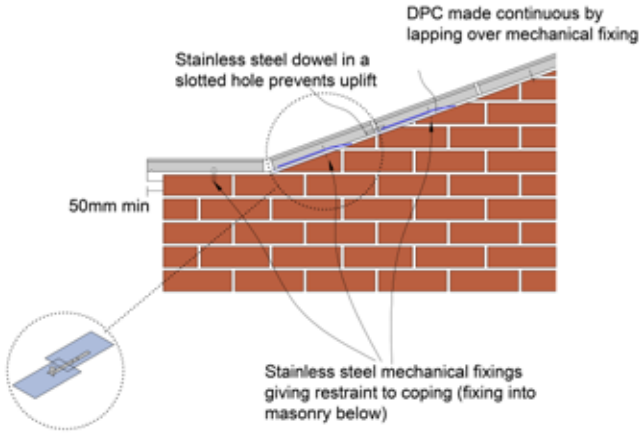


Figure 23: Fixing of copings to sloping parapets

7.1.19 Natural stone

General

The following additional guidance for natural stone shall be used in conjunction with any other information in this Manual. When selecting stone for cavity wall house building, it is important to consider the exposure rating for the area.

It is not recommended to use a soft, porous-type stone in a severe exposure zone. Consideration should be given to the compatibility of different stone to prevent staining and premature decay. Limestone and sandstone should not be mixed together.

It is advisable to use a stone that has been quarried within a reasonable location of the development, ensuring both weathering qualities and visual blending with existing buildings. Natural stone has a grain or natural bed that is determined during its formation in the strata of the quarry.

It is important that the stone is laid with the grain running horizontal to the bed. In the case of jambs and mullions, the grain should be vertical.

Walls constructed with a cavity are essential where the location is likely to be of moderate exposure or worse. A sawn bed of 100mm minimum thickness is to be used as the outer leaf of a cavity wall, although 150mm is recommended. Where dressed stone is used and the bed falls below 90mm due to the irregularities of the stone, the stone should be backed with either a brick or 50mm minimum thickness block wall to maintain the structural stability. It is not acceptable for the stone to be packed or wedged to maintain line and level without the backing wall being in place.

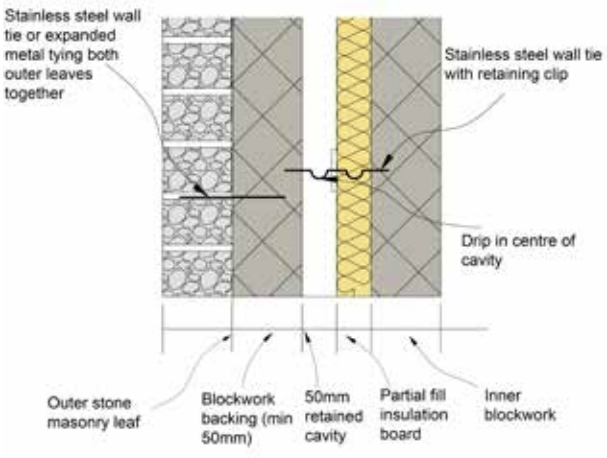


Figure 24: Masonry cavity wall with stone outer leaf

Mortar
The mortar for use with stone should comply with the relevant British Standards for sand, lime and cement, as set out in BS 5390.

This can vary in strength from 1:1:6 to 1:3:12 depending on the softness of the stone. It is important to use the correct mortar to allow for movement and associated shrinkage. Ensure that wall ties are stainless steel and of sufficient length to maintain a 50mm embedment. It may be necessary to double up the wall ties where the coursing is out of line due to the varying thickness of natural stone at the reveals, i.e. every other course, and to ensure that wall ties do not slope inwards.

Insulation
Full fill cavity insulation should only be considered where the outer leaf is backed by brick/blockwork, although this is still dependent on exposure, i.e. either partial fill, leaving a residual cavity of 50mm, or a clear cavity should always be the preferred options.

In movement control where sealants are used, it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Cavity trays
In addition to the previous guidance for cavity trays, the following shall apply:

When stone heads are being used, it is advisable to double up the cavity trays, one below and one above the stone head, and to provide stop-ends and weep-holes.

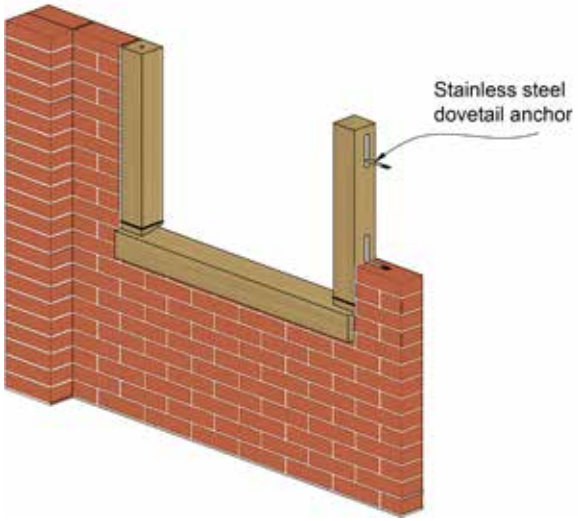


Figure 25: Stone jamb and mullion, fixing to walls

Jambs and mullions
Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs.

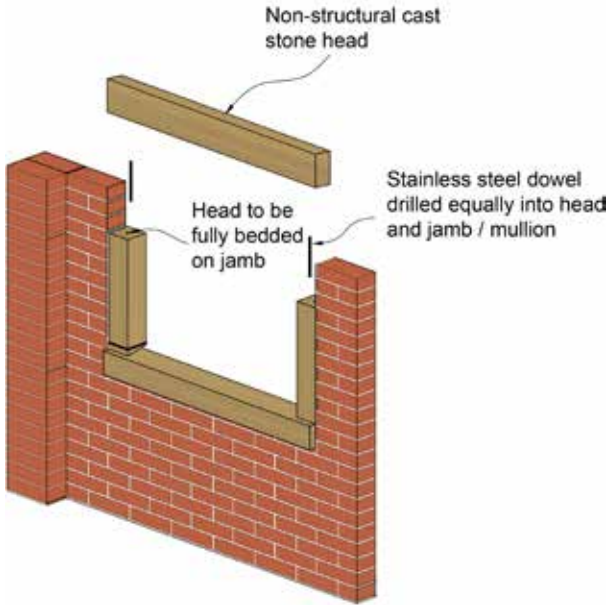


Figure 26: Joining stone jambs to sills and head

FUNCTIONAL REQUIREMENTS

7.2 STEEL FRAME

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. Steel frames should be appropriately treated to prevent corrosion.
iv. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The design of the steel frame must be supported by structural calculations completed by a suitably qualified engineer. The design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.2.1 Steel frame

Galvanised strip steel should be designated either grade S280GD or 350GD to BS EN 10326. The structural design should be in accordance with BS 5950–5: 1998, and imposed loads should be calculated in accordance with BS EN 1991, including:

- Dead loads
- Imposed loads
- Wind loads

Steel and fixings should be suitable for the design and adequately protected against corrosion. Load-bearing walls should be designed to support and transfer loads to foundations safely and without undue movement.

Wall panels may provide resistance to racking forces using one or more of the following techniques:

- Internal bracing
- Cross flat bracing
- External sheathing board
- Internal sheathing board
- Rigid frame action

The design should detail how joints between the wall panels and other elements are to be securely fixed:

- To the structure
- To adjacent panels
- To the floor and roof

The design should ensure that the structure is adequately protected from the effects of moisture. Exterior claddings should be compatible with the steel frame. Suspended floors should be designed to support and transmit loads safely to the supporting structure without undue deflection.

Services should be adequately protected from damage. Walls and floors should resist the spread of fire. Internal walls and floors should be designed to resist the passage of sound adequately.

7.2.2 Site tolerances

It is essential that the accuracy of setting out foundations and ground beams are checked well in advance of materials being delivered to site.

For accurate erection of the frame, the following tolerances are required at the level of the base of the wall frame:

- Length of wall frame: +/-10mm in 10m.
- Line of wall frame: +/-5mm from outer face of plate.
- Level of base of wall frame: +/-5mm over complete wall line.

Some packing may be needed to achieve the required tolerances:

- Less than 10mm; pack under each steel with pre-galvanised steel shims.
- 10mm–20mm; pack under each steel with steel shims and grout over length of sole plate.
- Over 20mm; refer to Frame Designer.

7.2.3 Fixing of frames to substructures

The oversite DPM should be attached to the side of the slab and returned under the DPC on which the frame is placed. The DPC/DPM detail requires careful attention to prevent the cavity being bridged and providing a ledge for mortar droppings.

Holding down anchors may be galvanised, or preferably stainless steel straps that are fixed to the stud wall and attached to masonry supports or concrete foundation, or holding down bolts fixed to the concrete slab.

7.2.4 Walls

If stainless steel straps are used, they should be grade 1.4301 steel to BS EN 10088 and isolated from the studs with neoprene gaskets or similar. Non-stainless connections should be isolated from the straps with suitable grommets and washers.

Resin or expanding anchors should be used in an in-situ concrete raft of a minimum C20/GEN3 grade concrete. If required, steel frames can be fixed to timber sole plates.

For guidance on fixing sole plates, refer to the timber frame section in this Manual. The metal frame should be located entirely above DPC level. Where this is not possible, Z460 galvanising or equivalent, or a suitable bituminous coating, should be applied to all components below DPC level. It is recommended that the inner leaf DPC is turned up approximately 30mm above the screed to protect the bottom of the studs from construction moisture and spillage, and weep-holes are provided at 900mm centres to drain cavities at ground level.

7.2.5 Metal stud framework

The wall panel usually consists of a head rail, base rail (sole plate) and possibly horizontal noggins at mid-height, together with vertical wall studs:

- Recommended site connections include self-drilling, self-tapping screws or 10mm–12mm diameter grade 4.6 bolts. Welding is not recommended on-site.
- Workmanship should comply with BS 8000: 5.
- Framed walls should be accurately aligned, plumb, level without twist and securely fixed to adjacent elements.

Vertical tolerances are:

- +/-15mm in overall height of wall 3 storey or
- +/-10mm in overall height of wall 2 storey or
- +/-5mm in storey height (approx. 2.5m)

A lintel should be provided where one or more studs is cut or displaced to form an opening. A lintel is not required where an opening falls between studs. Non-load-bearing walls should have adequate strength and support.

Non-load-bearing walls should not bridge movement joints in the main structure. A movement joint should be constructed between the frame and any chimney flue lift shaft to prevent load transfer. Cavity barriers and fire stops should be provided in accordance with relevant Building Regulations, and steel joists should be spaced at centres no greater than 600mm.

Cutting holes for services on-site is not recommended, but where essential should be carried out with specialist tools. The maximum size of rectangular holes should not exceed 40% of the overall section, and length should not exceed 60% of the overall section or be the depth of the section apart. No holes should be closer than 1.5 times the depth of the section to the end of the member. Notches are not acceptable.

7.2.6 Thermal insulation

Rigid thermal insulation material should be fixed to the outside face of the steel studs to create a `warm frame' construction.

Where the condensation risk has been assessed and shown to be negligible, additional insulation may be placed between the studs. The additional insulation should be placed in contact with the studs to minimise air gaps and prevent local condensation.

The following are acceptable:

- Mineral wool to BS EN 13162
- FR (flame retardant) grade expanded polystyrene to BS EN 13163
- FR (flame retardant) grade extruded polystyrene to BS EN 13164
- Rigid polyurethane foam and polyisocyanurate to BS EN 13166
- Cellular glass to BS EN 13167

7.2.7 Breather membranes

Breather membranes should be capable of allowing water vapour from within the frame to pass out into the cavity and protect the sheathing and frame from external moisture. These should be:

- Vapour-resistant to less than 0.6MNs/g when calculated from the results of tests carried out in accordance with BS 3177 at 25°C, and with a relative humidity of 75%.
- Capable of resisting water penetration.
- Self-extinguishing.
- Durable.
- Adequately strong when wet to resist site damage.
- Type 1 to BS 4016 in areas of very severe exposure to wind-driven rain.

If foil faced insulation is not used, then an independent breather membrane should be provided to the 'cold side' of the insulation.

7.2.8 Vapour control layers (VCL)

VCL resist the passage of water vapour from within the dwelling and should be a minimum of 500-gauge polyethylene sheet or vapour control plasterboard. The vapour resistance (not resistivity) of the vapour control material should not be less than 250 MN.s/g or 0.25 Pa/m^2.

Installation

A sheet membrane Vapour Control Layer (VCL) should be:

- lapped and sealed by at least 100mm at joints.
- lapped over studs, rails or noggins.
- sealed around service penetrations.
- lapped and sealed fully into window and door reveals.
- lapped and sealed with DPM/DPC at the junction with the ground floor/foundation.
- able to accommodate differential movements.

Small holes in the VCL should be sealed with a suitable self-adhesive tape. Larger holes should be re-covered with new laps located over adjacent studs and rails.

7.2.9 Plasterboard

Plasterboard should be to BS 1230 and not less than:

- 9.5mm for stud spacing up to 450mm or
- 12.5mm for stud spacing up to 600mm

To provide fire resistance, fire rated boards should be used and installed in accordance with the manufacturer's instructions.

7.2.10 Masonry cladding

- Cavity trays must be provided above all cavity barriers, windows and door openings, etc.
- Cavity trays should extend 150mm either side of the door or window openings and have stopped-ends.
- A continuous cavity tray should be provided where intermediate floors meet the external wall.
- External skin of brickwork should be attached to the metal frame with either epoxy coated galvanised ties or austenitic stainless steel ties (to DD 140, BS 1243, BS 5268, BS 8200).
- Ties are normally fixed in vertical channels. These channels are then fixed directly to sheathing boards or attached through insulation boards with stand-off screws (screws should be isolated from the channels with neoprene or similar washers).
- Ties should be spaced at jambs of openings, a maximum of 300mm vertically within 225mm of the masonry reveal.

Additional studs may be needed to achieve this:

- Ties should be inclined away from the frame.
- Ties should be fixed to the studs, not the sheathing.
- Ties should accommodate differential movement between the frame and the cladding.

- Soft joints should be provided to allow for differential movement. A gap of 1mm per metre of masonry should be provided at openings and soffits.
- All brick support angles should be installed by the manufacturer or Specialist Contractor.

7.2.11 Claddings

More traditional claddings can include, amongst others, timber boarding, plywood and tile hanging. These types of cladding should be fixed to battens and suitably attached at stud positions. For further details, refer to the timber frame section of this Manual and the manufacturer's recommendations.

Render on metal lath combined with a breather membrane should also be fixed to battens attached to studs.

Breather membranes should be provided in areas of severe exposure or worse.

Other claddings should only be used if they are provided with an acceptable third-party accreditation certificate.

FUNCTIONAL REQUIREMENTS

7.3 TIMBER FRAME

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product. Timber frame elements should be appropriately covered to keep components dry.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance, supported by structural calculations provided by a suitably qualified expert.
ii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
iii. Any off-site manufactured engineered beams/posts must have structural calculations endorsed by the manufacturer.

7.3.1 Specifications

7.3.1.1 Introduction

This Chapter refers to 'conventional' timber frame 'open panel' systems made 'off-site' under factory conditions. Such panel systems are required to be designed, manufactured and erected on-site under quality assured systems and be either Structural timber Association or TRADA BM registered.

Timber frame external walls are generally considered to consist of load-bearing solid timber studs at regular centres with insulation between them, lined with a structural sheathing board, breather membrane, drained cavity and cladding. A Vapour Control Layer (VCL) and fire-resistant linings are provided to the internal finishes. For guidance on other forms of timber construction, e.g. SIPs, I section studs, Glulam, etc., please refer to Chapter 3 – Modern Methods of Construction, in this Manual.

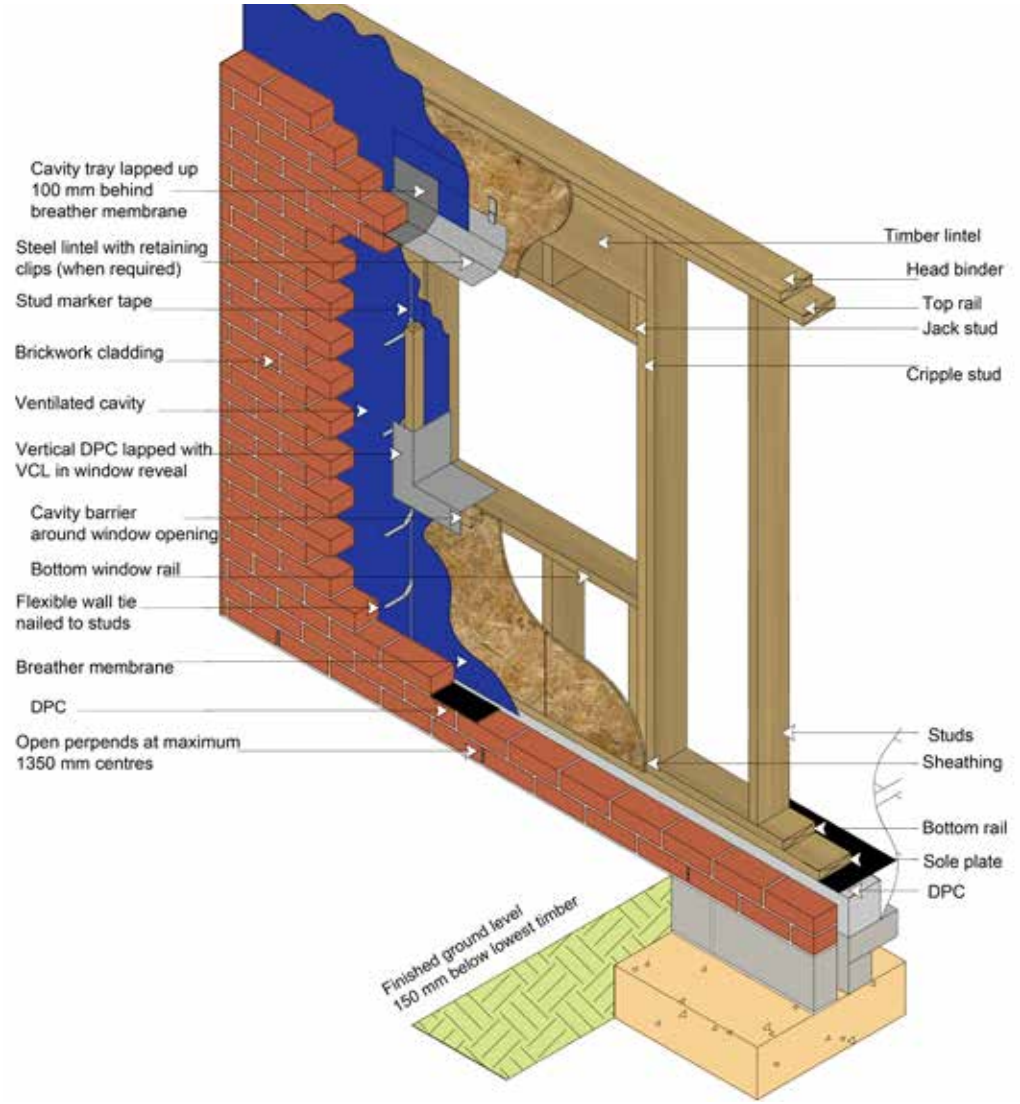


Figure 1: Typical timber frame external wall

7.3.1.2 General specifications

Note: Bespoke timber frame open panel systems that do not have such QA procedures as the 'conventional' timber frame open panel systems described in Chapter 7.3.1.1 will need either third-party accreditation or independent Structural Engineer supervision and monitoring of the installation, erection and completion (sign off) of the system. All load-bearing timbers will have to be treated in accordance with BS 8417 and according to their position within the frame, and evidence of the treatment carried out will be asked for.

Green Oak is not acceptable for use in external wall (and gables) constructions where it is exposed to the elements. Where not exposed (i.e. a continuous weather proof cladding protects the frame), the structural engineer must provide suitable details of the anticipated movement/ shrinkage that will occur over the Warranty period, and how the external cladding will accommodate that movement without putting the weather proof cladding at risk of allowing water penetration to occur.

Structurally Insulated Panels (SIPs) are a form of composite panel. Only systems with independent third-party approval will meet the requirements of the Technical Manual; please refer to Chapter 3.

7.3.1.3 Structural design

Wind, roof and floor loads should be considered in the design. All timber frame structures shall be designed in accordance with Eurocode 5. Structures designed in accordance with BS 5268 may still be acceptable, although these standards have now been superseded by Eurocode 5. When published, PD 6693: Complementary information for use with Eurocode 5 (currently in draft with BSI) will reference complementary, non-contradictory information found in BS 5268.

Quality assurance

All Timber Frame Designers, Manufacturers and Erectors should possess current certification from at least one of the following quality assurance schemes:

- BM TRADA QMark for timber frame
- ISO 9001
- CE Marking

7.3.1.4 Timber specifications

Grading of structural timber

All structural timber, whether machine or visually graded, shall be graded in accordance with BS EN 14081: Timber structures – Strength graded structural timber with rectangular cross section.

All load-bearing solid timber studs, rails, binders and sole plates should be of a minimum dry graded C16.



Figure 2: Typical grading stamp

Sizing of structural timber

Timber studs and rails shall be a minimum of 37mm in width.

Treatment of structural timber

All load-bearing timber components shall be either naturally durable or treated in accordance with BS 8417: Preservation of wood. Code of Practice. Sole plates and load-bearing timber studwork are considered to be in 'Use Class 2'. Sole plates are normally considered to be included in 'Service Factor Code C', while load-bearing timber studwork is included in 'Service Factor Code B'.

All structural timber should be treated with a preservative suitable for the 'Use Class' and 'Service Factor' applicable to its use.

Where treated timber is cut, the exposed end will not be protected by the original preservative treatment. When treated, timbers are cut in the factory or on-site; the cut ends shall be pre-treated with a preservative compatible with the original treatment used.

Sole plates

Sole plates are the first structural timber component installed on-site. Its purpose is to set out the building, transfer loads to the foundations and provide a level base for erecting the wall panels. All structural timber should be located at least 150mm above finished external ground level, except for localised ramping (incorporating satisfactory drainage and ventilation detailing) around door openings.

Sole plates should be fixed to the foundations with shot fired nails. Proprietary sole plate fixings, anchors, brackets or straps may be used, subject to suitable third-party certification or as specified by a Structural Engineer.

Sheathing boards

Sheathing boards are fixed to the timber frame in order to provide racking resistance to the structure. Structural sheathing board materials may be any of the following:

- Orientated Strand Board (OSB)
- plywood
- Impregnated soft board
- Medium board
- Tempered hardboard
- Other board material with suitable third-party certification for primary racking resistance

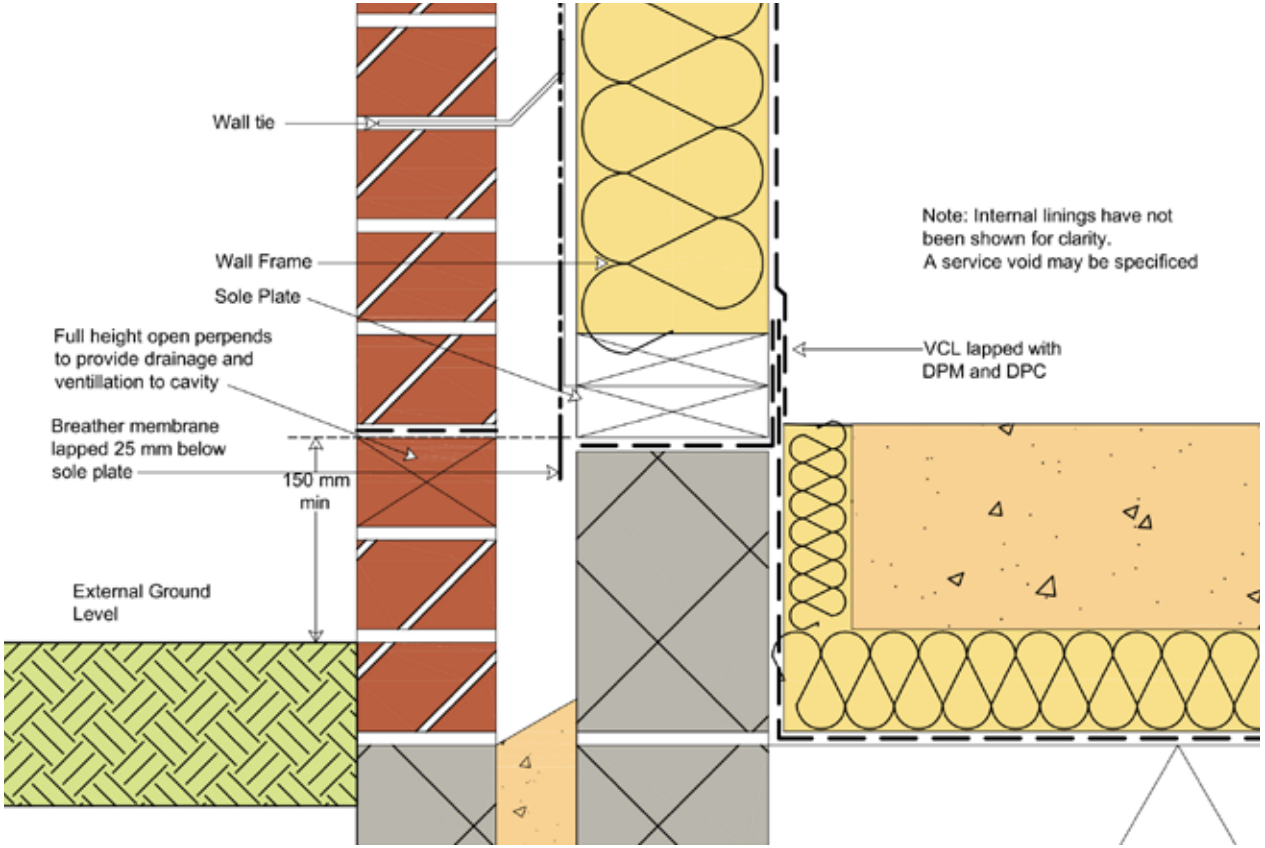


Figure 3: Sole plate/foundation junctions

All wood-based panel products should comply with BS EN 13986: Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking.

OSB should be grade 3 or 4 in accordance with BS EN 300: Oriented Strand Boards (OSB) –Definitions, classification and specifications.

Plywood should be Class 3 Structural in accordance with BS EN 636: Plywood Specifications.

Impregnated soft boards should be Type SB.HLS in accordance with BS EN 622-4: Fibreboards. Specifications. Requirements for soft boards.

Medium board should be type MBH.HLS1 or MBH. HLS2 in accordance with BS EN 622-3: Fibreboards. Specifications. Requirements for medium boards.

Tempered hardboards should be Type HB.HLA1 or HB.HLA2 in accordance with BS EN 622-2: Fibreboards. Specifications. Requirements for hardboards.

7.3.1.5 Other material specifications

Fixings
All sole plate fixings and holding down products should be austenitic stainless steel.

Timber components and structural sheathing boards may be fixed with:

- Nails
- Staples

Nail fixings should be:

- Austenitic stainless steel
- Galvanised
- Sheradised

Staple fixings should be austenitic stainless steel or similar.

Breather membrane
A breather membrane is a water-resistant, moisture vapour permeable membrane used to provide temporary weather protection during construction, and secondary protection from moisture once the building is complete.

The timber frame structure should always be protected by a breather membrane.

Breather membranes should be:

- A Type 1 membrane in accordance with BS 4016: Specifications for flexible building membranes (breather type).
- Self-extinguishing.
- Securely fixed to protect the outside face of the timber frame structure with austenitic stainless steel staples.

Cavity barriers
Cavity barriers are required to prevent the spread of smoke and flame within concealed spaces.

Cavity barriers may be constructed from:

- Steel at least 0.5mm thick
- Timber at least 38mm thick
- Polythene sleeved mineral wool
- Mineral wool slab
- Calcium silicate, cement-based or gypsum-based board at least 12mm thick
- An independently assessed and certified proprietary product

Insulation materials
Insulation materials should be chosen with consideration for their breathability and interaction with the timber frame.

Thermal insulation products typically used are:

- Mineral fibre (glass or rock)
- Wood fibre/wool
- Blown cellulose

Other insulation materials may be used, subject to relevant third-party certification.

Insulation may be specified in any or all of the following locations:

- Between the load-bearing studs
- On the outside of the timber frame
- On the inside of the timber frame

Insulation installed to the outside of the timber frame structure should have third-party certification for this application and retain a clear cavity dimension, as detailed in Table 1 in Chapter 7.3.4.

External walls should be subject to U-Value and condensation risk calculations. A wall build up will be considered satisfactory if there is no calculated risk of surface or interstitial condensation at any time of the year, and it fulfils the minimum National Requirement for thermal performance.

Special consideration should be given to condensation risk where non-breathable insulation products are installed on the outside of the timber frame structure.

Vapour Control Layer (VCL)
A VCL is a moisture vapour-resistant material located on or near the warm side of the thermal insulation.

Its purpose is to:

- Restrict the passage of moisture vapour through the structure of the wall
- Mitigate the risk of interstitial condensation

The VCL should have a minimum vapour resistance of 250 MN.s/g or 0.25 Pa/m^2. It is also typically used as an air tightness layer.

The VCL may take the form of:

- A vapour control plasterboard comprising a metallised polyester film bonded to the back face of the plasterboard.
- A minimum 125 micron thick (500 gauge) polythene sheet.
- A third-party approved proprietary vapour control membrane product.

Subject to a favourable condensation risk analysis, a novel or reverse wall construction may not require the use of a high moisture vapour-resistant vapour control membrane.

Wall linings
The internal lining of the timber frame wall may be required to perform four functions:

- Provide the finish or a substrate to accept the finish on the inner face of the wall.
- Contribute to the racking resistance of the wall.
- Contribute to the fire resistance of the wall.
- Contribute to the acoustic performance of the wall.

Wall linings are typically:

- Gypsum plasterboard
- Cement bonded particle board

Other lining materials may be used subject to the material satisfying any relevant performance criteria, e.g. fire resistance, and possessing relevant third-party certification.

Masonry supporting timber frame, foundations, kerb upstands, etc.
Foundations and masonry supporting timber frame structures should be in accordance with the relevant Technical Manual Chapter, as indicated below:

- Chapter 2 – Materials
- Chapter 4 – Site Investigation
- Chapter 5 – Foundations
- Chapter 6 – Substructure
- Chapter 7 – Superstructure

Claddings
Timber frame external walls should be finished externally with a cladding system, which may take the form of masonry or a lightweight rain screen system. Regardless of the cladding system used, a cavity with provision for drainage and ventilation should be provided between the cladding and the timber frame.

Wall ties

External wall ties and fixings between the timber frame and masonry cladding shall:

- Comply with BS EN 845: Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets.
- Be constructed from austenitic stainless steel
- Accommodate all anticipated differential movement.
- Be of adequate length and masonry bond to provide a clear cavity of at least 50mm.

7.3.2 Manufacture

7.3.2.1 Timber

All structural timber components should be specified in accordance with the requirements of Chapter 7.3.1.

Timber frame external wall panels shall:

- Be manufactured in accordance with the Structural Engineer's design.
- Consist of solid timber studs and rails.
- Have studs at a maximum of 600mm centres.
- Be braced with a structural sheathing board.

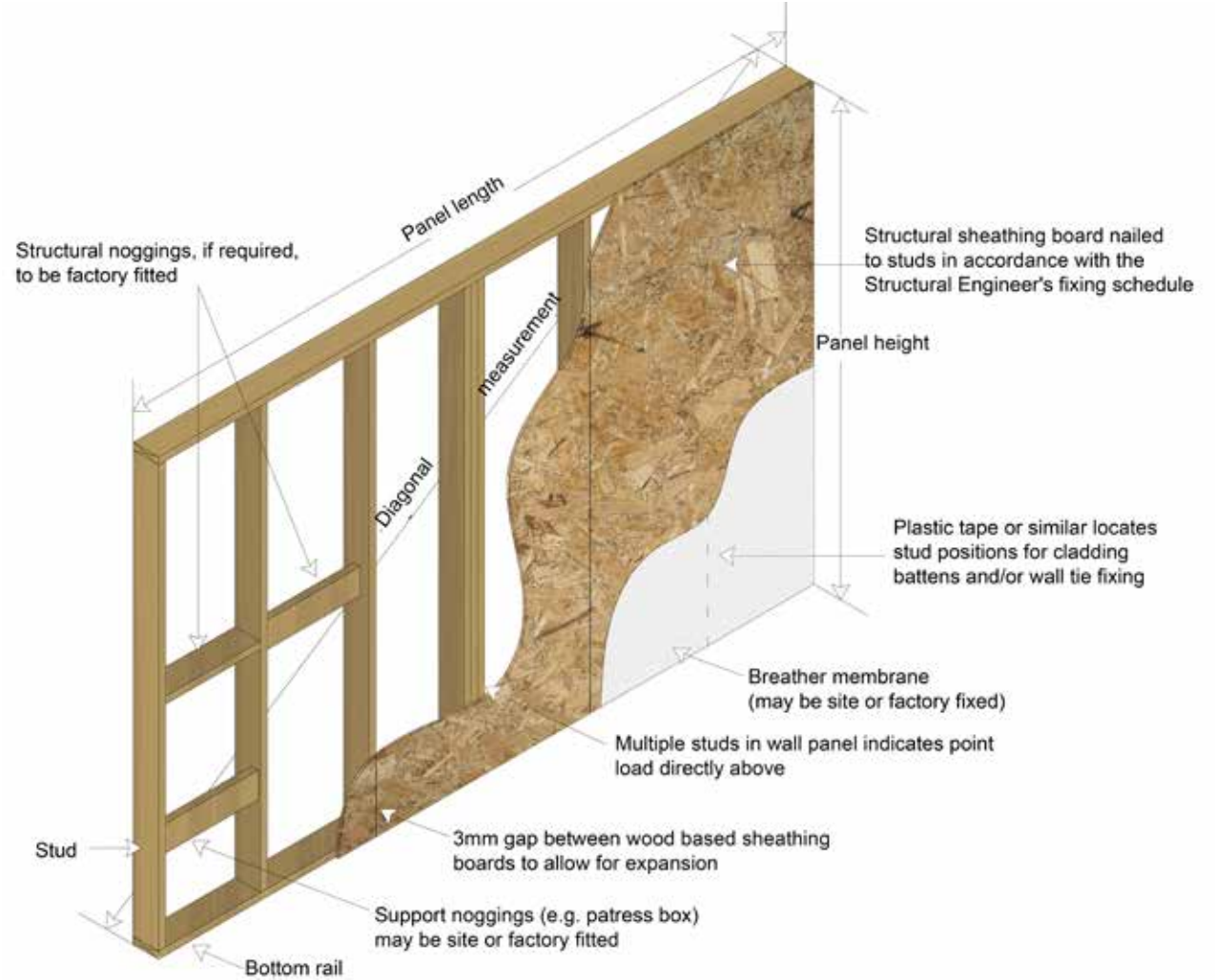


Figure 4: Typical wall panel

7.3.2.2 Panel moisture content

All structural timber components should be at a moisture content of 20% or less at the time of manufacture. Once panels are manufactured, they should either be stored in a covered storage area, or loosely covered with a waterproof sheet material, as shown in Figure 6.

7.3.2.3 Manufacturing tolerances

Based on the tolerances given in prEN 14732, wall panels shall be manufactured to the following tolerances:

- Length: +0mm, -5mm
- Height: +/-3mm, diagonals should be equal, acceptable deviation is +/-5mm
- Opening dimensions: +/-3mm

7.3.2.4 Sheathing

The fixings securing the structural sheathing board to the timber studwork wall panels provide racking resistance as calculated by the Structural Engineer.

The sheathing board shall be fixed to the timber studwork in strict accordance with the Structural Engineer's fixing schedule. Fixing centres should not exceed 150mm around the perimeter of the board and 300mm centres in the field of the board.

Sheathing fixings must not be over-driven through the face of the sheathing board.

Wood-based board materials used for sheathing should be fixed to the studwork frame leaving a 3mm minimum gap between boards to allow for moisture-related movement.

7.3.2.5 Studs

Any point load imparted onto the timber frame should be transferred down through the building to the foundations with the use of multiple studs. If these are not installed during the manufacture of the panels, the requirement for installation must be clearly conveyed to site.

Wall panels should be designed to minimise thermal bridging. Gaps between studs within the wall panel and at wall panel junctions should be large enough to allow the installation of insulation.

7.3.2.6 Openings

All openings, including doors, windows, flues and ventilation ducts, should be designed and constructed to maintain structural performance:

- A lintel may be required where openings do not fall between studs, unless vertical load is adequately transferred by other elements.
- Lintels will require support by cripple studs.
- Studs should be provided around window and door openings, and adjacent to movement joints, to allow the installation of wall ties or other cladding fixings.

7.3.2.7 Breather membrane

Breather membranes should be lapped by a minimum of 100mm at horizontal joints, and a minimum of 150mm at vertical joints. If breather membranes are trimmed flush with the edges of wall panels, additional strips of breather membrane, at least 300mm wide, should be supplied and site fixed over panel junctions.

The location of solid timber studs should be clearly marked on the outer face of the breather membrane to ensure that cladding fixings are installed into solid timber.

7.3.2.8 Closed panel construction

If wall panels are to be of closed panel construction, the guidance in Chapter 7.3.4 applies equally to manufacture. For the purposes of this Manual, closed panels are classified as open panels with at least insulation installed in the factory.

Special precautions must be taken to protect closed panels from moisture during storage, transportation and erection on-site.

7.3.3 Site preparation and erection

7.3.3.1 Pre-commencement

To allow the building to be constructed as designed, all necessary drawings, specifications and fixing schedules shall be provided to site before work commences.

Foundations

It is important that the tight tolerances for timber frame are understood. Getting the location and level of the foundation correct is one of the most important parts of the build process.

The foundations or upstands that support the timber frame should be set out to the dimensions noted on the timber frame drawings:

- Within +/-10mm in length, width and line
- Diagonals should be within +/-5mm up to 10m, and +/-10mm more than 10m
- Levelled to +/-5mm from datum

If ground conditions require gas membranes, they should be located so as not to inhibit drainage and ventilation to all areas of the timber frame structure.

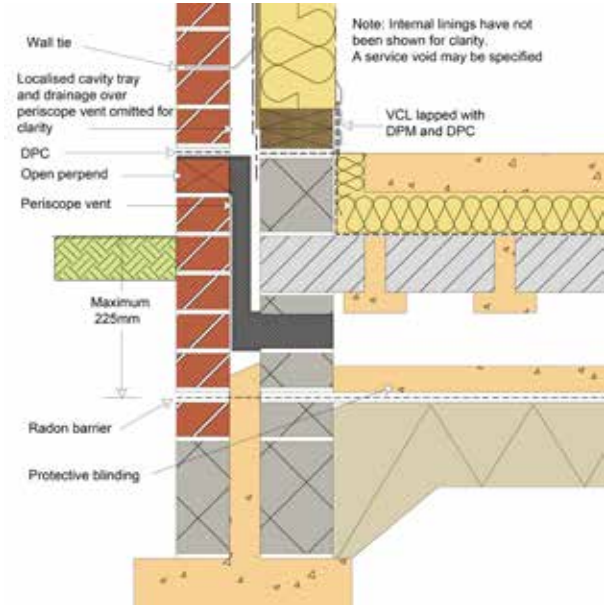


Figure 5: Possible gas membrane detail

Timber frame delivery and storage

Timber frame components should be:

- Carefully unloaded to avoid damage or distortion of components.
- Stored off the ground on an adequate number of level bearers.
- Loosely covered with a waterproof membrane to allow protection from moisture while allowing ventilation if they are not to be used for a prolonged period.
- Unwrapped if tightly bound in polythene and loosely recovered with a waterproof membrane to allow ventilation.
- Below 20% moisture content.
- Confirmed as square by sample checking for equal diagonal measurements, lengths and heights.

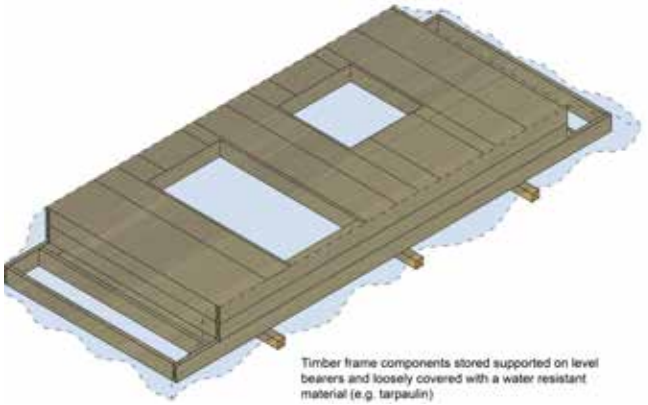


Figure 6: Storage of wall panels

7.3.3.2 Timber frame erection

Sole plates

The sole plate should be accurately levelled, located and securely fixed to the substructure as specified by the Structural Engineer. Where no sole plate is specified, the following guidance applies equally to wall panel bottom rails. Timber sole plates should be treated in accordance with Chapter 7.3.1.3 – Timber Specifications, Treatment of Structural Timber.

Location

Sole plates should:

- Be located so that all structural timber is at least 150mm above external ground level (except for localised ramping at door openings). The use of a foundation kerb upstand may be an appropriate method to achieve this.
- Be levelled to +/-5mm from datum.
- Not overhang or be set back from the foundation edge by more than 10mm.
- Be set out within +/-10mm in length and in line within +/-5mm, as defined by the timber frame drawings.
- Diagonals should be within +/-5mm up to 10m, and +/-10mm for more than 10m.

Damp Proof Course (DPC)

A DPC should:

- Be located directly below all timber sole plates bearing on other materials that may transfer moisture.
- Overlap at DPC junctions by at least 100mm.
- Be located flush to the outside edge of the sole plate.

Packing

Structural shims or grout may be required under sole plates to level them and transfer vertical load. Longer sole plate to foundation fixings may be needed to allow for the size of the gap.

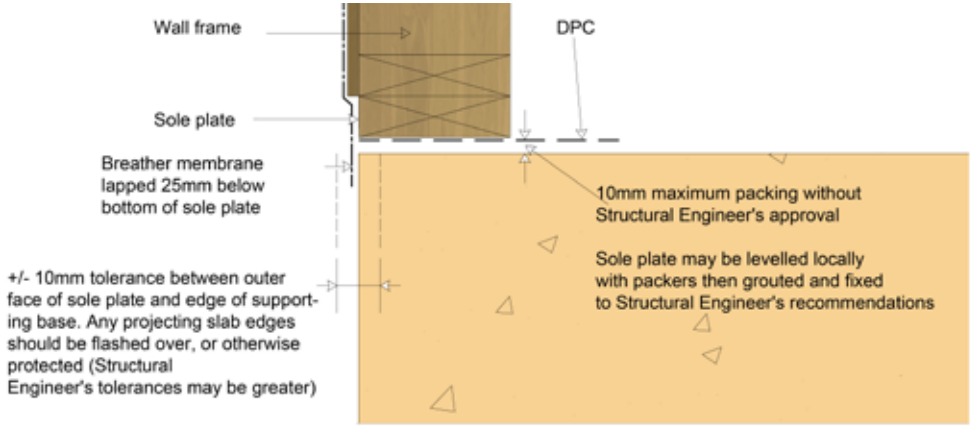


Figure 7: Locating sole plates

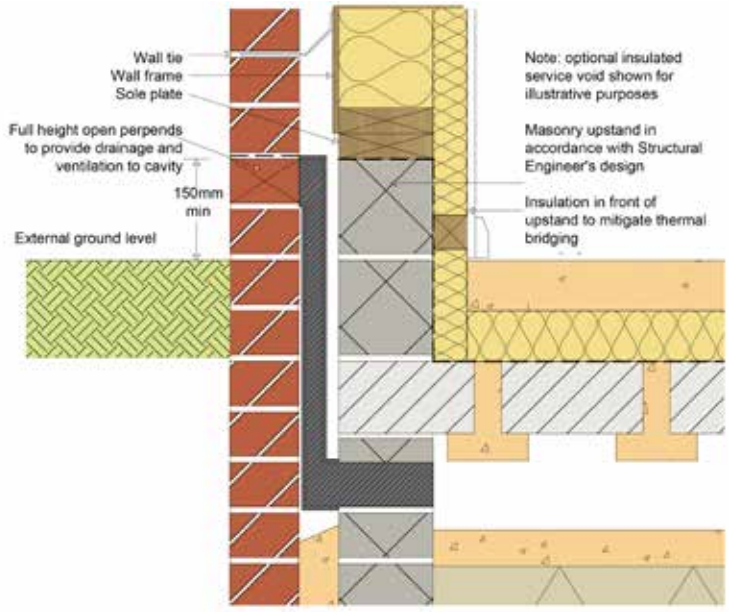


Figure 8: Kerb upstand detail to allow level threshold

Structural shims should:

- Be non-compressible and inert.
- Be located under every stud.
- Provide an equal cross sectional area to the studs they support.
- Be located under sole plates to provide full width bearing to studs.
- Provide full bearing under point loads.
- Not exceed a total of 10mm in height without a Structural Engineer's approval.

Structural grout should be:

- Considered for use by a Structural Engineer for gaps exceeding 10mm.
- Non-shrinkable.
- Full bearing under sole plates.
- Packed under the DPC.

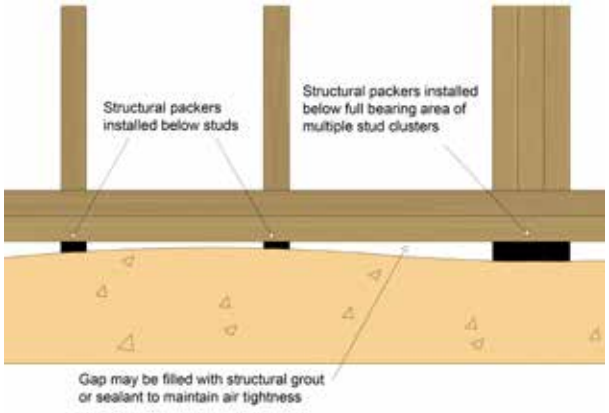


Figure 9: Packing of sole plates

Note: The use of structural grout is not considered suitable for gaps less than 10mm due to installation difficulties.

Fixings

Fixings should:

- Be installed to the Structural Engineer's specification.
- Not damage the substructure or sole plates during installation.
- Be placed to provide adequate lateral restraint at door openings.
- Be specified with consideration for use with gas membranes where appropriate.

Wall panel erection tolerances

Wall panels should be erected to the following tolerances:

- +/-10mm from plumb per storey height.
- +/-10mm from plumb over the full height of the building.
- +/-3mm from line of sole plate, with maximum +/-5mm deviation from drawing.
- +/-5mm from line at mid height of wall panel.
- Inside faces of adjacent wall panels should be flush.
- Adjacent wall panels should be tightly butted.

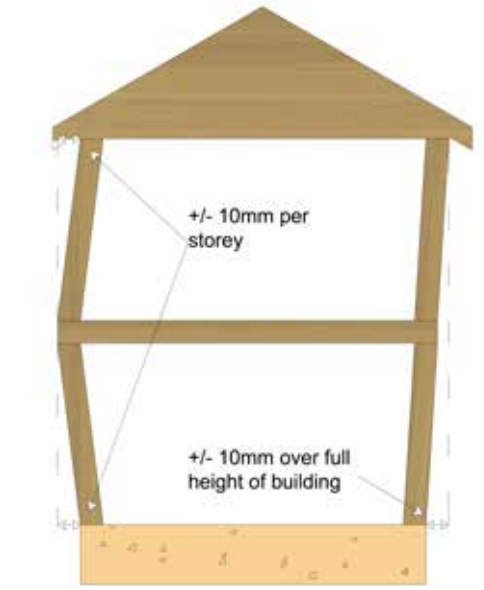


Figure 10: Wall panel erection tolerances

Fixings and junctions

All fixings are to be installed to the Structural Engineer's specification.

Unless otherwise justified:

- Junctions of wall panels and sole plates/head binders should not occur together.
- Head binder laps should wherever possible occur over a stud, preferably at least 600mm from the panel junction.

- Wall panel to wall panel connections should be a maximum of 300mm centres.
- Bottom rail to sole plate fixings should be one or two per stud bay.
- Wall panels should be adequately braced during erection to maintain tolerances.
- Disproportionate collapse fitting and fixings must be installed if specified.
- Multiple stud clusters must be installed to the full width of point load bearings.
- Point loads must be transferred down through wall panels and floor zones to foundations.
- Closed panel walls manufactured off-site must be fixed together as specified.
- Closed panel walls should not be exposed for longer than necessary to avoid moisture ingress.
- Engineered timber components should not be exposed to moisture for longer periods than those stated by the manufacturer.
- Roof trusses/rafters should be adequately fixed to wall panels.
- Floor joists should be nailed down to wall panels.
- If no head binder is present, floor joists must bear directly over studs.
- Waistbands and alignment of floors over walls should remain within tolerances for wall panels.

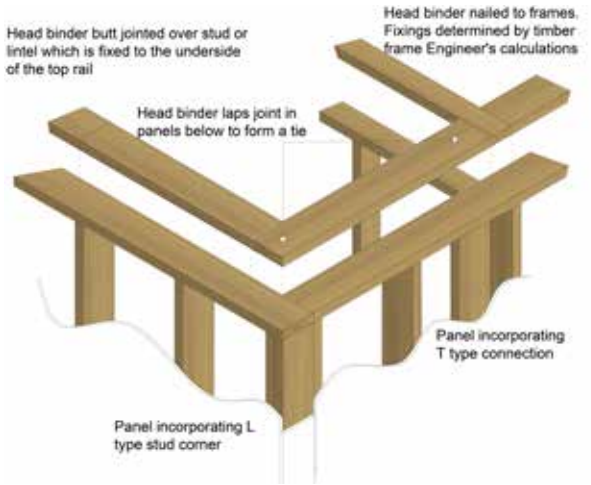


Figure 11: Head binder lapping

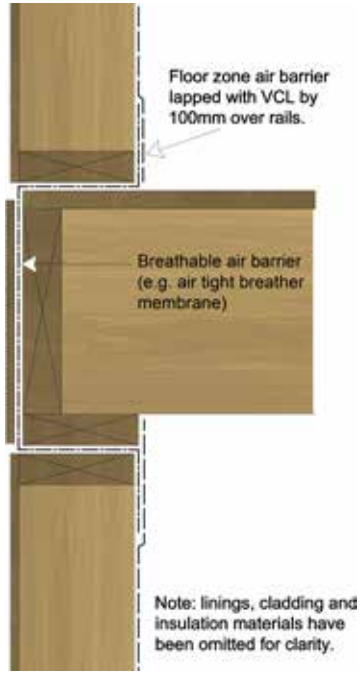


Figure 12: Typical floor zone air tightness detail

Air leakage

Detailing and installation instructions must be followed to achieve adequate air tightness.

Breather membrane

Breather membrane should be:

- Lapped to deflect moisture away from the timber frame structure.
- Lapped by a minimum of 100mm at horizontal joints and a minimum of 150mm at vertical joints.
- Trimmed to leave a 25mm lap below the lowest timber sole plate.
- Repaired if damaged.

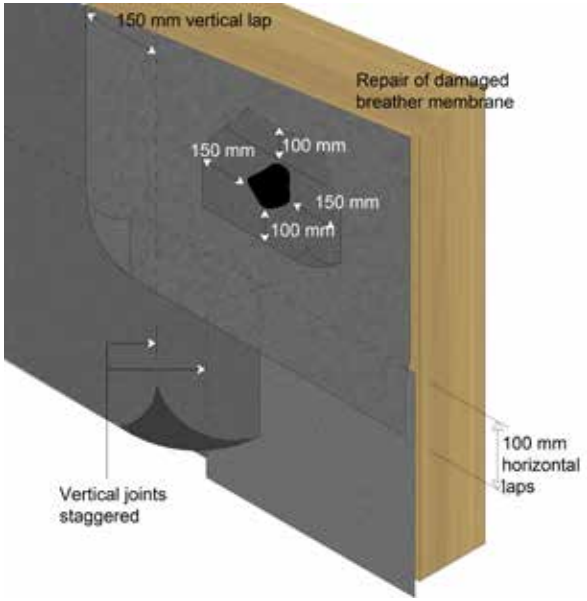


Figure 13: Lapping and repair of breather membrane

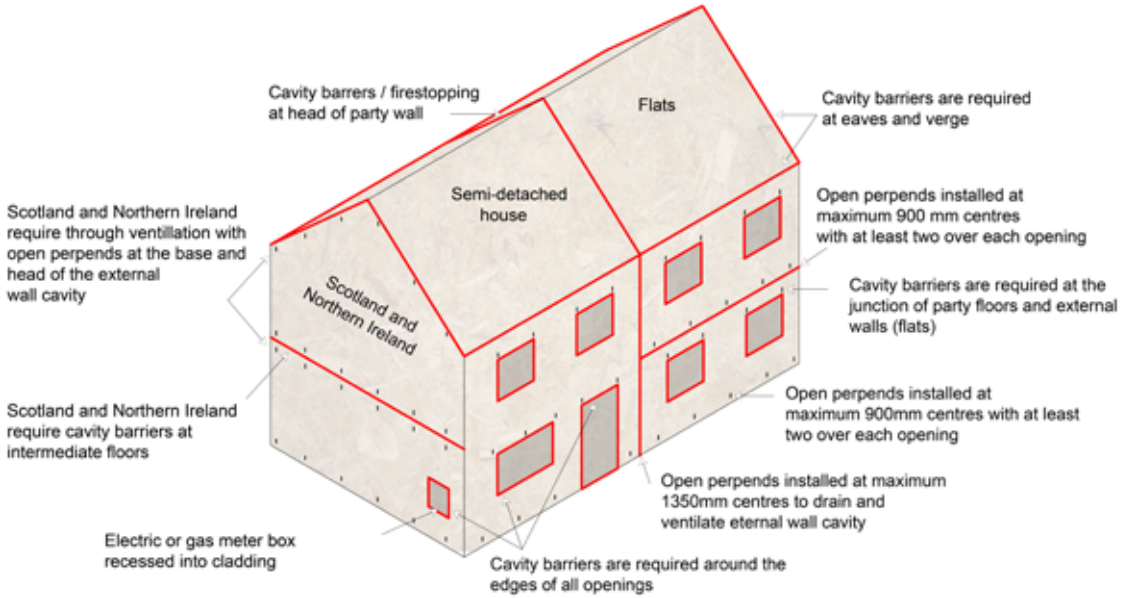


Figure 14: Locations of cavity barriers and open perpends

7.3.3.3 Cavity barriers

Location

In England and Wales, cavity barriers shall be installed:

- At the edges of all cavities, including around openings, e.g. windows, doors.
- Between an external cavity wall and a compartment wall or compartment floor.
- Around meter boxes in external walls.
- Around service penetrations in external walls, e.g. extract or boiler flue.
- To sub-divide extensive cavities; please refer to national regulations for specific requirements.

Note: Cavity barriers may also be required between walls and floors within the building. Consult National Regulations for further guidance.

Installation

Cavity barriers shall be installed:

- So they fully close the cavity.
- So the ends are tightly butted to form a continuous barrier.
- Backed by solid timber studs, rails or floor joist at least 38mm wide.
- In accordance with manufacturer or independent certifier's guidance.

A cavity tray should be proved directly above a horizontal cavity barrier, lapped at least 100mm behind the breather membrane (except at eaves and verges).

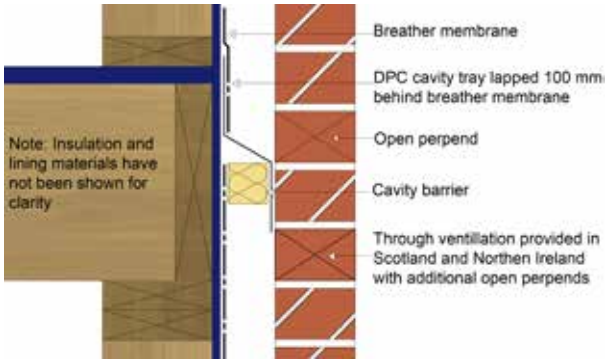


Figure 15: Cavity tray above horizontal cavity barrier

Timber cavity barriers should be protected from masonry cladding by the use of a DPC. The cavity face of the cavity barrier should be left uncovered to allow drainage and ventilation of the timber. The use of timber cavity barriers around openings allows for effective sealing to be installed between them and the opening frame.

7.3.4 Main contractor

7.3.4.1 Insulation

If insulation is specified between external walls studs, all voids shall be filled with insulation to maintain the thermal envelope of the building. When noggings or boards are installed between studs to support services or heavy fittings, the void behind them shall be fully insulated.

Insulation should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight, as wet insulation can retain moisture. If closed panel timber frame is specified, additional care must be taken to protect the panels from exposure to moisture during construction.

If external wall insulation is to be used:

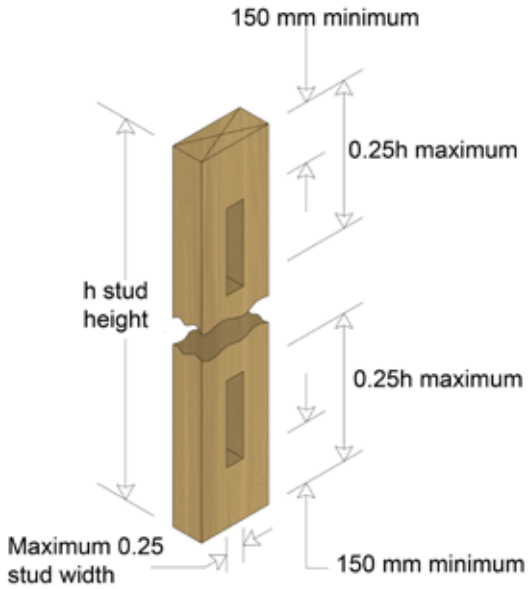
- Insulation should be installed in a manner to maintain its stated performance by minimising gaps that lead to thermal bridging and air washing.
- Installation should not allow external wall cavity moisture to become trapped between it and the timber frame.
- Cavity trays should be fixed and lapped to deflect cavity moisture away from the timber frame.
- Allowance should be made for differential movement to occur at floor zones.
- Cavity barriers should be tightly fitting and remain effective in a fire.
- It should not retain or transmit moisture to cause the timber structure to exceed 20% moisture content.
- Its stated thermal performance should not be affected by cavity moisture. A breather membrane installed over the insulation may be required to assist in this.
- A method of installing wall ties through the insulation directly into the studs should be used.

7.3.4.2 Services

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Electrical services are to be rated for their location with consideration for insulation.
- Wet services are not to be installed on the cold side of the insulation.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face of stud.

- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.



Drilling on centre line only. Hole diameters not greater than 0.25 stud width and hole centres not closer than 4d (d = hole diameter)

Figure 16: Drilling of studs

7.3.4.3 Vapour Control Layer (VCL)

A VCL should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight.

Installation

A sheet membrane (polythene or proprietary) VCL should be:

- Securely fixed to and cover all areas of the timber frame external walls, including all sole plates, head binders and window/door reveals.
- Lapped and sealed by at least 100mm at joints.
- Lapped and sealed over studs, rails or noggings.
- Sealed around service penetrations.
- Lapped and sealed fully into window and door reveals.
- Lapped and sealed with DPM/DPC at the junction with the ground floor/foundation by a minimum of 100mm.

Note: Small holes in the VCL should be sealed with a suitable self-adhesive tape. If a proprietary membrane is being used, the manufacturer's proprietary sealing tape should be used. Larger holes should be re-covered to lap over adjacent studs and rails.

Vapour control plasterboard should be:

- Fixed in accordance with the plasterboard manufacturer's installation guidance.
- Tightly cut and fitted around service penetrations.
- Discarded if the vapour control backing is damaged.

7.3.4.4 Plasterboard

Installation

In order to provide the specified period of fire resistance, the plasterboard must:

- Protect all areas of the timber frame structure
- Have all edges supported by timber studs or rails.
- Be fixed in accordance with the plasterboard manufacturer's guidance.
- Be cut and tightly fit around service penetrations.
- Have junctions of wall and ceiling linings detailed to maintain continuity.
- Be installed using the specified number of layers to achieve the required fire resistance.
- Have all joints staggered when installing multiple layers.

Fixing of plasterboard
When installing plasterboard linings:

- Each layer must be fully and independently fixed.
- Fixings of the correct length and centres should be installed in accordance with the plasterboard manufacturer's installation instructions.
- Walls requiring plasterboard to provide racking resistance should be clearly identified with plasterboard installed to the Structural Engineer's specification or the plasterboard manufacturer's specification, whichever is more onerous.

7.3.4.5 Openings

All openings, including doors, windows, flues and ventilation ducts, should be designed and constructed to maintain:

Fire performance

- Internal reveals require equal fire resistance to the rest of the structure.
- Window fixing straps should not compromise the integrity of any fire-resistant reveal linings.
- Cavity barriers should be installed in the external wall cavity around the perimeter of openings.
- If profiled steel lintels are used as cavity barriers, triangular gaps behind lintels, which occur at each end, should be closed with careful positioning of adjacent cavity barriers.

Acoustic performance

- Seal gaps between timber frame wall and the element being installed into the opening
- The element being installed into the opening may have a minimum acoustic requirement

Weather tightness and thermal performance, including thermal bridging and air tightness:

- The element being installed into the opening is likely to have a minimum thermal performance.
- Seal gaps between the timber frame wall and the element being installed into the opening to provide thermal performance, weather tightness and air tightness.
- Cavity trays should be installed over the heads of all openings, lapped behind the breather membrane by a minimum of 100mm. A flashing may be acceptable for some types of claddings.
- Lap cavity barrier DPC with internal VCL around openings. Where no DPC is used, breather membrane should be lapped with internal VCL.

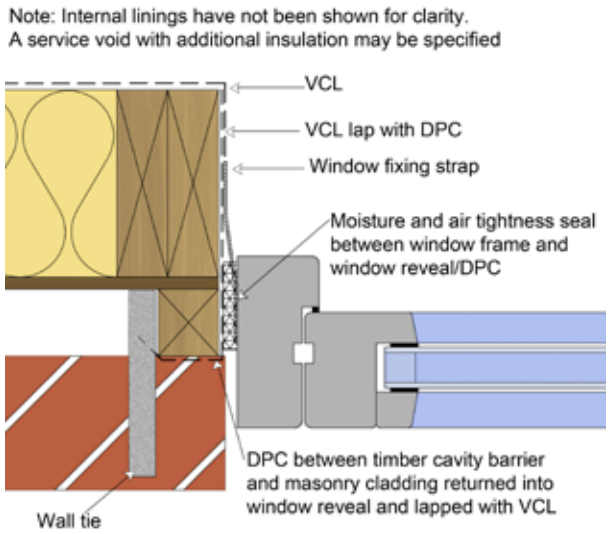


Figure 17: Window/wall junction (jamb)

7.3.4.6 Claddings

All external wall claddings should be separated from the timber frame structure by a drained and ventilated clear cavity. If partial fill cavity insulation is to be used, the same width of clear cavity is to be maintained in addition to the insulation depth.

In some locations, for example close to boundaries, National Regulations require claddings to provide fire resistance to the structure from the outside in. Cavity barriers must be provided to meet National Regulations.

Self-supporting claddings (masonry)
Self-supporting (masonry) claddings should be connected to the timber frame using wall ties:

- Installed into studs provided around openings and movement joints, not just through sheathing.
- Angled to drain moisture away from the timber frame, even after differential movement has occurred.
- Installed at a minimum density of 4.4/m2 (a maximum of 375mm vertically with studs at 600mm centres and a maximum of 525mm vertically where studs are at 400mm centres). In accordance with BS 5268-6, closer centres may be required in exposed locations.
- Installed at a maximum of 300mm centres vertically and 225mm horizontally around openings and movement joints.
- Installed within 225mm of the head of a wall.

Cavity drainage and ventilation in masonry cladding should:

- Be provided with the use of full height open perpends at a maximum of 1350mm centres or equivalent open area.
- Be fitted in the brick or block course below the lowest timber sole plate, above external finished ground level and below DPC.
- Be provided to ensure drainage and ventilation to each external wall concealed space, directly above horizontal cavity barriers/trays.
- Be installed over openings in the external wall cavity, e.g. windows and doors, at a maximum of 900mm centres.
- Maintain a clear cavity, with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction, and open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered.

In areas of severe or very severe exposure, check reveals should be constructed to provide additional weather protection.

Vertical loadings from masonry claddings must not be supported by the timber frame structure.

Claddings supported on the timber frame
Claddings supported on the timber frame should be connected to it on vertical treated timber battens, or a carrier system, to form a drained and ventilated cavity to all areas of the external timber frame wall. These should be fixed into structural timber, not just through the sheathing, to the Structural Engineer's specification.

Cavity drainage and ventilation should provide an open area of not less than 500mm^2 per metre run:

- At the base of the external wall concealed space.
- Above horizontal cavity barriers/trays.
- Over openings in the external wall cavity, e.g. windows and doors.
- Allowing differential movement to occur while retaining an adequate gap.
- With openings protected by a mesh to prevent the passage of insects.

Timber frame external wall minimum cavity widths	
Masonry	50mm
Render on unbacked lath	50mm
Render on backed lath or board	25mm
Timber	19mm
Tile hanging	25mm

Table 1: Minimum cavity widths

7.3.5 Differential movement

Appropriate allowances must be made for differential movement to occur without causing damage to the building.

Differential vertical movement occurs as a result of compression, closing of gaps and shrinkage of the timber frame structure, and occurs during the first 24 months following completion. Shrinkage occurs across the grain and is due to a reduction in the

moisture content of timber elements. The shrinkage of plates, rails, binders, floor and roof joists should be considered. The building should be designed to ensure that differential movement occurs evenly to external elevations and the internal structure.

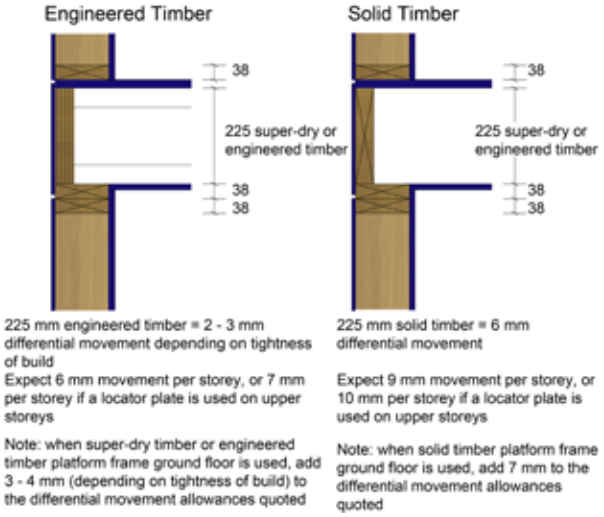


Figure 18: Differential movement at floor zones

Anticipated differential movement can be calculated using the allowance of 1mm for every 38mm of horizontal cross grain timber. As solid timber joists contribute significantly to anticipated differential movement, engineered timber joists should be considered where it is desirable to reduce differential movement.

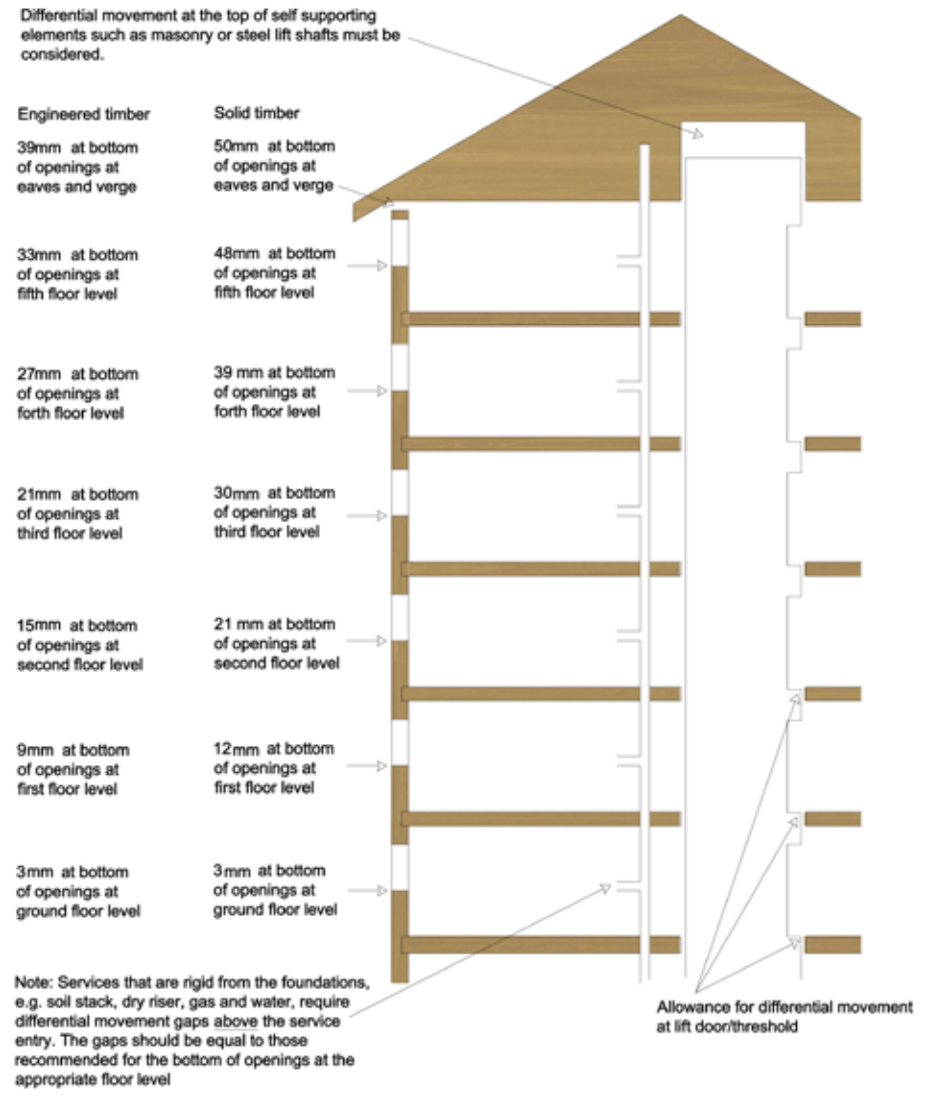


Figure 19: Anticipated differential movement dimensions

If fillers or seals are to be installed into differential movement gaps, their fully compressed dimension, considering the area of the seal and force required to compress it, must be added to the calculated gap size. Materials should be chosen to provide an effective weather tight seal dependant on whether they are to be subjected to compression, expansion or shear forces. Cover strips may also be used.

Self-supporting claddings (masonry)

Any material or component attached to the timber superstructure that overhangs the brick or blockwork (e.g. cladding attached to the timber frame, window sills, roof eaves and verges) or projects through the masonry (e.g. balcony supports, flues, extractor fan vents or overflow pipes) should have a clear gap beneath and at the top of the masonry cladding to allow differential movement to take place, thus avoiding damage to the component or cladding.

The size of the gap should be calculated by allowing 1mm for every 38mm of horizontal cross grain timber present between the gap location and the lowest structural timber. Gaps will therefore increase in size up the building. The dimensions provided in Figure 19 should be used if site-specific calculations have not been provided.

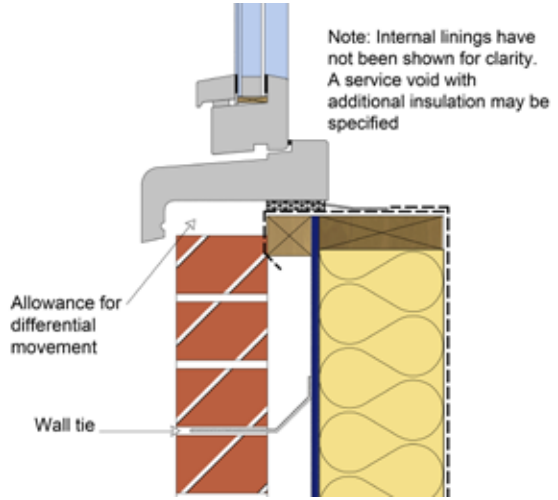


Figure 20: Differential movement gap under sill

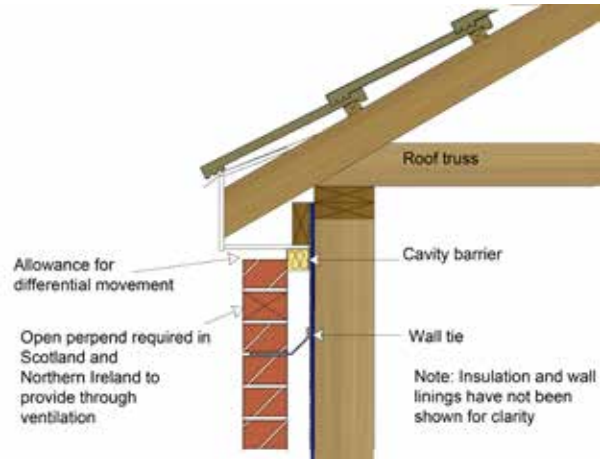


Figure 21: Differential movement at eaves

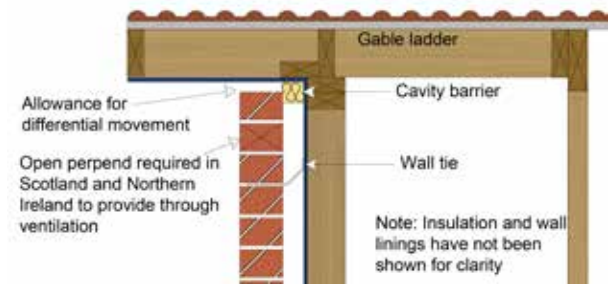


Figure 22: Differential movement at verge

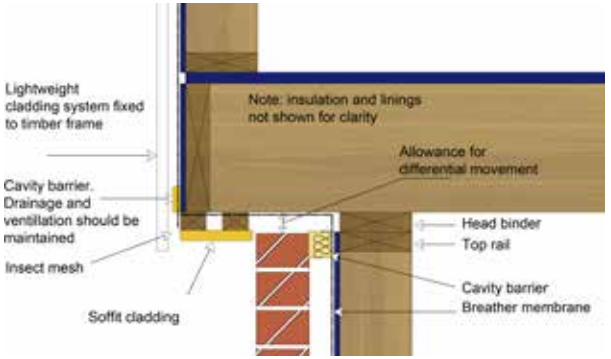


Figure 23: Differential movement at cantilevered overhang

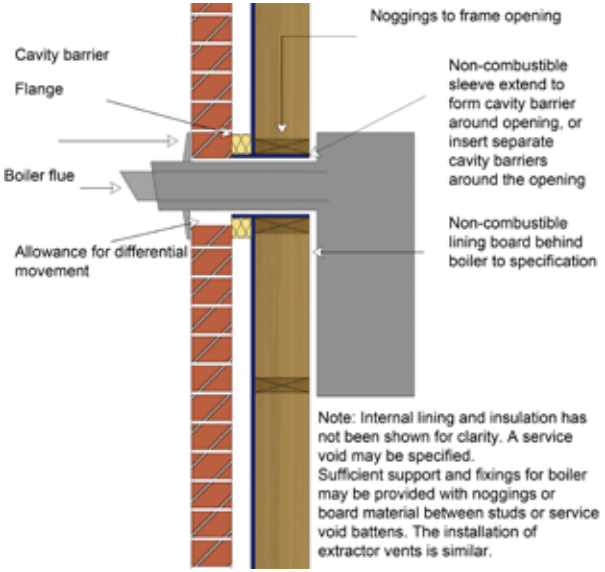


Figure 24: Differential movement at service penetration

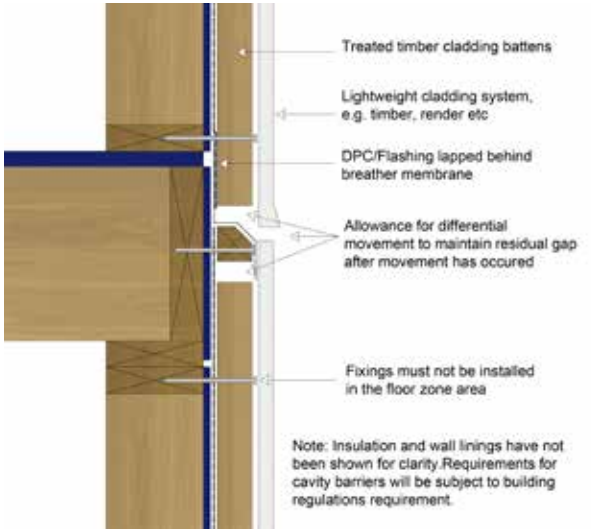


Figure 25: Differential movement at floor zone with cladding supported on timber frame

Masonry cladding should not be supported on the timber frame structure, but claddings do need to be supported.

Horizontal cross grain timber and construction gaps are concentrated at floor zones, and this is where the majority of movement occurs. Vertical timber battens or other rigid cladding support systems should not span over the floor zones of timber frame buildings. Gaps should be provided to accommodate anticipated differential movement. Unlike self-supporting claddings, movement is not cumulative but should be calculated individually for each floor zone using the formula above of 1mm for every 38mm of horizontal cross grain timber.

Gap sizes should allow for anticipated differential movement while allowing for drainage and ventilation requirements. Insect infestation should be avoided by using screens to cover gaps exceeding 4mm.

Services

Rigid services within the timber frame structure also require an equal allowance for differential movement, as shown in Figure 19. Examples include copper gas and water pipes, dry risers, internal downpipes, SVPs and blockwork lift shafts. While gap allowances externally are allowed below, for example, a sill, when a branch comes off a rigid stack internally, the gap needs to be left above a service to allow the timber frame to drop around it.

7.3.6 References

BS EN 1995-1-1: 2004+A1: 2008 Eurocode 5 Design of timber structures. General. Common rules and rules for buildings.

BS 5268-2: 2002 Structural use of timber. Code of Practice for permissible stress design, materials and workmanship.

BS 5268-3: 2006 Structural use of timber. Code of Practice for trussed rafter roofs.

BS 5268-4 Section 4.1: 1978 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.1 Recommendations for calculating fire resistance of timber members.

CHAPTER 7: SUPERSTRUCTURE

BS 5268-4 Section 4.2: 1990 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.2 Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions.

BS 5268-6.1: 1996 Structural use of timber. Code of Practice for timber frame walls. Dwellings not exceeding seven storeys.

BS 5268-6.2: 2001 Structural use of timber. Code of Practice for timber frame walls. Buildings other than dwellings not exceeding four storeys.

BS EN 14081-1: 2005 Timber structures. Strength graded structural timber with rectangular cross section. General requirements.

BS 8417: 2003 Preservation of timber. Recommendations.

BS EN 13986: 2006 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking.

BS EN 300: 2006 Oriented strand boards (OSB). Definitions, classification and specifications.

BS EN 636: 2003 Plywood. Specifications.

BS EN 622-4: 2009 Fibreboards – Specifications. Requirements for softboards.

BS EN 622-3: 2004 Fibreboards – Specifications. Requirements for medium boards.

BS EN 622-2: 2004 Fibreboards – Specifications. Requirements for hardboards.

BS 4016: 1997 Specification for flexible building membranes (breather type).

BS EN 845-1: 2003+A1: 2008 Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets.

EN 14732: 2011 Timber structures. Prefabricated wall, floor and roof elements. Requirements Draft for comment.

FUNCTIONAL REQUIREMENTS

7.4 WINDOWS AND DOORS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.4.1 Windows and doors

Timber used for external joinery should be a species classified as suitable in BS EN 942 and preservative treated; if not, use a moderately durable species or better (sapwood excluded). Guidance on selection is provided in TRADA Wood Information Sheets 3.10 and 4.16.

Workmanship should follow the recommendations of BS 1186: 2. Preservative-treated joinery cut or adjusted on-site should be brushed liberally with an appropriate and coloured preservative. Where the colour of the preservative will adversely affect the final appearance of the joinery, an appropriate clear preservative should be used.

Bay, oriel and dormer windows require particular care in detailing and fitting so that they are stable, weather tight and reasonably air tight.

Roof lights should be proprietary components, fixed within prepared openings in accordance with the manufacturer's instructions, and have effective weather sealing.

Non-timber components should comply with the following British Standards (as appropriate), and be installed and fixed in accordance with the manufacturer's recommendations:

- BS 4873 Aluminium windows
- BS 5286 Specification for aluminium framed sliding

Glass doors

- BS EN 514 PVC-U windows
- BS 7412 PVC-U windows
- BS 6510 Steel windows and doors

PVC-U windows and doors should also be subject to independent third-party certification.

Windows should comply with the current Building Regulations taking into consideration:

- Means of escape in the event of a fire
- Thermal insulation
- Ventilation
- Safety

7.4.2 Thresholds and sills

Thresholds and sills should be at least 150mm above ground level. Where the top of a threshold is more than 225mm above ground level, the following steps are necessary:

- Where level (threshold) access is required, builders can follow the general guidance given in Figures 1, 2 and 3, ensuring a high level of supervision and workmanship, together with the correct specification of materials and consideration to design, location and exposure.
- Wherever possible, locate the entrance door away from the prevailing weather and provide a storm porch.

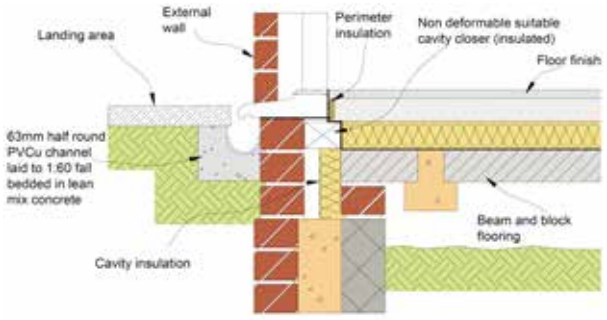


Figure 1: Typical level threshold suspended beam and block floor

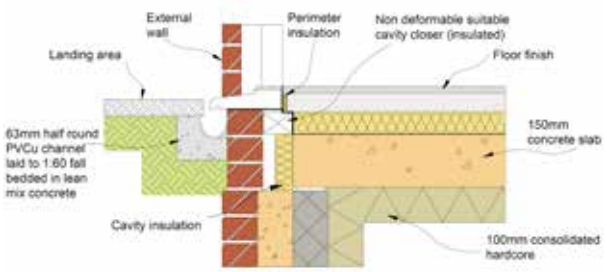


Figure 2: Typical level threshold suspended concrete slab

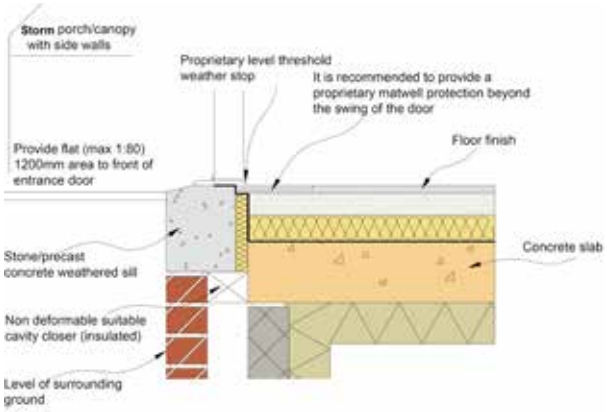


Figure 3: Typical level threshold with canopy protection

It is recommended that a matwell be constructed within the entrance hall to accommodate the swing of the door without fouling the carpet and/or the proprietary door seal to maintain the integrity of the seal.

External doors and opening lights to windows should be reasonably air tight by ensuring that effective draught seals are fitted.

External joinery should be designed and constructed in accordance with the requirements of the following British Standards:

- BS 4787: 1 Internal and external wood door sets, door leaves and frames
- BS 6262 Code of Practice for glazing for building
- BS 6375: 1 Performance of windows
- BS 644: 1 Wood windows
- BS 8213: 1 Windows, doors and roof lights

7.4.3 Security

External door leaves should be of a robust construction. Timber doors should be no less than 44mm thick (or equivalent strength for other materials). Flush doors should be of solid core construction. Door stiles to which locks are fitted should be of sufficient width so as not to create a weak point in the general robustness of the door (119mm minimum width is recommended for timber). Non-glazed panels should be sufficiently small to prevent access into the dwelling. Additional security may be provided within the design if required.

7.4.4 Protection from falling

For houses and flats, the guidance in Approved Document K2 specifies a minimum guard height of 800mm to window openings in the external wall. This would normally be achieved by forming window openings of at least 800mm above finished floor level. The wall beneath the opening is therefore considered to be the barrier to falling.

Where window openings are formed less than 900mm from the finished floor level, permanent guarding should be provided to the opening in accordance with the design requirements specified in the relevant Building Regulations.

Where window openings are formed less than 900mm from finished floor level and no permanent guarding is provided, with the glass required to act as the barrier and provide containment to persons falling against it, the glass shall be designed in accordance with the requirements of BS 6180. The Designer shall determine the potential impact energy by establishing the perpendicular unhindered distance that could be travelled prior to impact.

In the absence of an assessment by a suitably qualified person, any glass that is required to provide containment will be designed to meet BS EN 12600 Class 1(C)1.

7.4.5 Control of condensation

Minimise the effects of condensation on glazing and frames by:

- Using insulated metal frames.
- Using details that prevent condensation running onto walls or floors.
- Housing window boards into frames to prevent condensation entering the joint.
- Providing thermal insulation to walls at lintels, sills and jambs. Guidance on this subject is provided in BRE's report Thermal insulation: Avoiding risks.

7.4.6 Security

Door frames should be securely fixed and the rebate formed preferably from a solid section. Where planted stops are used, they should be glued, screwed and pelleted. Door and window frames should be fixed to vertical reveals with corrosion-resistant fixings at a minimum of 600mm centres, with the end fixings being located within 150mm of the top and bottom of the frame.

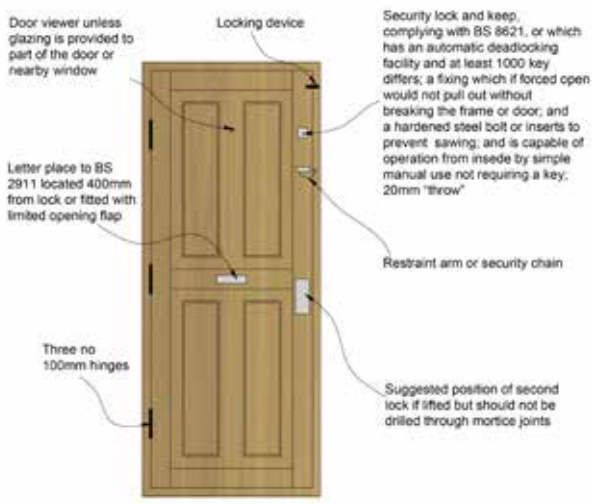


Figure 4: Security provisions to an entrance door

External doors should be hung on 3 no.100mm hinges. A restraint arm or security chain should be provided to main entrance doors, which should also be provided with at least one security lock and key.

If a second lock is fitted, it is suggested that this is positioned 600mm away. A five-lever deadlock should be provided to other external doors, including patio doors. The lock should comply with BS 8621 (and BS EN 12209) or be of a similar performance standard. Locks to entrance doors of flats should not operate automatically and the deadlock mechanism on the dwelling side of the door should be non-key operated (this is a fire precaution requirement).

On the ground floor, with the exception of kitchens, all habitable rooms should either open directly onto a hall leading to the entrance or other suitable exit, or be provided with a suitable window or door.

External doors (except main entrance doors) and sliding patio doors should be provided with robust bolts at the top and bottom of the closing edge of the door, e.g. 100mm barrel bolts fixed with 30mm No. 8 screws (see Figure 4). Where espagnolette multi-locking points are provided, the bolts can be omitted.

Sliding doors should be designed so that they cannot be lifted out of the frame from the outside. Letter plates should comply with BS EN 13724 and either be located no closer than 400mm from the door lock or be fitted with a limited opening flap. Where fitted to a fire-resistant door, e.g. flats, the letter plate should not adversely affect the fire resistance of the door. Windows should be provided with a securing device that cannot be sprung by levering the casement or sash from the outside of the building when in a closed position. A key operated lock should also be provided to all ground floor windows and others that are readily accessible from the outside, either as part of the securing device or as a separate unit.

Roof lights should not be used on single storey or other accessible roofs unless they are specifically designed to provide a deterrent against forced entry and can be locked with a removable key. Externally located hinge pins should be non-demountable, e.g. welded or disturbed ends.

7.4.7 Means of escape

In terms of emergency egress windows in two storey dwellings, with the exception of kitchens, all habitable rooms in the upper storey served by one stairway shall be provided with a window:

- With an unobstructed opening area of at least 0.33m^2.
- At least 450mm high x 450mm wide.
- With the bottom of the opening area not more than 1100mm above the floor.

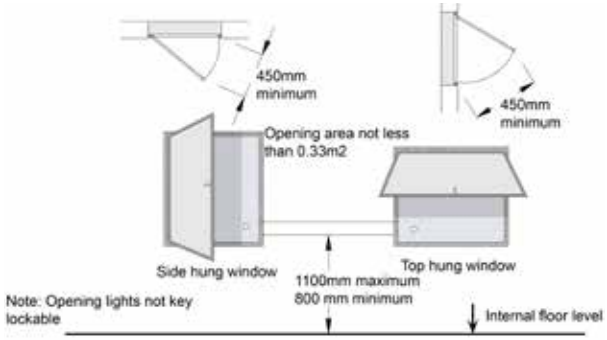


Figure 5: Emergency egress window provision

7.4.8 Installation of doors and windows

Window and door frames should be installed so that:

- They do not carry loads unless designed to do so.
- The face of the frame is set back at least 38mm from the masonry face; masonry on the external side of a vertical DPC should not be in contact with internal finishes.
- The window head is set back behind the edge of the cavity tray.
- The frame to wall junction is weather tight and reasonably air tight.
- In areas of very severe exposure, checked rebates should be provided.

The frame should be set back behind the outer leaf and should overlap it, as shown in Figure 6.

Alternatively, an insulated finned cavity closer with third-party certification may be used.

- Distortion is minimised by not locating radiators or other heaters close to doors.
- The water drip to window and door sills projects beyond the wall or sub-sill by at least 10mm, and the sill edge by at least 25mm.

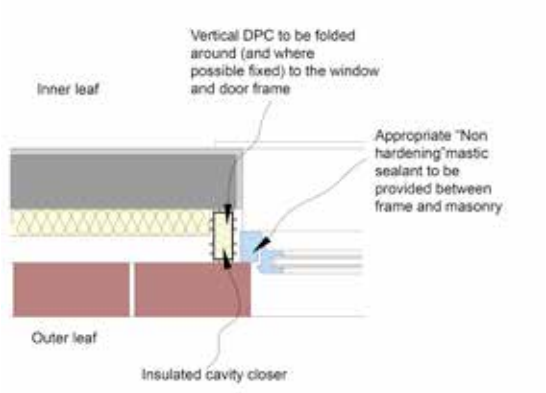


Figure 6: Rebated window framed for areas of very severe exposure

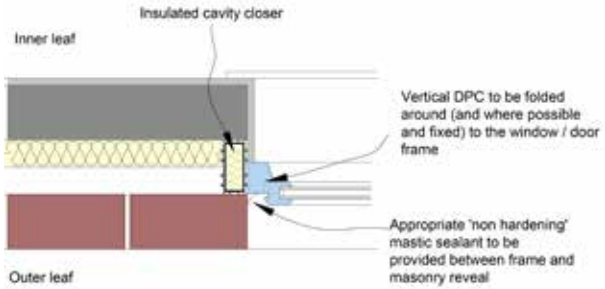


Figure 7: Typical window reveal detail (normal exposure)

Proprietary materials with third-party certification should be used to close cavities at window and door openings. They should also be installed in accordance with the manufacturer's recommendations.

7.4.9 Fire doors

Any door between a dwelling and an attached or integral garage should be a half-hour fire-resisting door and frame.

7.4.10 Bay windows

The vertical DPC and cavity closer should be installed as shown in Figure 8.

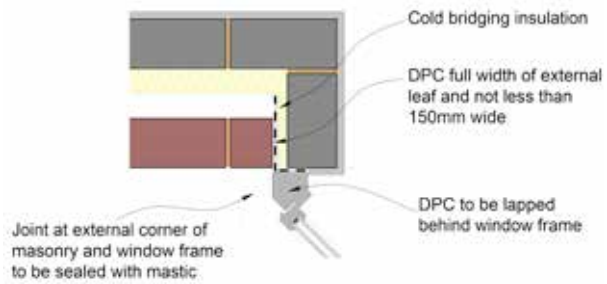


Figure 8: Typical bay window detail

7.4.11 Workmanship

Window and door frames should be installed either by building in tightly as work proceeds or by fitting into pre-formed openings, suitably dimensioned to provide an accurate fit for the frame plus the perimeter weather tight joint.

Timber frame windows and doors can be installed so that they abut the masonry. Any gap provided should not exceed 10mm, and for gaps less than 5mm, the sealant must cover both the frame and the masonry by 6mm. For gaps greater than 5mm, a backing strip should be provided behind the sealant. The sealant should have a minimum depth of 6mm.

PVC-U frame windows and doors should be installed with a gap of between 5mm and 10mm to allow for thermal expansion. For large framed units, such as patio doors, the gap can be up to 15mm.

Frames should be fixed in accordance with the manufacturer's recommendations or, if no instructions are given, with the following guidance:

- Fixings should be at 600mm maximum centres and within 150mm of corners of the frame
- Frames should be fixed either by galvanised steel cramps or by non-corrodible screw fixings to the surrounding wall

7.4.12 Glazing

Critical locations

Glazing in doors and windows in areas known as 'critical locations' need to be given special consideration in order to prevent potential injury to people within or around the building.

These 'critical locations', as shown in Figure 9, are:

- In a door or, in a side panel adjacent to a door; where the glazing is within 300mm of the door and the glazing is situated between floor level and a height of 1500mm.
- In an internal or external wall or partition between floor level and a height of 800mm.

It is important that any glazing within these 'critical locations' should be either:

- Provided with permanent protection
- Small panes
- Robust
- Break safely

If permanent protection is provided, there is no requirement for the glazing itself to be of a special type. Permanent protection may take the form of railing or barriers and should:

- Be designed to be robust.
- Have a maximum opening or gap in any railing of 75mm or less.
- Be a minimum of 800mm high.
- Be non-climbable (especially where floor is acting as a balcony).

Small panes, either an isolated pane within glazing bars or copper or lead lights, should be restricted in size so that any breakage would be strictly limited.

Small panes should be:

- No more than 0.5m^2 in area
- No wider than 250mm

Where concealed glass is used, a minimum of 6mm thickness is recommended (4mm for copper or lead lights). Some materials are inherently strong, such as glass blocks or polycarbonates, whereas concealed glass will need to be of an increased thickness as the area of the panel increases to be considered 'safe'. As an alternative to any of the above solutions, it is possible for the material to break 'safely' when tested to BS EN 12600, which would mean that:

- Only a small opening was created with a limited size of detached particles.
- The balance would create only small pieces that are not sharp or pointed.

- The pane disintegrates with only small detached particles.

Detailed guidance on this aspect of glazing can be found in Approved Document K: 2013 to the Building Regulations.

A glazing material would be suitable for a critical location if it meets the requirements of BS EN 12600 Class 3 or of BS 6206. Glass installed in a door or in a side panel to a door that exceeds 900mm wide must meet the requirements of BS EN 12600 Class 2 or BS 6206 Class B.

Glazing should be in accordance with BS 6262. Insulated glass units (IGU) should meet requirements of BS EN 1279 – Glass in building – insulating glass units, and should carry third-party accreditation. This includes windows in possession of a BBA certificate and timber windows.

- They should have dual seals; single seal units are not acceptable.
- Desiccant should be provided to every spacer bar.
- Any glazing on-site must have a drained and ventilated bottom bead.

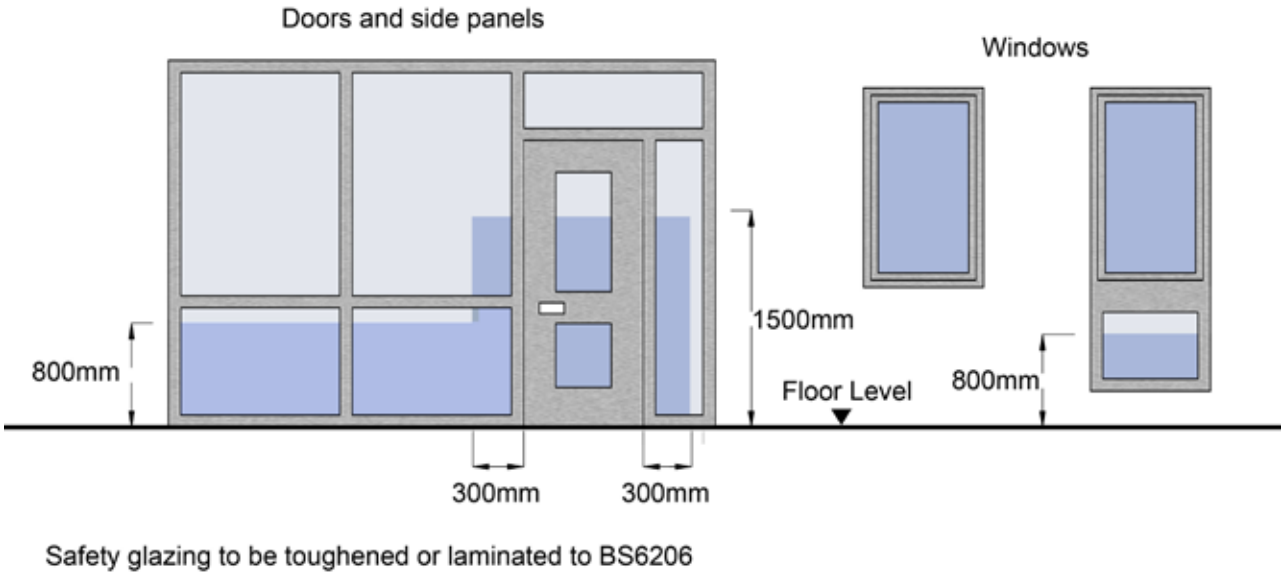


Figure 9: Glazing to critical locations

- Any glazing with an area greater than 1m^2 must have a drained and ventilated bottom bead.
- Glazing with an area less than 1m^2 may be solid bedded.
- All spacer bars should be stamped with BS EN 1279.
- PVC-U frames and spacer bars should be stamped with BS 7412, 7413 and 7414.

Linseed oil glazing putty should not be used when the joinery is finished with vapour permeable paint or stain; glazing putty should also not be used with organic solvent-based stains. Putty should be neatly finished to receive a protective paint coat.

Putty is not suitable for double-glazed units. Workmanship should be in accordance with BS 8000: 7. To ensure the compatibility of the whole glazing system with a high level of workmanship and control, it is recommended that factory pre-glazed systems be installed in all external openings.

External glazing beads should be pinned at a maximum of 150mm centres (a maximum of 50mm from corners) or screwed at 200mm centres (maximum 50mm from corners).

The preferred method of installation for double-glazed units is either:

- Drained and ventilated frames, as recommended by the Glass and Glazing Federation (GGF). Where possible, this method should be adopted for external glazing.
- Solid bedding of units in 16mm–18mm deep frame rebates; 18mm rebates are recommended by the GGF to allow for tolerances. In all cases, sealants should not be sensitive to ultraviolet light. External glazing beads should be fixed at a maximum of 150mm centres, and the glazing bedded in non-setting putty. Louvre windows should not be used. Double-glazing should be fixed and bedded as recommended by the GGF.

Control of condensation

Minimise the effects of condensation on glazing and frames by:

- Using insulated metal frames.
- Using details that prevent condensation running onto walls or floors.
- Housing window boards into frames to prevent condensation entering the joint.
- Providing thermal insulation to walls at lintels, sills and jambs.
- Using trickle ventilators, or similar, to provide background ventilation where required by the Building Regulations. Further guidance on this subject is provided in BRE report BR 262, Thermal insulation: Avoiding risks 2002.

Glazing

Glass must meet the visual assessment criteria of CWCT Technical Note 35 (TN 35). The total number of faults permitted in a glass unit shall be the sum total of those permitted by the relevant BS EN Standard for each pane of glass incorporated into the unit concerned.

Faults include:

- Bubbles or blisters
- Hairlines or blobs
- Fine scratches not more than 25mm long
- Minute particles

When assessing the appearance of glass:

- The viewing distance used shall be the furthest stated in any of the BS EN Standards for the glass types incorporated in the glazed unit. In the event of doubt, the viewing distance shall be three metres.
- The viewing shall commence at the viewing distance, and shall not be preceded by viewing at a closer distance.
- The viewing shall be undertaken in normal daylight conditions without use of magnification.

The above does not apply within 6mm of the edge of the pane, where minor scratching is acceptable. Scratches on doors, windows and frames and factory finished door and window components should not have conspicuous abrasions or scratches when viewed from a distance of 0.5m.

- Surface abrasions caused during the building-in process should be removed in accordance with the manufacturer's instructions, which may include polishing out, re-spraying or painting.
- In rooms where there is no daylight, scratches should be viewed in artificial light from fixed wall or ceiling outlets, and not from portable equipment.

Where window openings are formed less than 900mm from finished floor level and no permanent guarding is provided, with the glass required to act as the barrier and provide containment to persons falling against it, the glass shall be designed in accordance with the requirements of BS 6180. The Designer shall determine the potential impact energy by establishing the perpendicular unhindered distance that could be travelled prior to impact.

In the absence of an assessment by a suitably qualified person, any glass required to provide containment must meet with BS EN 12600 Class 1(C)1 standard.

7.4.13 Cast stone jambs and mullions

Stainless steel dowels in the sides of the jambs should be bedded into adjacent mortar joints as the masonry is constructed.

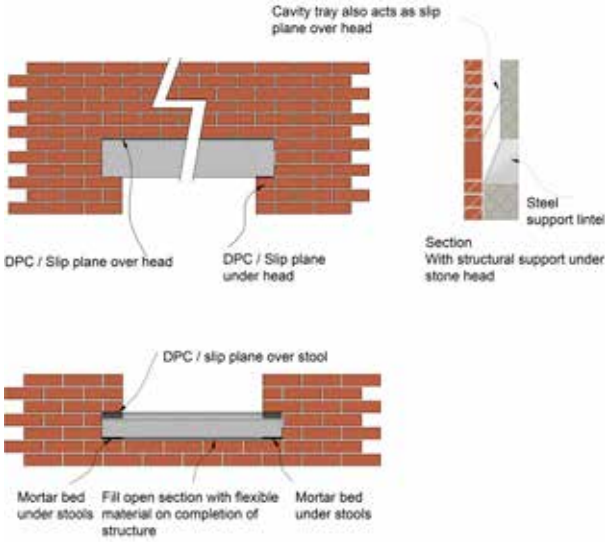


Figure10: Stone heads and sills

Cast stone heads

A cavity tray must be provided above all heads, as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head, as well as a soft joint between the top of the head and the steel support lintel.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement, e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated, or the cast stone should be flexibly jointed.

Sills

The DPC should be overlapped by the vertical DPC at the jambs, and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

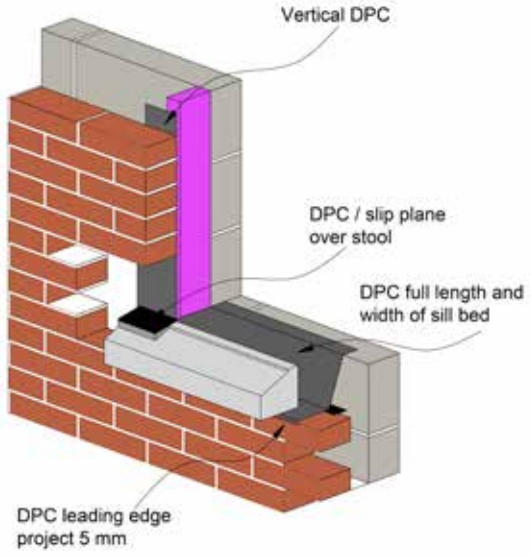


Figure 11: Stone sill with insulated cavity closer

FUNCTIONAL REQUIREMENTS

7.5 CHIMNEYS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.5.1 Support

If a chimney is not provided with adequate support using ties, or not securely restrained, its height (measured to the top of the chimney) should not exceed 4.5 times its least horizontal dimension when measured from the highest point of intersection with the roof surface (density of masonry must be a minimum of 1,500kg/m^3).

7.5.2 Chimneys and flues

Ensure that all gas flues terminate to the open air, i.e. flue blocks must terminate at an appropriate ridge vent or similar even where no appliance is fitted prior to the sale/occupancy of the property. To demonstrate that flues comply with Building Regulations, reports showing that flues have passed appropriate tests are to be made available.

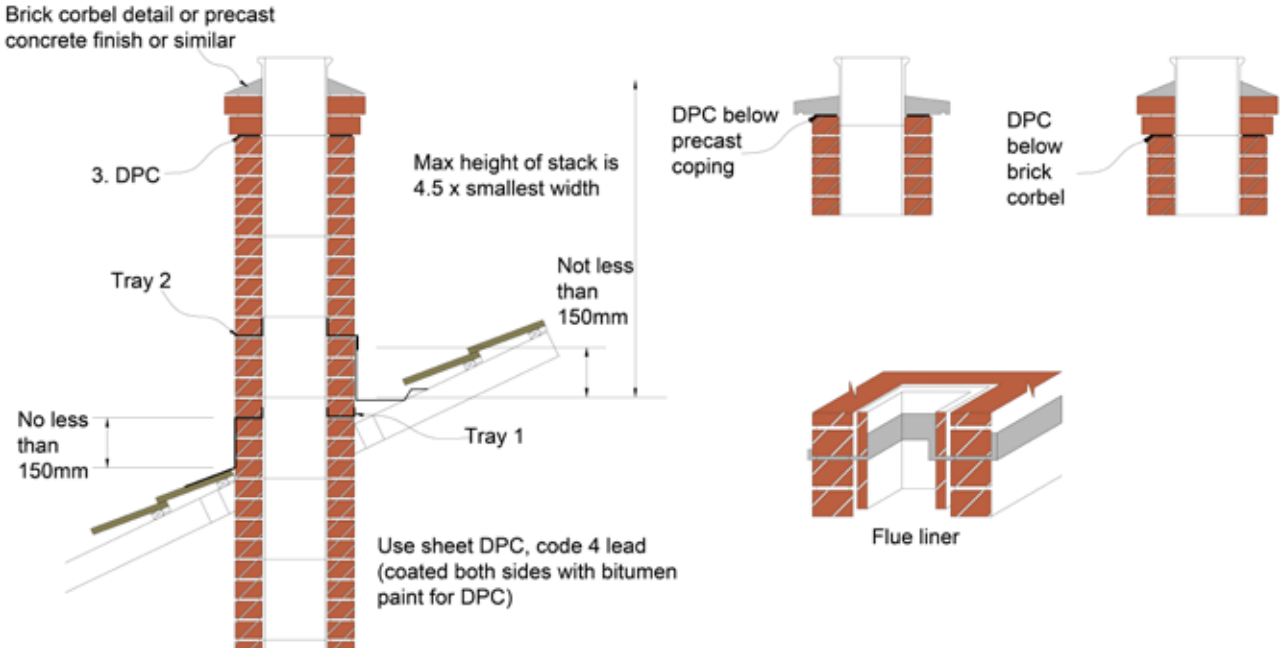


Figure 1: Typical chimney details

A suggested checklist for these reports is provided in Approved Document J. Special blocks are made to accommodate gas fire flues, which tend to be slightly thicker than normal units. When used in external walls, care should be taken not to reduce the clear cavity width below 50mm.

If the chimney is in a severe exposure zone, the cavity should extend around the outside of the stack and be continuous up to roof level, as per BS 5628, Part 3: 2001. Where the chimney breast is gathered in, the lower projecting masonry should be protected with a suitable capping and cavity trays. A 50mm cavity at the back of the chimney breast is maintained to prevent rainwater penetration.

Flue liners are used as specified with sockets uppermost and jointed with fire-resisting mortar. Flue liners should be:

- Non-combustible.
- Reasonably smooth internally.
- Correctly jointed with mortar, with the space between the liners and the brickwork filled with weak insulating concrete, unless the manufacturer recommends an alternative specification.
- Properly jointed at the junctions with the starter block or lintel and outlet terminal.

A notice plate containing safety information about any hearths and flues should be securely fixed in an unobtrusive but obvious position within the home.

Where a chimney forms part of a wall, the foundation should project at least 100mm wider than the chimney base and should be the same depth as the adjacent wall foundation. Factory-made insulated chimneys should have a life of at least 30 years and be designed in accordance with BS 4543 and BS EN 1859, and installed in accordance with BS 7566. Where a chimney is not directly over an appliance or opening, a soot box accessible for emptying should be formed.

7.5.3 Corrosion of lead work

Where free lime from mortar comes into contact with lead trays or flashings (due mainly to the continual saturation of the brickwork) in areas such as chimneys, the lead should be protected from corrosion by the use of a thick coat of bitumen paint covering the faces likely to be in contact with the mortar. The protection against corrosion of lead work buried in mortar is suggested in guidance issued by the Lead Sheet Association. This treatment can also reduce the staining of lead and brickwork. It is unnecessary to treat flashings buried only 40–50mm into mortar joints (cover flashings), as this close to the drying surface the carbonation of free lime is rapid and there is no risk of corrosion in such circumstances.

7.5.4 Chimney tray, low level

Required at low level where a cavity-walled chimney with brick shoulders is built onto an external wall, the tray prevents water that may enter the shoulders from penetrating to the inner leaf of the wall.

The material used is 1mm aluminium alloy sheet to BS EN 485-2: 1995 Aluminium and aluminium alloys. Sheet strip and plate. Mechanical properties. This has a higher melting point than lead, so is suitable for installation close to a heat source.

A high level may be required to prevent the entry of water at high level where a chimney rises through a pitched roof; suitable for new build or remedial work, this minimises disturbance to surrounding construction in remedial work.

The material used is lead sheet to BS 1178: 1982 Specification for milled lead sheet for building purposes. Code 4 as standard. Standard sizes are 800mm x 800mm, 900mm x 900mm, 950mm x 950mm, to suit either a 195mm square or 195mm diameter circular flue.

7.5.5 Lead work

Lead sheet used for roofs, flashings and weatherings should, in terms of suitability, meet the requirements of the Technical Manual, or be in accordance with BS EN 12588 or a UKAS (or European equivalent) valid third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use (see Chapter 2.3.5).

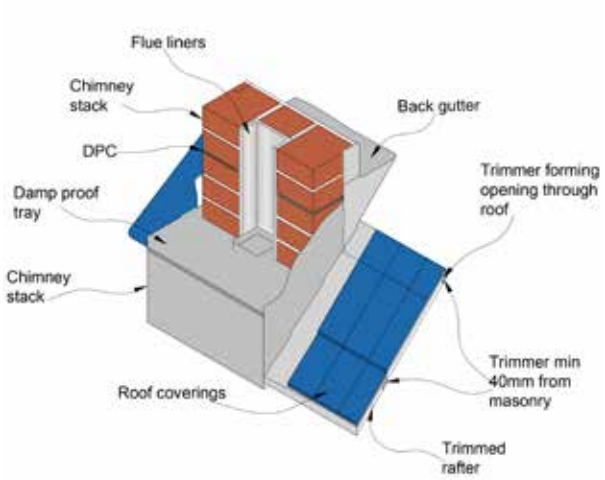


Figure 2: Typical flashing to chimneys

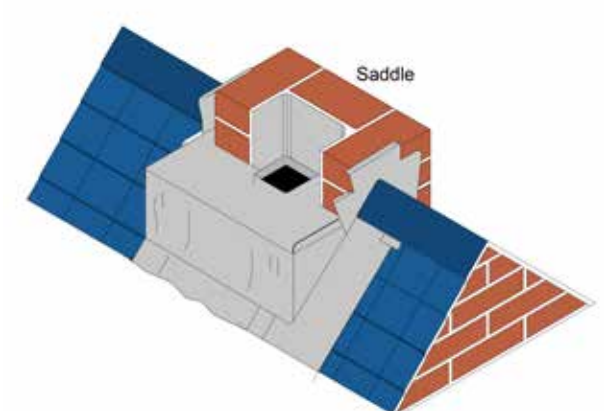


Figure 3: Flashings to chimneys at ridge

FUNCTIONAL REQUIREMENTS

7.6 BALCONIES

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. Balconies must have appropriate guarding meeting the relevant Building Regulations.
iv. The balcony design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.6.1 Introduction

This section should be read in conjunction with Chapter 7.10. Where appropriate, cross reference will be provided to the relevant section in 7.10. This provides specific advice and requirements in respect of balconies and terraces for the following situations only:

- Where the balcony or terrace forms part of or forms the entire roof to other occupied parts of a building and is either a 1) warm deck construction or 2) an inverted warm deck system of construction.
- Where the balcony or terrace projects beyond the building elevation and has a cold deck roof system.

7.6.2 Design

7.6.2.1 Selection of system type

Selection of system type

The cold deck roof system is not permitted on balconies or terraces that form part of the entire roof to other occupied parts of the building. In these circumstances, the selection of system type (warm deck or inverted warm deck) should be based upon the following criteria:

- Roof zone depth (height from ceiling to termination of waterproofing).
- Likely point loading.
- Construction process (a complete inverted warm deck roof, with suitable protection, and which may be suitable for storage or access by other trades; a warm deck roof may not be suitable for storing heavy loads).

7.6.2.2 Loading

Statutory requirement

Design for loading must comply with Statutory Building Regulations.

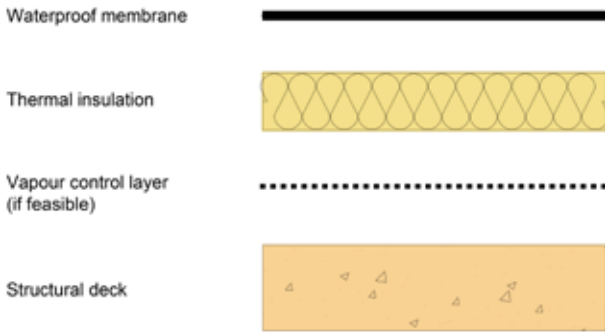


Figure 1: Warm roof (section)

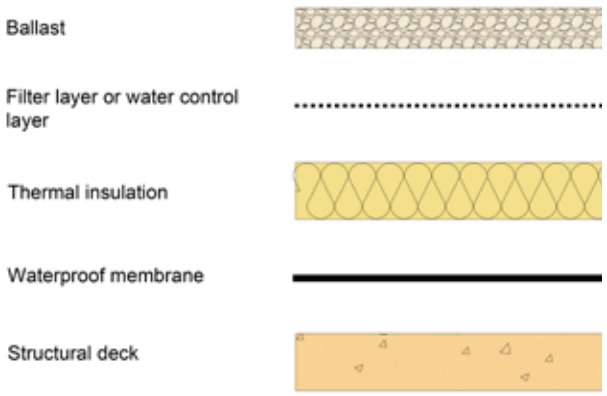


Figure 2: Inverted warm roof (section)

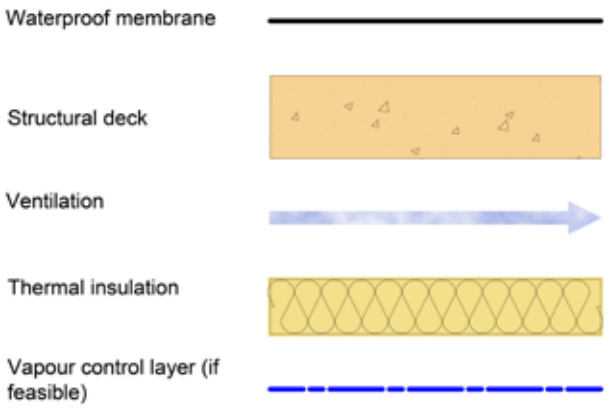


Figure 3: Cold roof (section)

Resistance to wind load
In all situations, including ballasted and inverted roofs, a calculation of wind load to BS EN 1991-1-4 should be undertaken by a suitably competent person. Wind load acting on a balcony will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

Resistance to imposed loads
At the earliest possible stage, the employer should define the range of potential imposed loads for which the balcony is to be designed, such as planters, storage and public access. In the absence of such a performance requirement, the loading limits of the balcony should be defined.

7.6.3 Falls and drainage

7.6.3.1 Statutory requirement
Design for drainage should comply with the Building Regulations 2000, Approved Document Part H – Drainage and waste disposal – Part H3 – Rainwater drainage.

7.6.3.2 British and industry standards
The requirements of BS 6229 should prevail in respect of balconies and terraces, whether or not they form part or the entire roof to occupied parts of a building, and irrespective of the type of waterproof membrane.

Falls are not required for podium decks, provided:

- They are designed with pedestrian finishes, which allow rainwater to drain rapidly from the finished surface and not to accumulate upon it.
- The waterproof membrane has current certification (see Chapter 7.10 Roof Coverings – Continuous Membranes) for use at zero falls in this application.

Wherever practical, balconies and terraces should be designed to fall away from the building elevation. If this is not practical for reasons of continuity of rainwater services, the falls should be arranged across the balcony, parallel to the elevation.

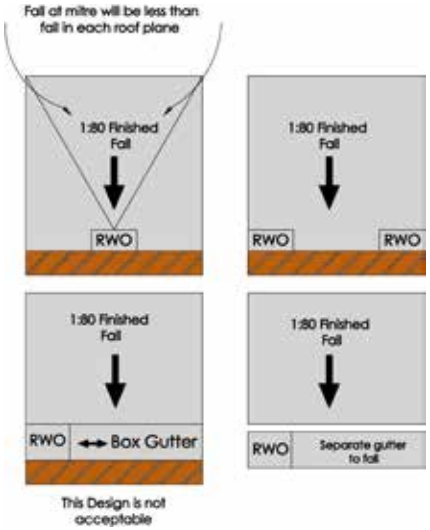


Figure 4: Drainage layout options

7.6.3.3 Creation of falls
Roof falls may be created either during the construction of the deck or alternatively through the use of tapered insulation systems (warm deck roof systems only).

Where the roof finish is to include paving on supports, consideration should be given to the height difference created by the falls and spacing of rainwater outlets so that the maximum height of paving supports is not exceeded, the minimum height of upstands is not affected or trip hazards created. On large balconies and terraces, it may be necessary to increase the number of outlets in order to reduce maximum roof zone depth.

7.6.3.4 Drainage
If a balcony is served by a single rainwater outlet, an overflow facility of equivalent capacity and clearly visible externally should be provided at or near the same location, no more than 50mm above the level of the waterproof membrane.

Rainwater outlets should be readily accessible, without disruption to the pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or water control membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking.

Where rainwater downpipes from other higher roof areas or balconies discharge via a lower balcony or terrace, an open downpipe shoe is not permitted. The downpipe should be connected directly to the downpipe serving the lower balcony or terrace.

7.6.4 Thermal performance

Design for thermal performance must comply with the current Building Regulations, as appropriate.

7.6.5 External fire performance

7.6.5.1 Statutory requirement

Design for external fire performance must comply with the current Building Regulations.

7.6.6 Provision for access

7.6.6.1 Statutory requirement

Balconies should have suitable access and drainage meeting the requirements of the current Building Regulations.

7.6.6.2 Edge protection

The guarding to the perimeter of balconies, terraces and podium decks should be designed to provide the simplest means of achieving waterproofing integrity, given that installation of balustrade or glazing stanchions may occur after the installation of the roof system.

Acceptable examples include the following, in order of preference:

- Full-height parapet walls.
- Stanchions or rails secured to low parapet walls above the level of the waterproof membrane (incorporated in copings or secured to elevation).
- Stanchions secured, clamped and sealed to stainless steel bolts set in raised plinths, which were constructed prior to application of the waterproof membrane (suitable for warm deck and inverted warm deck roof systems).
- Stanchions secured, clamped and sealed to stainless steel bolts set at deck level, which were installed prior to application of the waterproof membrane (suitable for warm deck roof systems only).

If the design requires a collar of waterproof membrane at the stanchion, the stanchion should be of circular section at this point and should incorporate a weathering apron.

7.6.6.3 Protection of waterproof system during construction

At the earliest possible stage, the anticipated loading of the balcony, terrace or podium area by plant and access during service should be assessed in terms of:

- Load, e.g. foot traffic, equipment
- Frequency
- Risk of impact

If such usage is intense or long-lasting during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased, as follows:

- Warm deck roof system: installation of temporary Vapour Control Layer (VCL), to be overlaid when remainder of system is installed.
- Inverted warm deck roof system: overlay of completed waterproof membrane with geotextile and continuous temporary decking, such as plywood, oriented strand board or compatible recycled thermoplastic board.

7.6.6.4 Pedestrian access finishes

The design should include protection to suit the anticipated conditions as appropriate:

	Roof system type			Waterproof membrane type			
Finish	**Warm**	**Inverted**	**Cold (Podium)**	**Single ply membrane**	**Bitumen membrane**	**Mastic asphalt**	**Liquid applied**
Porous concrete tiles adhered to waterproof membrane (1)	Y	N	Y	N	Y	Y (2)	Y
Fired tiles bedded in screed and grouted (1)	Y	N	Y	Y	Y	Y (2)	Y
Precast concrete paving slabs on adjustable supports (3)	Y	Y	Y	Y	Y	Y	Y
Timber decking on timber supports (4)	Y(6)	Y (5, 6)	N	Y(7)	Y	Y	Y

Notes:

(1) Product should be certified for use with waterproof membrane (see Chapter 7.10);

(2) Consideration should be given to the effects of solar gain on the stability of mastic asphalt under point loading in this situation;

(3) Paving support pad bearing area should be suitable for the compressive strength of the insulation under design loadings;

(4) Bearers should not impede drainage and should be sized to suit the compressive strength of the insulation under design loadings;

(5) Decking should be of sufficient dead load to provide resistance to wind load and temporary flotation of insulation;

(6) Suitable certification for external fire performance should be provided;

(7) Membrane manufacturer's recommendations should be followed, regarding the protection layers required to isolate the waterproof membrane from spillage of liquids or timber preservatives.

Table 1: Pedestrian finishes for balconies, terraces and podium decks

7.6.7 Detailing

7.6.7.1 General principles

At an early stage in the design process, an audit of balcony, terrace or podium geometry should be carried out to establish what types of details will be required and whether they are to be weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in the design of all details:

- Upstands to extend 150mm above finished roof level, except at door access to balconies and terraces (see Details section below).
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum of 75mm.
- Where the balcony or terrace forms part of the entire roof of an occupied building, a continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection should be avoided.

The total roof zone depth should be assessed at critical points, such as the top of drainage slopes, to ensure there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, except at door access to balconies (see continuous water checks and verges). Balconies are a frequent and acceptable exception due to the need for level or unobstructed access, provided the recommendations in this section are followed.

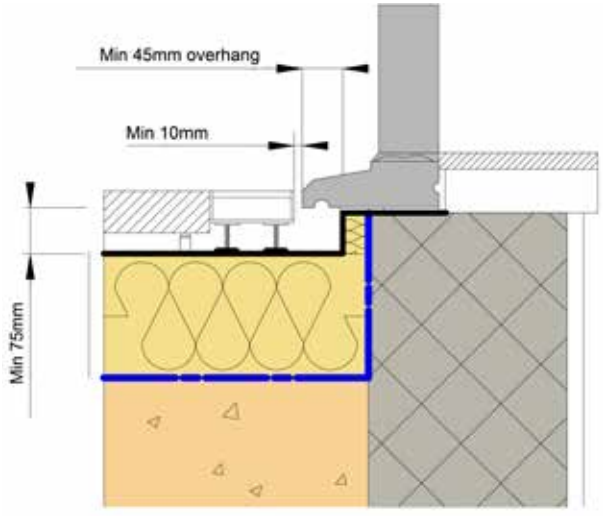


Figure 5: Details
Principles: Upstand at door access: warm deck roof: level threshold

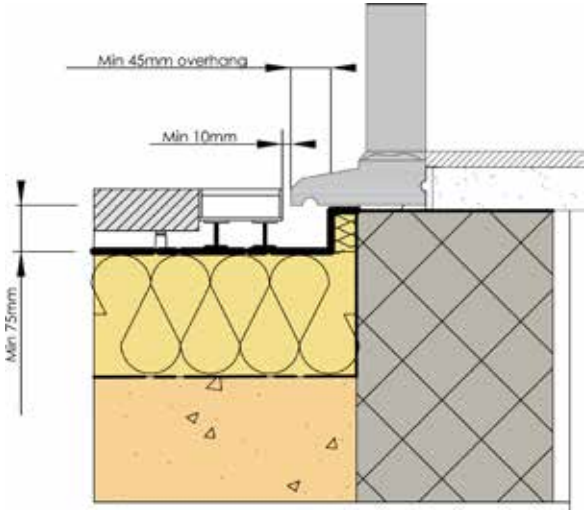


Figure 6: Details
Principles: Upstand at door access: inverted warm deck roof

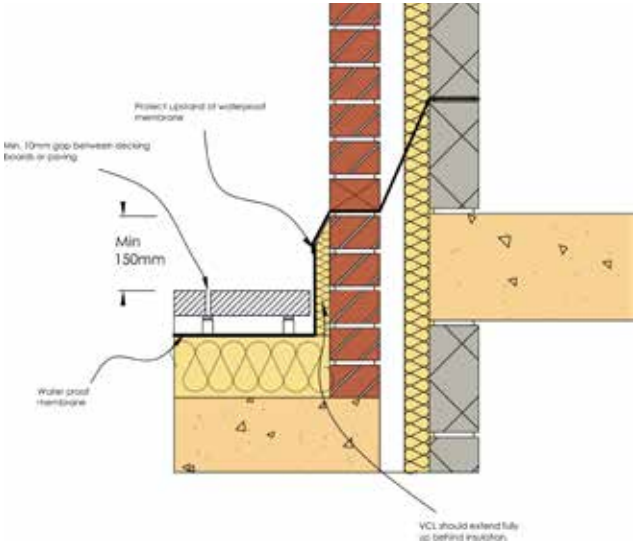


Figure 7: Details
Principles: Upstand to decking and paving finishes (e.g. balcony parapet): warm roof

7.6.8 Design for sustainability

As per Chapter 7.10 Roofing.

7.6.9 Materials

As per Chapter 7.10 Roofing.

7.6.10 Installation

7.6.10.1 Protection of the roof

Temporary protection (during construction)

Responsibility for temporary protection and a method statement for its use should be agreed prior to the commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets.
- Rolled recycled thermoplastic or elastomeric sheets.

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

Permanent protection (during service)

Permanent protection should not be laid on routes where access is most likely, or routes where temporary ponding is likely, e.g. near parapet walls, in the absence of cross falls between rain water outlets.

It is recommended that concrete paving is laid on support pads as this allows adjustment, reducing risk of trip hazard. Recommendations are as follows:

- The height of support pads should not exceed the maximum recommended by the manufacturer.

- Paving should not be cut.
- Paving should be firmly butted up against support pad separating pegs.
- Support pad separating pegs should provide clear space for rapid disposal of rain water between paving slabs.
- Provision for movement at perimeters should comprise either a 75mm margin of washed stone or a compressible rubberised fill. In either case, drainage should not be obstructed and a suitable restraint trim should be used to ensure stone does not fall beneath the paving adjacent.

7.6.10.2 Vapour Control Layer (VCL)

As per Chapter 7.10 Roofing.

7.6.10.3 Thermal insulation

As per Chapter 7.10 Roofing.

7.6.10.4 Waterproof membrane

As per Chapter 7.10 Roofing.

7.6.11 Testing

7.6.11.1 Final inspection

At practical completion of the balcony, terrace or podium deck, all areas should be clear of stored material, other site operations and all protection. A thorough, recorded, visual inspection of all areas, including details, should be carried out with representation from the General Contractor and Roofing Contractor in attendance.

7.6.11.2 Procurement of testing services

If testing to demonstrate waterproofing integrity is required, it should be undertaken by a third-party that is independent of the roofing contract. The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.6.11.3 Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs, where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is a suitable method of demonstrating the integrity of balconies, terraces and podium decks. However, consideration should be given to the effect of possible ingress to the construction during the test and risk of entrapped water in insulation (warm deck roofs) and decks (all types). The area under any one test should not exceed $50m^{2.}$

7.6.12 Provision of information

7.6.12.1 Operation and maintenance Manual

The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
  - Thermal insulation: generic type, product(s) and thickness.
  - Acoustic insulation: generic type, product and (as appropriate) thickness.
  - Vapour Control Layer: generic type, product (as appropriate) and thickness (as appropriate).
  - Rainwater outlets: type, product, capacity, location and means of access.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.

FUNCTIONAL REQUIREMENTS

7.7 CLADDING

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be handled and stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies that can be inspected and replaced and which are not integral to the structure may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The cladding materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
iii. The design of primary framing members (e.g. mullions and transoms, backing wall framing sections, etc.) and the connections of these members/panels to the structure must be supported by structural calculations provided by a suitably qualified professional.

7.7.1 Render

Rendering should be in accordance with BS 5262 and workmanship in accordance with BS 8000. In particular, the following should be considered:

- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement.
- Any joints in the wall where movement may occur should be continued through the rendering.
- Render should not bridge the Damp Proof Course (DPC) and be finished onto a durable render stop.
- External rendering should comply with BS 5262.
- Sand for rendering should be stored separately from other building and concreting sands.
- For bellcasts, a galvanised steel bead is acceptable.
- For other beads and stops, an epoxy or PVC-coated galvanised steel is acceptable.
- Render systems that include a cavity as a secondary defence system should also incorporate cavity barriers within the cavity to prevent the spread of fire through the cavity. The cavity barriers should not obstruct more than 50% of the cavity. The cavity must retain its ability to drain. The cavity barrier must activate and fully close the cavity when exposed to fire.
- Renders will be reinforced at corners and penetrations.
- Renders installed between pedestrian level and 6.0m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.

7.7.1.1 Timber frame background

A drained and vented cavity should be provided behind render on timber frame construction. The mesh or metal lathing used should be approved by an independent authority and fixed to vertical battens at stud centres. The minimum size of the cavity should be 19mm when the mesh or metal lathing is backed by a water-resistant membrane, and 50mm when the mesh or metal lathing is unbacked. A DPC should be provided between unbacked render and timber battens.

Battens should be either 25mm x 38mm or 50mm x 50mm, preservative treated (BS 8417, or equivalent, hazard class 2) and fixed at spacings recommended in BS 5262. Fixings and preservatives should be compatible.

Battens should be fixed to each stud with annular ring nails of length at least twice the batten thickness plus the sheathing thickness. Nails should be hot dipped galvanised stainless steel or equally durable. Where cavity barriers are required, they should be correctly fitted without gaps, fill the cavity and be fixed with stainless steel staples or equally durable fixings. Maintain settlement joints below external frames and soffits.

Where cement render spans across an intermediate floor zone in timber frame construction, allow for differential movement due to timber shrinkage by incorporating a movement joint. Vertical movement joints should also be provided at maximum 5m horizontal centres.

7.7.1.2 Masonry background

Walls should be examined for excessive moisture content prior to rendering. This is particularly important where the masonry background has no upper limit on its soluble salts content, e.g. N designation clay bricks. Sulphate-resisting cement should be employed in the render and mortar used for parapets, chimneys, retaining walls and walls below DPC level with this background.

It is recommended that:

- The backs and exposed horizontal surfaces of parapets are not rendered.
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces to throw water clear.

- Rendering to chimneys should only be carried out where brickwork contains little or no sulphates. Splatterdash treatment should be used.
- As before, horizontal DPC and damp proof membranes (DPM) must not be bridged.
- Rendering is not used below DPC. However, where this is not practical, the render must still not be allowed to bridge the DPC. A bellcast must be formed in the render above the DPC.

7.7.1.3 Other construction detailing

Ensure that drips and throating to sills, coping, etc. project beyond the face of the finished render above the DPC.

Notwithstanding wind loadings, the larger the eaves overhang the better. This will provide protection to the top joint and prevent rain water percolating behind the render.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings, and not with gypsum plaster.

Check whether the rendering can be applied directly onto the wall, or whether any preparatory treatment is required in accordance with the manufacturer's instructions.

The surface should be checked for suction by dampening the wall with clean water.

7.7.1.4 Vertical and horizontal flatness

Rendering should have a maximum vertical and horizontal deviation from flatness of +/-10mm in 5m, and is measured in a similar way to straightness on plan and plumb of masonry.

7.7.2 Curtain walling

7.7.2.1 General

Curtain walling systems should have third-party certification confirming satisfactory assessment, and comply with the requirements of the CWCT Standard for Systemised Building Envelopes, including the following sections:

- Part 1: Scope, terminology, testing and classification.
- Part 2: Loadings, fixings and movement.
- Part 3: Air, water and wind resistance.
- Part 4: Operable components, additional elements and means of access.
- Part 5: Thermal, moisture and acoustic performance.
- Part 6: Fire performance.
- Part 7: Robustness, durability, tolerances and workmanship.
- Part 8: Testing.

The CWCT Standard provides detailed guidance on performance and testing.

Dead and live loads should be transferred safely to the building structure without undue permanent deformation or deflection of any component.

Imposed loads should be calculated in accordance with BS EN 1991. Movement should be accommodated without any reduction in performance.

Fixings and supports should be designed to accommodate specified loads and take account of the product manufacturer's recommendations.

CE marking is to be provided for all curtain walling covered by EN 13830 in buildings constructed after July 2013, and will therefore include the following curtain wall types:

- Stick construction
- Unitised construction
- Double skin walls
- Structural sealant glazing
- Bolted glazing

Cavity barriers and fire stops should be provided in accordance with relevant Building Regulations.

7.7.2.2 Testing

The curtain wall system will have been tested and provided with a classification given in BS EN 13830.

Pull-out or destructive testing of anchors should be carried out in accordance with BS 5080 and the Construction Fixings Association Guidance Note, Procedure for Site Testing Construction Fixings.

Packing of brackets to achieve surface tolerance should be permitted only in accordance with the manufacturer's recommendations, and should not exceed the maximum depth stated in the Designer's calculations.

All packers for brackets supporting or restraining the curtain wall must be metal.

The completed curtain wall system should resist the passage of water to the inside of the building, allowing free drainage and not trapping water, and should have:

- External and internal air and water seals.
- Drained and ventilated glazing rebates.

Sealants should be specified in accordance with BS 6213 or BS EN 15651, and the performance determined by BS EN 11600 and the manufacturer's recommendations.

The system should be designed to minimise the risk of surface and interstitial condensation by the use of thermal breaks and a continuous Vapour Control Layer. It should be designed to resist the passage of airborne and impact sound within the building, and particular attention should be given to flanking transmission at:

- The edges of separating floors.
- The outer edges of separating walls.
- The outer edges of partition walls.
- The junctions with roof constructions and parapets.

Where curtain wall members run uninterrupted past floor slabs and partition walls, consideration must be given to structure-borne sound (impact sound).

It should comply with BS 7671 Requirements for electrical installations for electrical continuity and earth bonding, and where it is required to form part of a lightning protection system it must be designed to comply with the requirements of BS 6651.

The risk of bimetallic corrosion should be avoided through the isolation of dissimilar metals.

The curtain wall system should not include materials liable to infestation attack by micro-organisms, fungi, insects or vermin.

7.7.2.3 Tolerances

Design should allow for the line, level, plumb and plane of the completed curtain wall to be within the acceptable tolerances of:

- Line: +/-2mm in any one storey height or structural bay width, and +/-5mm overall.
- Level: +/-2mm of horizontal in any one structural bay width, and +/-5mm overall.
- Plumb: +/-2mm of vertical in any one structural bay width, and +/-5mm overall.
- Plane: +/-2mm of the principle plane in any one storey height or structural bay width, and +/- 5mm overall.

7.7.3 Insulated render systems

These are systems applied to the exterior walls of existing or new buildings, comprising of an insulant and a weather protective finish, of which there are three main types:

- Traditional renders and finishes.
- Thin coat renders and synthetic finishes.
- Pre-formed cladding materials.

All insulated render systems must have appropriate third-party certification.

7.7.4 Timber cladding

Timber and boards for exterior use should be of a durable species, with sapwood excluded, or preservative treated by pressure impregnation using preservatives suitable for use in hazard Class 3 in compliance with BS 8417: 2003, or equivalent. Further guidance on the durability of timber is provided in Chapter 2 – Materials.

Where timber boarding or plywood spans across an intermediate floor zone in a timber frame construction, allow for differential movement caused through timber shrinkage by incorporating a movement joint.

Where cavity barriers are required, they should be correctly fitted without gaps, fill the cavity and be fixed with stainless steel staples or equally durable fixings.

Abutments between cladding and other weather-resisting elements should be neatly made, weather tight and allow for differential movement. Workmanship should comply with BS 8000: 5.

7.7.4.1 Timber boarding

Timber boarding should be at least 16mm thick, and allowance for moisture movement in boarding should be achieved by making tongues, joints or overlaps at least 10% of the board width.

Timber boarding should be battened off the supporting background to provide a minimum 19mm cavity for draining and venting.

Battens should be a minimum of 38mm wide, preservative treated and at maximum 600mm centres. A breather membrane should always be installed when horizontal battens are located against the sheathing. Battens on timber frame should be fixed to each stud (and not to the sheathing) with annular ring nails of length at least twice the batten thickness plus the sheathing thickness (or plain shank nails of length 2.5 times the batten thickness plus the sheathing thickness).

Boards should be fixed to battens by face or secret nailing with annular ring nails at least twice the board thickness or plain shank nails at least 2.5 times the board thickness.

Butt joints at board ends should occur at battens. Nails should be either hot dipped galvanised, stainless steel or equally durable. Aluminium nails should not be used with timber treated with a preservative containing copper. Galvanised nails should not be used with Western Red Cedar.

FUNCTIONAL REQUIREMENTS

7.8 ROOF STRUCTURE

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.8.1 Statutory requirements

Roof structure and loading
Roof framing and rafter design must be in accordance with current Building Regulations.

The roof of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

Section 2A of Approved Document A (England and Wales) gives basic requirements for the stability of low rise residential buildings. With respect to the roof, it requires that the structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

In this respect, it is acknowledged that a traditional cut roof, i.e. using rafters, purlins and ceiling joists, generally has sufficient built-in resistance to instability and wind forces, e.g. from either hipped ends, tiling battens, rigid sarking or the like. However, the need for diagonal rafter bracing equivalent to that recommended in BS EN 1995-1: 2004+A1, or Annex H of BS 8103-3 for trussed rafter roofs, should be considered, especially for single-hipped and non-hipped roofs of more than 40° for detached houses.

Section 2B of Approved Document A (England and Wales) contains advice on 'sizing of certain timber members in floors and roofs for dwellings', and refers the Designer to the following sources:

- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by TRADA.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1: 2004+A1, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

Section 2C of Approved Document A
The design criteria set out is intended to be adequate for imposed roof loads of 1.00kN/m^2 for spans not exceeding 12m, and 1.50kN/m^2 for spans not exceeding 6m.

All structural timber used in a conventional cut roof, i.e. rafters, purlins, ceiling joists, binders and other timber elements, should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded, or 'green', timber is not acceptable.

Allowances for wind loading
The need for a roof to withstand wind pressure and suction will be met if the proposed roof is braced effectively, as discussed elsewhere in this Manual, and secured to the structure, as detailed below, with walls adequately restrained.

The securing of roofs to the supporting structure roof timbers normally involves a timber wall plate or similar, which should be levelled using a spirit level so that loadings from the roof are directed perpendicularly down the supporting wall.

The wall plate may, as good practice, be fixed to ensure correct positioning when roof timbers or trusses are being installed by means of galvanised mild steel holding down straps (30mm x 5mm x 1,000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.

There is a need to ensure that holding down straps are provided in areas of severe wind exposure where required by the roof design.

7.8.2 Treatment of timber

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice, and in the following circumstances:

- Roof timbers should be preservative treated where the insulation and ceiling line follow the roof pitch.
- The Approved Document of Regulation 7 of the Building Regulations for England and Wales requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The areas at risk are:

- The District of Bracknell Forest
- The Borough of Elmbridge
- The Borough of Guildford (other than the area of the former Borough of Guildford)
- The District of Hart (other than the area of the former Urban District of Fleet)
- The District of Runnymede
- The Borough of Spelthorne
- The Borough of Surrey Heath
- In the Borough of Rushmoor, the area of the former district of Farnborough
- The District of Waverley (other than the parishes of Godalming and Haslemere)
- In the Royal Borough of Windsor and Maidenhead, the parishes of Old Windsor, Sunningdale and Sunninghill
- The Borough of Woking

The treatment should be impregnation with a preservative suitable for use in hazard Class 2, in accordance with BS 8417: 2003, or equivalent, for a 60 year anticipated service life. Cut ends must be liberally brushed or dipped with an end-grain preservative.

It is strongly recommended that, where punched, metal fasteners are proposed to roof trusses. Only micro-emulsion or organic solvent preservatives should be used for timber treatment, to limit the possibility of corrosion of the fasteners and so as not to adversely affect glued joints.

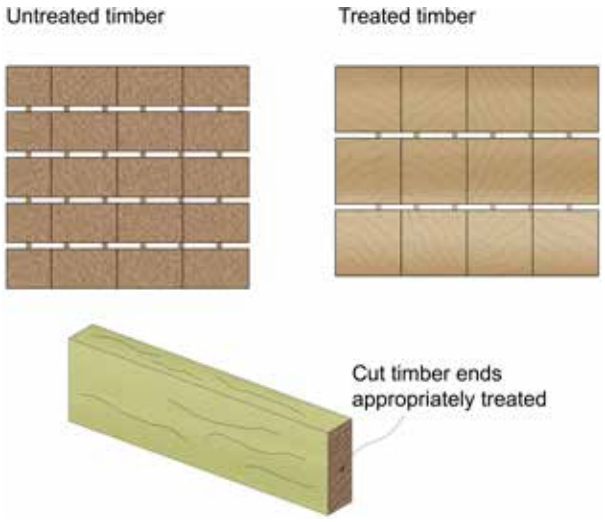


Figure 1: Timber treatment

7.8.3 Trussed rafter design

7.8.3.1 Design responsibility

The Building Designer is responsible for the 'framing' of any given roof as a whole. This means that he or she must take responsibility for the bracing together (framing) of the trussed rafter configuration, which then supports the roof covering and the tying together of the supporting walls.

Whilst it is the supplier of the rafters who generally has the knowledge and expertise required to achieve the best engineering solutions, the Designer must be certain that the loading calculations and resultant configuration is fit for purpose.

The following checklists, derived from BS EN 1995-1: 2004+A1, set out:

- Information required by the manufacturer from the Designer.
- Information that should be supplied by the manufacturer to the Designer.

Designer to Truss Manufacturer

- The height and location of the building, with reference to any unusual wind conditions.
- The profile of the trussed rafter, including camber if required.

- The span of the trussed rafter.
- The pitch or pitches of the roof.
- The method of support and position of supports.
- The type or weights of roof tiles or covering, including sarking, insulation and ceiling materials.
- The size and approximate position of any water tanks or other equipment to be supported on the trussed rafters.
- The overhang of the rafters at eaves, and other eaves details.
- The positions and dimensions of hatches, chimneys and other openings.
- The service use of the building, with reference to any unusual environmental conditions and the type of preservative treatment where required.
- The spacing of trussed rafters and special timber sizes where these are required to match existing construction.

Truss Manufacturer to Designer

- Finished sizes, species, stress grades or strength classes of timber members.
- The type, sizes and positions of all jointing devices with tolerances, or the number of effective teeth or nails required in each member at each joint.
- The positions and sizes of all bearings.
- Loadings and other conditions for which the trussed rafters are designed.
- The spacing of trussed rafters.
- The positions, fixings and sizes of any lateral supports necessary to prevent buckling of compression members, such as rafters and struts. (Details of the permanent bracing necessary to ensure the overall stability of the complete roof structure and supporting walls should be provided by the Building Designer).
- The method of support for tanks and ancillary equipment, together with the capacity or magnitude of additional load assumed.
- The range of reactions to be accommodated at the support positions, including those required to resist wind uplift forces.
- The basis of the design.
- Details of any changes in spacing to accommodate chimneys or openings.
- Any special precautions for handling and erection, in addition to those covered by BS EN 1995-1: 2004+A1.

7.8.3.2 Spans

Maximum permissible spans for the most common building types and rafter configurations are given in BS EN 1995-1: 2004+A1 Section 9. For designs that fall outside BS EN 1995-1: 2004+A1 conditions, the trussed rafter must demonstrate adequate jointing and structural integrity by calculation.

7.8.3.3 Loads

Trussed rafters and the framed roof must support the dead loads as specified in BS EN 1991-1 and BS EN 1991-1-7, the wind loads in BS EN 1991-1-4: 2005+A1 and the imposed loads in BS EN 1991-1-3. Loads acting on rafters are dead loads (tiles/slates, battens, underlay and rafter self-weight), imposed loads (snow load and maintenance) and the wind uplift load. Other dead loads that act on the ceiling ties (ceiling, insulation, water tanks and the tie self-weight) and imposed loads (loft access and weight of storage) will also have to be taken into account by the Designer.

BS EN 1991-1 and BS EN 1991-1-7 specify the following limits for imposed loads on the rafters uniformly distributed over the whole roof, measured on plan:

- Roofs pitched 10° to 30°: 0.75kN/m^2.
- Roofs pitched 31° to 75°: 0.75kN/m^2 – 0 kN/m^2 (reduced linearly).

Or:

- A concentrated load of 0.9kN, whichever produces the greater stress or deflection.

Experience shows that for most common tiled and slated roofs, the uniformly distributed load is more severe.

7.8.3.4 Bracing, support and typical roof openings (BS EN 1995-1-1: 2004+A1)

As stated above, the Designer is responsible for framing the roof. The correct bracing configuration locks all timber supporting roof elements into a single structural, load-bearing unit. Standard bracing details are given in BS 5268-3.

Appendix A and further information can be found in BRE Defect Action Sheets 83 and 84.

Where recovering of existing roofs occurs: Approved Document A Section 4, deals with the requirements for checking the structural integrity of the roof and supporting structure when considering the re-roofing of buildings.

For information and design criteria necessary for ordering: BS 5268: 3, provides a comprehensive list of criteria that should be supplied by the Building Designer or Site Supervisor to the Trussed Rafter Designer/Fabricator to enable a design to be prepared.

This includes:

- Span of the trussed rafter, wall plate to wall plate plus the width of wall plate at each end.
- Pitch of the roof.
- Method of support.
- Position of support.
- Anticipated loading of the roof structure, i.e. The weight of the roof tiles and the exposure of the site should it attract excessive wind loads.
- Position and size of water tanks.
- Position and size of openings, i.e. Loft hatches, roof windows, chimneys.
- Due to the site locality, any particular preservative treatment necessary for the timber, e.g. to protect against House Longhorn Beetle.
- Eaves details, i.e. overhang required, etc.

In return, the Trussed Rafter Designer should supply the following details for site use:

- Position, bearing and spacing of trussed rafters
- Position, fixings and sizes of lateral supports to prevent buckling of compression members such as rafters and struts.
- Deviations from standard spacings, etc. to accommodate openings.
- Support details for water tanks.
- Any special handling equipment.

7.8.3.5 Site storage

The delivery of trussed rafters should be planned so as to minimise the period of storage necessary on-site. When delivered, the trusses should, at all times, be kept clear of the ground and vegetation and be supported by level bearers sited under or adjacent to the points of support assumed by the design.

To prevent any distortion, there is a need to ensure that the trusses are stored in a vertical position, as in Figure 2.

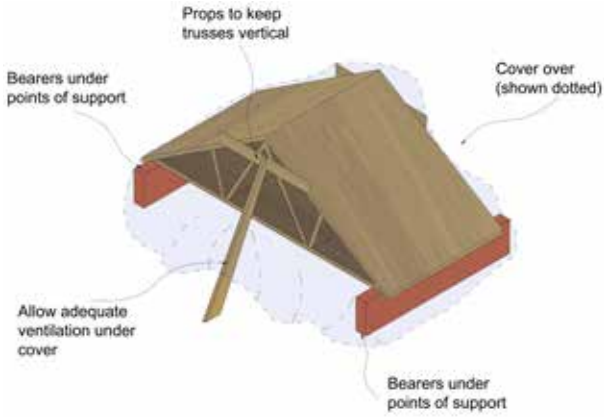


Figure 2: Site storage of trusses

Horizontal storage is sometimes possible, as in Figure 3. In both cases, stacks of trusses should be covered with a weather proof cover, whilst maintaining adequate ventilation to prevent the occurrence of condensation. Trusses should be checked visually upon arrival on the site for damage occurring during transportation, and again before site use for damage occurring during storage. Trusses with a moisture content exceeding 20% should not be installed.

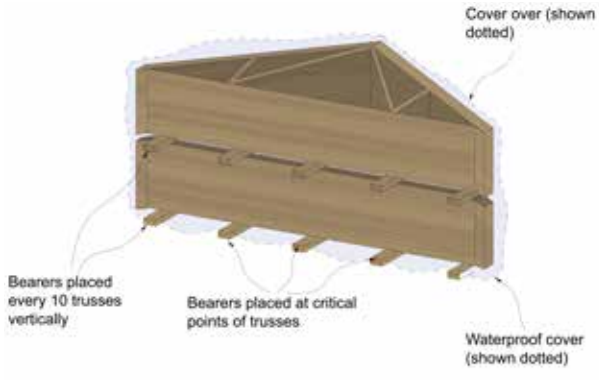


Figure 3: Horizontal storage of trusses

7.8.3.6 Handling and transportation

When transporting and handling trussed rafters, sagging and flexing should be avoided at all times. Whether handling is manual or by using mechanical equipment, trusses should be moved in a vertical position unless support can be provided to every joint.

Manual lifting

On long-span trusses, it may be necessary to employ additional labour at intermediate positions. If required, the truss may be inverted so that the apex hangs down. See-sawing the truss across walls and scaffolding must be avoided. Individual designs and site conditions may dictate different requirements in order to install trusses in their final position.



Figure 4: Suggested method of manual lifting

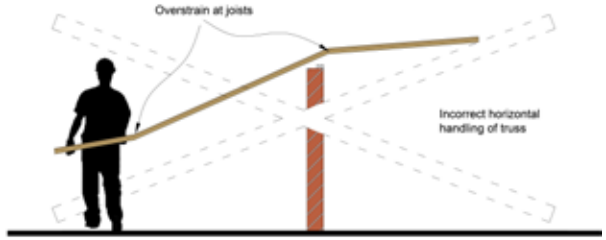


Figure 5: Avoid bending or see-sawing of trusses

Mechanical lifting

Ideally, when using mechanical lifting the trusses should be lifted in banded sets and lowered onto suitable supports. Lifting points should be rafter or ceiling intersections or node points. Lifting trusses singularly should be avoided, but where unavoidable a suitable spreader bar should be used to withstand the sling force.

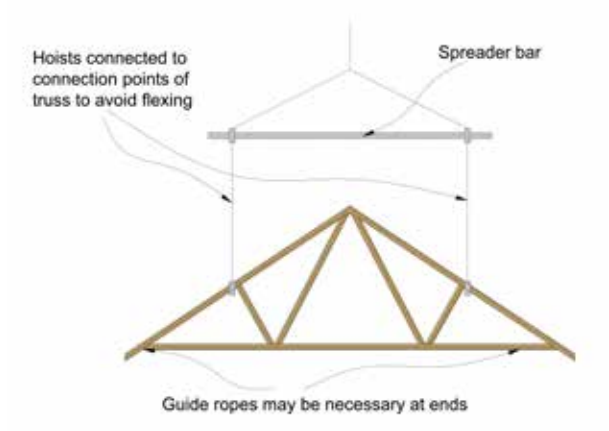


Figure 6: Mechanical lifting

7.8.3.7 Erection

It is essential when erecting a trussed rafter roof to ensure that the first trussed rafter is erected and braced rigidly in the correct vertical position so that it provides a base model against which all the other trusses can be set out.

Any temporary bracing should not be removed until permanent bracing has been installed. Immediately prior to the fixing of permanent bracing, the trussed rafters should be checked again for alignment and verticality.

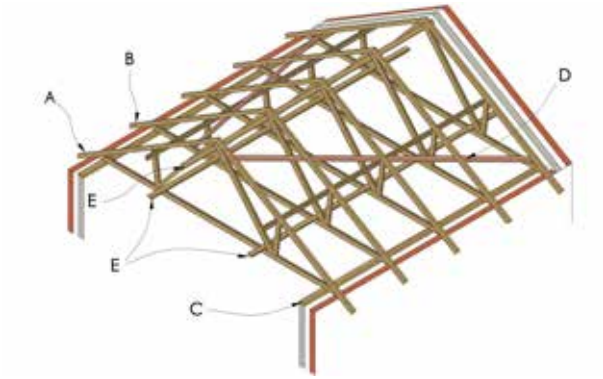


Figure 7: Trussed roof installation

- Before placing first truss, mark required position of trussed rafters on opposing wall plates.
- Erect and brace first trussed rafter (A) (only one shown but fix others as necessary).
- Erect next adjacent trussed rafter (B) and brace back to (A) using brace (C).
- Erect other trussed rafters as with (B).
- When the final accurate positioning of the trussed rafters has been confirmed, the rafter feet can be fixed into position.
- Fix permanent diagonal bracing (D) (only one brace shown for clarity).
- Fix longitudinal bracing (E) (only three shown for clarity).
- Fix all remaining bracing.
- Remove all temporary bracing.

The International Truss Plate Association Technical Handbook, available from trussed rafter suppliers, provides additional advice on trussed rafter erection.

7.8.3.8 Bracing to duo-pitched roofs

Fixing

To achieve a stable and wind-resistant roof and gable wall structure, the roof must be secured to the gable wall, if applicable, and fully braced by 100mm x 25mm timber, twice nailed to roof timbers using 65mm long x 3.35mm diameter galvanised wire nails. Where nail guns are used, 75mm long x 3.1mm diameter annular ring-shank nails are allowed. They do not need to be galvanised.

Types of bracing

There are three main types of wind bracing, which should be fixed:

- Diagonal rafter bracing.
- Longitudinal bracing.
- Chevron bracing (only necessary on trussed rafter spans over 8m).

Diagonal and longitudinal bracing are required in all trussed rafter roofs. Bracing for wind loads can also be enhanced by adequately fixed tiling battens and/or sarking boards. The ceiling plasterboard (12.5mm thickness) or a similar rigid material will also contribute to the bracing process. Sarking boards, such as moisture-resistant plywood (minimum thickness 9mm) and moisture-resistant chipboard (minimum thickness 12mm), may provide adequate bracing without the need for additional wind bracing to the roof. Sarking boards should be laid with staggered joints and nailed at 200mm centres on every truss with 50mm long x 3mm diameter galvanised round wire nails.

Longitudinal bracing

Longitudinal bracing is shown in Figure 7; it should be positioned tightly to abut separating and gable walls. In timber frame construction, you should ensure that longitudinal braces are fixed to timber frame gables/separating walls to provide additional lateral restraint.

Chevron bracing

Chevron bracing is only required for roof spans exceeding 8m, and it can be identified as diagonal bracing to the web members of the roof truss.

For spans of between 8m and 11m, such bracing may only be required to a single web member on either side of the roof. For spans exceeding 11m, more extensive chevron bracing may be necessary.

Mono-pitched roof bracing

In mono-pitched trussed rafter roofs, the diagonal bracing pattern for narrow-fronted houses should be adopted. The requirement for longitudinal bracing is the same as for duo-pitched trussed rafter roofs.

Chevron bracing is required to the webs in roofs exceeding a 5m span, and also to upright members where inadequate lateral restraint is provided at the apex of the roof.

7.8.3.9 Diminishing trusses

The Truss Roof Designer should provide details of fixings for the diminishing truss to the main roof truss.

- Where the diminishing truss has a splayed bottom chord that matches the pitch of the main truss (usually where the roof pitch is less than 30°), the truss can be skew-nailed to the main truss with two no 3.35mm diameter x 75mm galvanised wire nails.
- Where the diminishing truss has a square bottom chord, the truss can be skew-nailed to the main truss and supported on a continuous binder also fixed to the main truss. The top of the binder should be splayed to suit the bottom chord and; 2 no. 3.35mm diameter x 75mm. Galvanised wire nails should be used for the fixing.

7.8.3.10 Mono-pitch and girder trusses on trussed rafter hipped-end roofs

Mono-pitch trussed rafters can be used in conjunction with girder trusses on trussed rafter hipped roofs.

Mono-pitched trusses are fixed to girder trusses using metal shoes. The bearing of mono-pitched trusses onto the mild steel proprietary girder shoe should be confirmed with the Roof Designer before site installation is attempted.

Girder trusses are strengthened trusses designed to support loads in another plane (such as mono-pitched trusses).

7.8.3.11 Multiple-trussed rafters

Multiple-trussed rafters may be specified for a particular purpose, and may be delivered to site already fastened together. Alternatively, fixing together on-site of multiple rafters may be necessary, in which case it will be necessary to get full details of the fixing specification from the Roof Designer.

7.8.3.12 Provision for openings, i.e. loft hatches, chimneys, etc.

Wherever possible, a trussed rafter roof should be designed to accommodate necessary openings within the trussed rafter spacing, e.g. a loft hatch. If this is not possible, the spacing of trussed rafters may be extended to accommodate an opening. The Roof Designer should provide all necessary details.

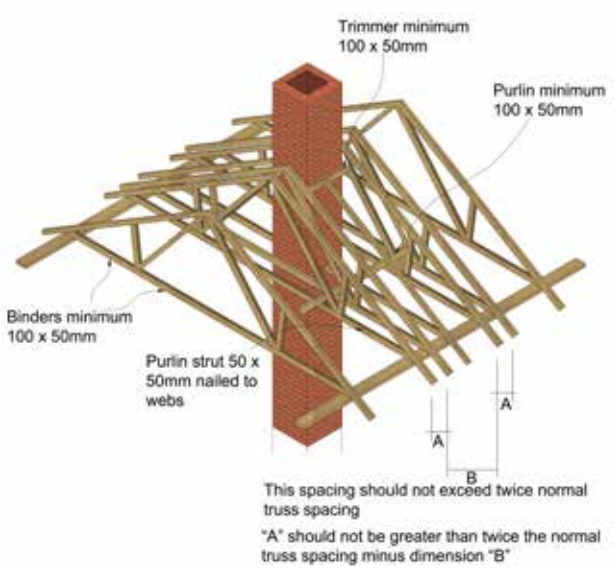


Figure 8: Roof trusses trimming around a chimney

7.8.3.13 Tank stands

Confirmation should be obtained from the Roof Designer that a trussed rafter roof design is capable of supporting water storage tanks. Tanks should be supported by bearer beams, on the ceiling ties portion of the truss. Bearers should be skew-nailed to supports as appropriate. Alternatively, proprietary joist hangers can be used. Tank bearers should be situated as close as possible to the node or intersection points of

the trussed rafter. The dimensions of the bearers depend upon the size of the supported tank and the span of the trussed rafters.

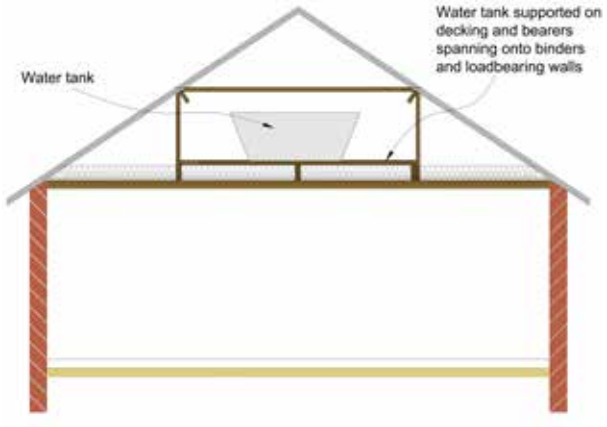


Figure 9: Tank stand configuration

7.8.3.14 Modifications to trussed rafters

Trussed rafters should never be cut, altered or repaired for use without the full agreement of the Trussed Rafter Designer. Remedies for defects to erected trusses can be found in BS 5268: 3, but the Roof Designer's advice should be sought prior to repairs being carried out.

7.8.3.15 Combined trussed rafter and traditionally framed roofs

Extra care is necessary where the two principal timber pitched roof types are used in conjunction. The trussed rafters should be specifically designed to accept any additional loadings imposed by an adjacent traditional roof. Similarly, account should be taken of any loadings imposed by trusses on traditional roofs where only nominal loadings have been allowed for. If in doubt, consult the Roof Designer.

7.8.4 Traditional pitched roofs

7.8.4.1 General

Traditionally framed roof

The moisture content of structural timber should not exceed 20% at the time of stress grading and at the time of erection. All structural timber for use within the building fabric should be stress graded and marked 'KD' (Kiln Dry) or 'DRY'.

The purlins/binders should be adequately supported to contribute fully to the roof structure. For example, they could be built into the inner leaf of a gable end wall and supported by struts onto the load-bearing structure at centres specified in the design.

Always ensure that the correct strength class of timber is both ordered and used. Structural timbers are allocated a strength class by BS 5268: 2. The most common strength classes used are C16 and C24.

- The timber supplier will require the following information before supplying timber: type and strength class of timber required.
- Required sizes of timber.
- Any treatment required.

7.8.4.2 Definitions

Couple roof

This is the simplest method of producing a pitched roof, consisting of pairs, or couples, of rafters pitched against each other at their heads, with feet bearing on opposite walls. It is economical, but structurally limited, as heavy supporting walls are required to resist outward spread. When a steep pitch is combined with low eaves, the resulting clear roof space can be used to advantage. Where such roofs are designed, full structural calculations prepared by a Chartered Structural Engineer should be provided to demonstrate how eaves spread will be prevented.

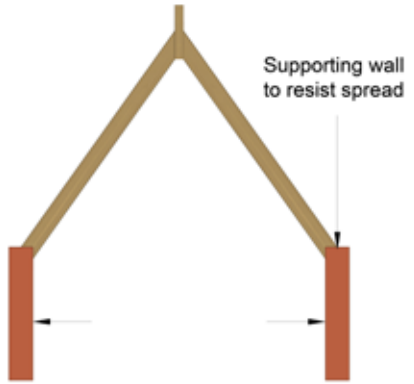


Figure 10: Couple roof

Close couple

Pairs of rafter feet are joined together with ties, often doubling up as ceiling joists, to form triangulation. The tie resists the outward thrust, and load is transferred vertically to supporting walls. The connection of ceiling joists or ties with a binder, supported from the ridge by hangers, allows a smaller timber section to be used. Rafter and ceiling joist dimensions for typical spans are given in the TRADA document, Span Tables for Solid Timber Members in Floors, Ceilings and Roofs for Dwellings.

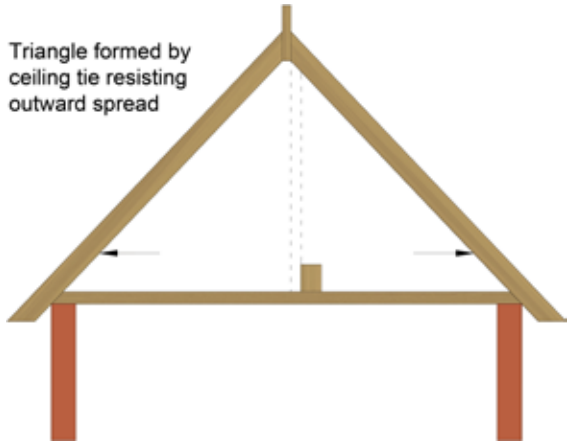


Figure 11: Close couple roof

Raised collar roof

When ties are introduced at a higher level than the rafter feet, they are termed 'collars'. The higher the collar, the less influence on rafter spread and the larger the rafter section required to resist the bending moment. The height of supporting walls may be reduced, as the roof is effectively lowered so that the rafters and collars support the ceiling. To resist eaves spread, the height of the collar should be no higher than a third of the vertical height between the wall plate and ridge. Rafters supporting collar ties should be designed by a Chartered Structural Engineer, taking into account the additional point load imposed by the collar. The collar should be fixed to the rafters using 10mm bolts and incorporating large washers to prevent the bolt from being pulled through the timber.

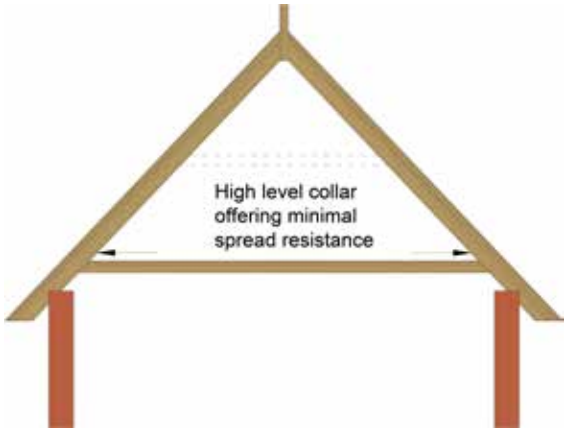


Figure 12: Raised collar roof

7.8.5 Fire stopping

Compartmentation

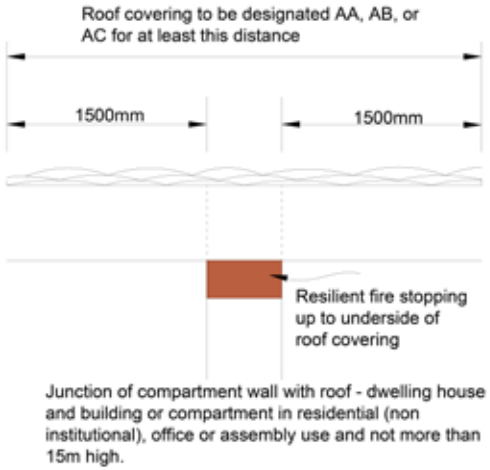
The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

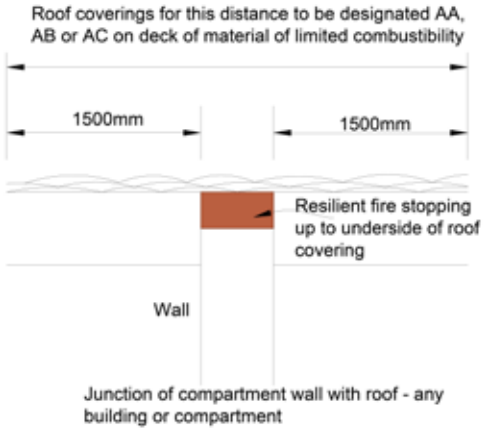
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment.

To reduce this risk, a roof zone 1,500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.





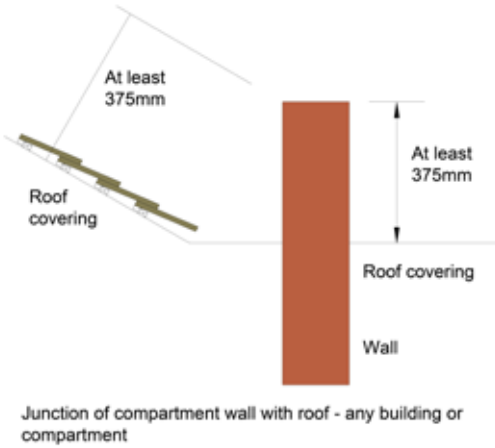


Figure 13: Typical fire stopping details

FUNCTIONAL REQUIREMENTS

7.9 ROOF COVERINGS - TRADITIONAL SLATE AND TILES

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture from passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents A must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.9.1 Legislation and planning

Tiled and pitched roof coverings should be in accordance with the relevant Building Regulations.

The principal British Standards relevant to this document are:

- BS 5534 Code of Practice for slating and tiling (including shingles). This gives recommendations for the design, materials, application, installation and performance of slates and tiles (BS 5534 should be read in conjunction with BS 8000-6).
- BS 8000-6 Workmanship on building sites. Code of Practice for slating and tiling of roofs and claddings. This applies to the laying and fixing of clay and concrete tiles, natural and fibre cement slates and their associated fixings and accessories.
- BS 5250 Control of condensation in buildings. This describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for control of condensation in roofs.

To ensure safe working practices during construction, the Designer should consider relevant safety regulations. These include the Construction (Design and Management) Regulations and the Health and Safety Executive's Approved Code of Practice for Management of Health and Safety at Work.

Certain advisory bodies, such as the Loss Prevention Council, Building Research Establishment Ltd (BRE) and Timber Research and Development Association (TRADA), also produce recommendations and guidance on roof construction.

7.9.2 Weather exposure

7.9.2.1 Rain and snow

The roof of the building shall adequately protect the building and people who use the building from harmful effects caused by precipitation and wind-driven spray. Roofs are required to resist the penetration of precipitation (rainfall) to the inside of the building, thereby preventing damage to any part of the building where it might be carried.

Most pitched roofs keep the rain and snow out of the building and give a satisfactory performance. However, it is acknowledged that similar roofs built to the same design and using identical roof materials, but in different locations, may not necessarily provide the same level of assurance since they will be subject to different weather conditions and exposure.

Exposure to driving rain

The UK has a high risk of severe driving rain, and even in some sheltered locations may be subject to high levels of deluge rainfall. BS 5534 defines two categories of exposure, based on the driving rain data given in BS 8104 and BR 262, and should be used for buildings up to 12m in height. For buildings over 12m in height, the influence of increased wind speeds should be taken into account using BS EN 1991-1-4: 2005+A1.

Performance of tiles and slates

Rain penetration of the roof covering is dependent on a combination of the rainfall rate, wind speed and the ability of the roof tile or slate to resist the ingress of snow and rain water. The Designer should therefore be aware of the various means by which rain and snow can, under certain conditions, penetrate the roof covering.

These include:

- Capillary action and rain water creep.
- Raindrop bounce and negative pressure rain suction.
- Driving rain, deluge rain and flooding.
- Surcharging of rain water over laps on long-rafter roofs.
- Wind-driven snow.

Roof pitch
When determining the pitch, head-lap and/or side-lap of a tile or slate, the roof pitch is taken to be equal to the rafter pitch. Hence, all references to pitch refer to the rafter pitch, with the laid angle of the roof tile or slate always being less than roof pitch.

The actual pitch of a slate or tile should be determined in accordance with the following guidelines:

- Tile/slate to rafter pitch angles.
- Plain tiles: 7° less than rafter pitch.
- Interlocking single-lap tiles and slates: 5° less than rafter pitch.
- Double-lap fibre cement slates: 1.25° less than rafter pitch.

If the design rafter pitch is less than the minimum recommended rafter pitch for the particular tile or slate, then they can be considered as having an aesthetic function only. In such cases, the true weather proofing of the roof system must rely on a fully supported waterproof membrane with an uninterrupted drainage path between counter battens to the eaves gutter.

7.9.2.2 Wind

Design for wind loading
When considering the wind loading on the roof covering, Designers should consult BS 5534. This provides calculation methods to assess the wind load on each tile or slate as a uniformly distributed load, and also takes into account the porosity of the tiles or slates and the effectiveness of the substrate (boarding or sarking), and/or underlay shielding, when calculating wind uplift loads.
The standard method in BS EN 1991-1-4: 2005+A1 Eurocode 1. Actions on structures. General actions. Wind actions should be used to determine the basic wind speed of the site, which is then used to calculate the effective wind speed and dynamic wind pressure on the roof by applying a series of factors to account for terrain, topography, building height and length, etc.

Control of internal pressure
The total wind force on a roof is dependent on the pressure differential between the inner and outer faces of the roof covering. Such pressures are significantly reduced by the use of underlay or boarding beneath tiling or slating. Its contribution towards shielding the underside of the tiles or slates from the full transmission of internal pressures means the underlay is required to have an adequate tensile strength for the specific application. The tensile strength of the underlay, its air permeability factor and the withdrawal resistance of batten nail fixings are therefore important when determining the overall resistance to wind uplift of the roof system.

Ridges, hips, verges and valleys
The use of mortar for the bedding of concrete or clay ridge and ridged hip tiles on concrete or clay tiles or fibre cement slates; does not provide sufficient tensile bond strength to resist wind uplift as it can be affected by a number of factors, such as wind loadings, mix of mortar, design and movement of the roof structure. The use of mortar bedding should be supplemented by suitable mechanical fixings to ensure the component is mechanically fixed.

Note: Dry fix ridge and hip systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

Aircraft vortices
Roofs near airports can experience high local wind load forces due to air vortices created by certain aircraft when taking off and landing, which may be greater than the wind loads calculated to BS 5534. Designers should seek advice from the Airport Authority Planning Department when designing roof fixings in these locations, and refer to the guidance contained in BRE Digest 467 Slate and tile roofs: avoiding damage from aircraft wake vortices.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for tiles and slates in accordance with BS EN 1991-1-4: 2005+A1 and BS 5534 are complex to undertake. Designers are advised to obtain a full roofing fixing specification either from the slate or tile manufacturer or by reference to the Zonal Fixing Method tables, which provide a conservative interpretation of the fixing requirements in BS 5534.

Zonal fixing method

The zonal method is a means of obtaining a fixing specification for roof tiles and is a simplification of the calculations defined in BS 5534 Code of Practice for slating and tiling (including shingles) and BS EN 1991-1-4: 2005+A1 Eurocode 1. Actions on structures. General actions. Wind actions. The assumptions made in the simplification process may produce a specification with more or stronger fixings than those required if the full BS 5534 calculation is used.

Zonal fixing specification	Single lap tiles	Double lap tiles
A	No fixings required	Refer to manufacturer
B	Each tile once nailed (right hand nail hole – flat tiles)	
C	Each tile twice nailed (flat tiles only)	
D	Each tile clipped	
E	Each tile once nailed and clipped	
F	Each tile twice nailed and clipped	

Notes:

(1) The manufacturer may also specify the use of improved nails for fixing tiles, e.g., ring shank nails. Where these are required, the Zonal fixing specification letter will be marked with an asterisk, e.g., C*.

(2) Manufacturers may define additional fixing specifications to those in the table and assign fixing specification letters from 'G' onwards.

(3) In some cases, the manufacturer may specify a 'proprietary fixing system' and this will be marked 'PS'. The manufacturer should be contacted for details of the requirements for this fixing method.

Table 1: Zonal fixing specification

7.9.3 Condensation and ventilation

7.9.3.1 Statutory requirements

The roof should be designed and constructed in accordance with clause 8.4 of BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250 Code of Practice for control of condensation in buildings, Section 8.4 Roofs.

Prevention of condensation in roof voids is best achieved through the provision of natural air ventilation. BS 5250 states that the Designer should take account of the following moisture sources in buildings:

- Water incorporated during the construction process (including precipitation).
- Precipitation after construction.
- Water vapour arising from the occupants and their activities.
- Temporary condensation occurring when cold weather conditions are followed by warm, humid weather.

Sealed ceilings

BS 9250 emphasises the importance of well-sealed ceilings as a means of curbing the transfer of moisture into a roof space by means of moisture-laden air.

This means:

- The avoidance of gaps and holes in a ceiling.
- The siting of access doors or hatches into the roof space away from moisture-producing areas, such as bathrooms or kitchens.
- That hatch covers must be effectively sealed.
- High levels of workmanship.

Air tightness of ceilings

Air leakage through gaps in a ceiling transfer more heat and moisture into the roof by convection than passes through the ceiling materials by diffusion. Sealing the ceiling is therefore an essential requirement when considering the design of the roof envelope.

Key design issues to consider are as follows:

- Avoid construction gaps.
- Avoid roof access doors or hatches in rooms that produce excessive moisture.
- Use a proprietary sealed loft hatch and frame, and seal correctly in accordance with the manufacturer's recommendations.

There is advice found in BS EN 13141-1 Ventilation for buildings. Performance testing of components/ products for residential ventilation. Externally and internally mounted air transfer devices:

- Seal all services and roof lights.
- Use recessed light fittings rated IP60 to IP65 to BS EN 60529.
- Seal the head of cavity walls to prevent the transfer of warm moist air into the loft.

It is recommended that Designers should undertake a Condensation Risk Analysis in accordance with BS 5250 to determine the level of ventilation required.

7.9.3.2 Cold roof

The following suggest the correct positioning of vents and the precise amount of free airspace required for four types of 'cold roof' construction, in accordance with current Building Regulations and BS 5250.

These recommendations apply if a high water vapour resistance (type HR) underlay is used.

Mono-pitch/lean-to roof

If the roof space is 15° or less, a free airspace of 25,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than 15°, a free airspace of 10,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). A free airspace of 5,000mm^2/m should also be provided at high level (equivalent to a continuous 5mm opening).

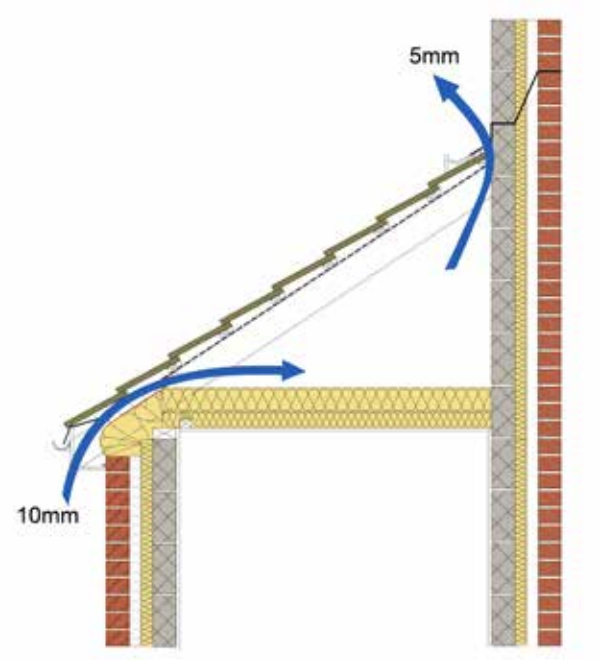


Figure 1: Mono-pitch/lean-to roof

Duo-pitch roof A

On each side of the roof, a free airspace of 10,000mm²/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is 15° or less, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening).

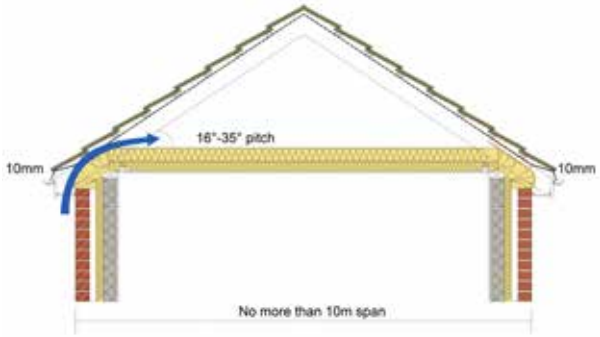


Figure 2: Duo-pitch roof A

Duo-pitch roof B

Where pitches are 35° or greater and spans are 10m or wider, a free airspace of 5,000mm²/m should also be provided at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation.

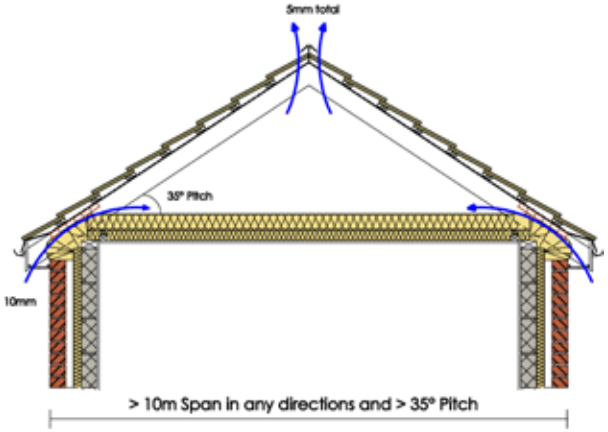


Figure 3: Duo-pitch roof B

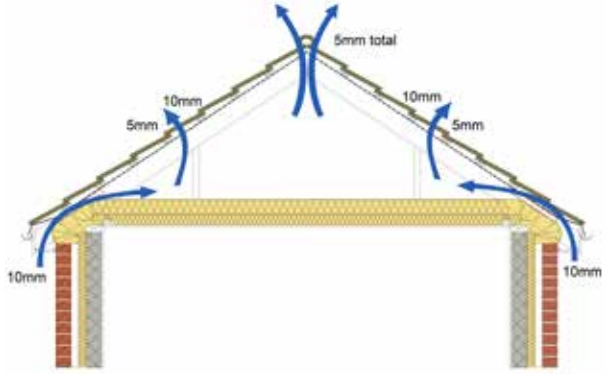


Figure 4: Duo-pitch roof with fire break walls

Duo-pitch roof with fire break walls

This is similar to examples A and B, but with a firewall beneath each roof pitch. The roof now comprises three voids instead of one, and for the purposes of ventilation, each roof void is treated separately. The two smaller voids each require 10,000mm²/m of free airspace at the eaves or at low level, and 5,000mm²/m at high level below the firewall.

The larger void requires 10,000mm²/m of free airspace immediately above the firewall at low level, and 5,000mm²/m at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation.

Vapour permeable (type LR) underlays

If an LR underlay is used, interstitial condensation is unlikely to occur, provided the ceiling is well sealed and the eaves have a minimum continuous ventilation opening of 3mm. If the ceiling is not well sealed, openings equivalent to 7mm should be used; 10mm eaves vent systems will satisfy both requirements.

BS 5250 does not consider the situation where it is proposed to provide no ventilation to the roof void, or ventilation more limited than described above. Should Designers wish to adopt this principle, they should refer to the conditions attached to Technical Approvals given by UKAS (or European equivalent) accredited technical approval bodies.

7.9.3.3 Roof with sloping ceilings

The following illustrations suggest the correct positioning of vents and the precise amount of free airspace required for three types of 'warm roof' construction, in accordance with BS 5250.

Duo-pitch roof

On each side of the roof, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening). A free airspace of 5,000mm²/m should also be provided at the ridge or at high level on each slope (equivalent to a continuous 5mm opening). A minimum 50mm clear air path must always be maintained between the insulation and the underlay to ensure effective through-ventilation.

Mansard roof

Mansard ventilation is similar to that for duo-pitch constructions, requiring a free airspace of 25,000mm²/m on each side at the eaves or at low level (equivalent to a continuous 25mm opening), and 5,000mm²/m at the ridge or at high level (equivalent to a continuous 5mm opening).

A minimum 50mm clear air path must be maintained between the insulation and the underlay at mansard level to ensure effective through-ventilation.

Pitched roof with pitched and flat dormers

For the main roof, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening), plus 5,000mm²/m at the dormer sills and 5,000mm²/m on each side of the ridge or at high level on each slope (equivalent to a continuous 5mm opening). For dormers with cold pitched roofs, a free airspace of 10,000mm²/m is required at the dormer eaves (equivalent to a continuous 10mm opening). For dormers with flat roofs, a free airspace of 25,000mm²/m is required at the roof edges (equivalent to a continuous 25mm opening).

A minimum 50mm clear air path must always be maintained between the insulation and the underlay to ensure effective through-ventilation.

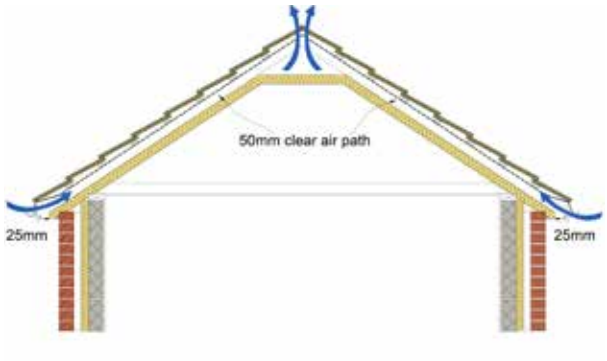


Figure 5: Duo pitch roof with sloping ceilings

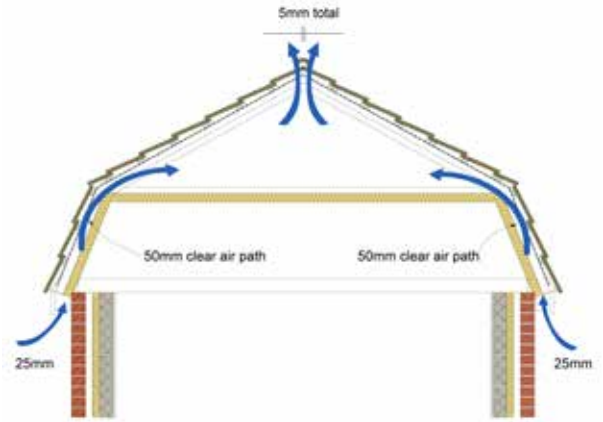


Figure 6: Mansard roof

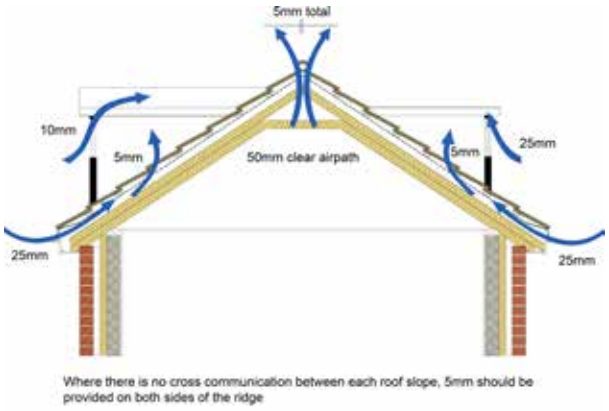


Figure 7: Pitched roof with pitched and flat dormers

Tiled and slated roofs containing rooms
These should be ventilated in accordance with Figures 5–7, but if an obstruction to a ventilation path occurs, such as fire-separating walls, additional ventilation openings should be provided:

- Immediately below the obstruction, equivalent to 5mm along the length of the obstruction.
- Immediately above the obstruction, equivalent to 25mm along the length of the obstruction.

7.9.3.4 Warm roof construction

Insulation may be provided above the rafter and between rafters to form a warm roof construction. The position of insulation and Vapour Control Layers (VCL) must strictly adhere to the insulation manufacturer's recommendations. All warm roof construction products must have appropriate third-party certification.

Ventilation to counter batten void will be required where vapour permeable (type LR) underlays are not used.

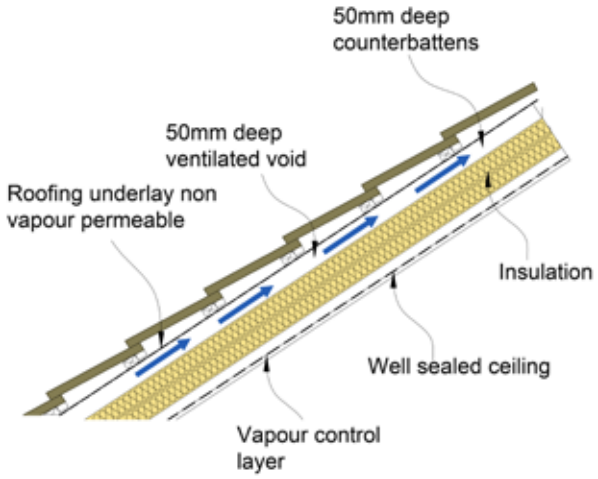


Figure 8: Warm roof construction (vented battens)

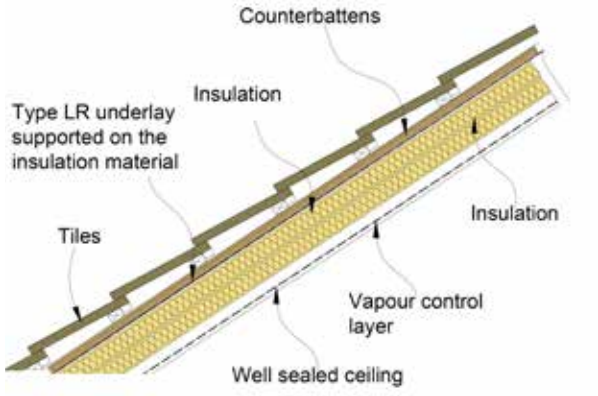


Figure 9: Warm roof construction (vapour breathable underlay)

7.9.4 Thermal insulation

7.9.4.1 Building Regulations

Thermal insulation must be installed to meet current Building Regulations, to an acceptable level of workmanship, to avoid cold bridges and to meet the following provisions:

- If required by BS 5250, use a vapour control plasterboard or a separate VCL behind the plasterboard.
- Use a proprietary eaves ventilator to ensure ventilation is in accordance with BS 5250.
- The use of over joist and under rafter insulation is considered best practice, as it eliminates the cold bridge caused by the joist/rafter.
- The installation of the eaves ventilator must not prevent free water drainage below the tiling battens.

7.9.4.2 Compliance

The requirements of the regulations are designed to reduce carbon emissions from new buildings and improve the performance of existing buildings where new work is carried out.

7.9.5 Materials

7.9.5.1 Underlay

Underlay nails

Nails for use with roofing underlays should be clout head nails of no less than 3mm shank diameter and 20mm length made of copper, aluminium alloy or steel coated by any of the zinc or zinc alloy coating methods specified in BS EN 10230-1.

Underlay

These types of underlay should comply with BS EN 13859-1 or have third-party accreditation, i.e. a BBA certificate.

There are two categories of underlay: HR, non-vapour permeable and LR, vapour permeable. These types of underlay should comply with BS EN 13859-1 or have third-party accreditation, i.e. a BBA certificate. They should also have sufficient tensile and nail-tear strength, and low extensibility, to produce the required resistance to wind uplift.

Underlays for use beneath tiles and slates are either fully supported over boarding, sheathing or sarking, or unsupported and draped over rafters/counter battens, and should meet the conditions detailed in Figure 10.

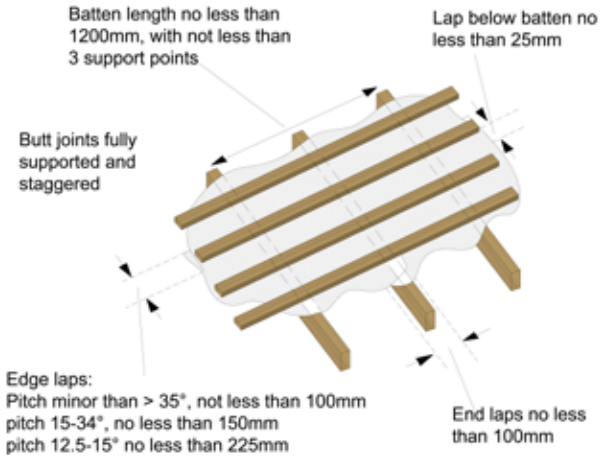


Figure 10: Roof underlay provision

Fully supported underlays

- BS 8747 Class 1B Bitumen (Fibre base).
- 2HR* underlay to BS EN 13859-1 Class W1 water penetration classification with third-party certification for the use intended.
- 3LR† underlay to BS EN 13859-1 Class W1 water penetration classification with third-party certification for the use intended.

Unsupported underlays

- BS 8747 Class 1F reinforced bitumen or Class 5U polyester reinforced bitumen.
- HR* underlay to BS EN 13859-1 Class W1 water penetration classification with third-party certification for the use intended.
- LR† underlay to BS EN 13859-1 Class W1 water penetration classification with third-party certification for the use intended.

* HR (high water vapour resistance) underlay > 0.25MN.s/g

† LR (low water vapour resistance) underlay < 0.25MN.s/g

(LR underlays are sometimes referred to as 'vapour permeable' or 'vapour open').

Vapour Control Layer (VCL)

If a VCL is installed it should be placed on the warm side of the insulation. Installation of a VCL at ceiling level will increase the need for sufficient ventilation below it during the drying out of wet trade construction phases. The performance of a VCL depends not only on the material selected, but also on the workmanship and the ability of the construction to be assembled on-site (see BS 5250). It is essential that a VCL be adequately lapped and all joints sealed, and that its integrity is maintained. Particular attention should be paid to detail design and installation around penetrations through the VCL, e.g. services, compartment walls and to the sealing of punctures caused by fixings.

7.9.5.2 Timber battens

Timber species
Tiling battens and counter battens should be selected from the timber species set out in BS 5534, and their characteristics and defects should not exceed the permissible limits given in Annex C of BS 5534.

Sizes
Timber battens should be graded and marked in accordance with BS 5534. Timber batten sizes should be not less than the minimum values recommended in BS 5534 for the common applications listed therein.

Other sizes
Battens for large spans or special loading conditions should be designed by structural calculation for strength and stiffness, in accordance with Annex E of BS 5534.

Preservatives
BS 8417: 2011 provides recommendations for preservatives for timber. Indicative preservative treatment schedules are given in Annex D of BS 5534. Battens treated with preservatives can contain toxic substances that could introduce an environmental hazard, and should be disposed of safely.

7.9.5.3 Tile and slate fixings

BS 5534 recommends the use of aluminium or stainless steel nails under normal conditions of exposure. Plain or galvanised nails may be used for fixing battens to rafters, but care must be exercised when there is high humidity as certain timber preservative treatments may corrode steel, zinc or aluminium.

Tile nails
Nails for use with tiles should be of copper, aluminium, stainless steel, phosphor or silicon bronze. Aluminium nails intended for use with tiles should conform to BS 1202-3 and should be clout head nails of 3.35mm or 2.65mm diameter. The length of nail will be determined by the required wind uplift and the design of the tile. Stainless steel nails for use with tiles should conform to BS 1554 grade 302, 304, 315, 316, 321 or 347, and should be specified for coastal areas, areas of high exposure or where there is a risk from chemical reaction.

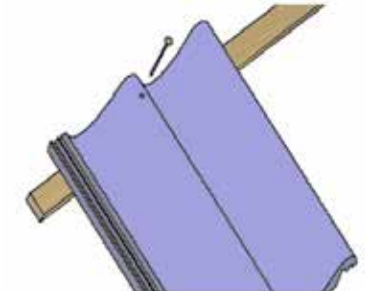


Figure 11: Nailing tiles to battens

Tile clips
Located over the side lock of the tile immediately behind the overlapped tile, and nailed to the tiling batten, tile clips provide resistance to the applied overturning moment more successfully than a nail fixing. The latter is closer to the pivot line, where the nib touches the batten and cannot resist the uplift force at the tail. The phenomenon is also related to roof pitch and the step height of the roof covering, and BS 5534 acknowledges that, at roof pitches of 45–55°, all tiles should be at least nailed to battens to prevent displacement. At pitches exceeding 55° all tiles must be both head nailed and tile clipped to reduce 'chatter' in high winds.

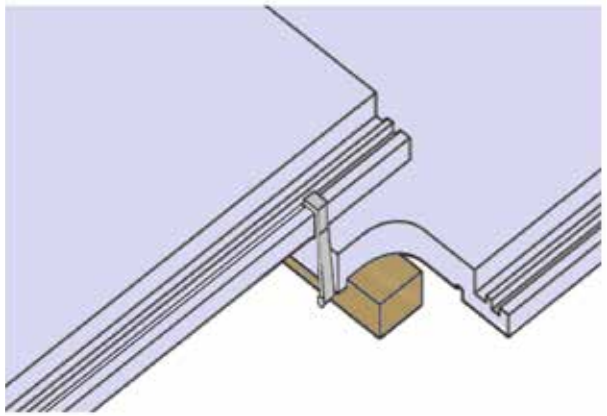


Figure 12: Tile clips

Slate nails and rivets
Nails intended for use with fibre cement slates should be of copper, conforming to the requirements for clout nails specified in BS 1202-2. The shank diameter and length should be determined by the exposure of the site and the nail's withdrawal resistance. Normally, 30mm x 2.65mm copper nails are adequate for most applications. For exposed sites, or where aggressive environments are encountered, contact the slate manufacturer. Copper disc 'tail' rivets are used to further secure the tail of fibre cement slates against wind chatter.

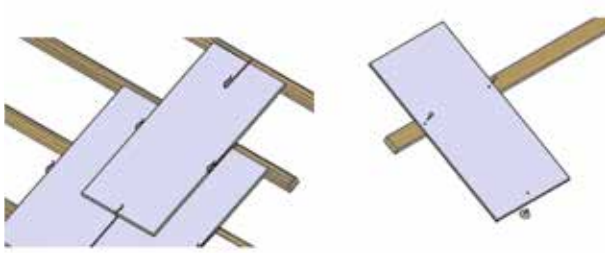


Figure 13: Fixing slates

Slate hooks
Hooks are formed from stainless steel wire conforming to BS 1554 grade 316 S11 or 316 S19. For further advice on the use of slate hooks, refer to BS 5534 Section 4.13.3 Hooks and rivets for slates.

7.9.5.4 Flashings and weatherings

Lead is generally ideal for roofing purposes; it is easily dressed over complicated shapes using simple hand tools, and can be joined by soldering or lead burning. For most roofing purposes, Codes 3, 4 and 5 will be adequate, but for extreme conditions of exposure, thicker codes may be necessary.

Lead sheet used for roofs, flashings and weatherings should, in terms of suitability to meet the requirements of the Technical Manual, be in accordance with BS EN 12588 or a valid UKAS (or European equivalent) third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use (see Chapter 2.3.5).

Clips
Clips for flashings are important in all roofing applications, and where used should be fixed at 300mm–500mm centres, depending on the exposure of the building.

Clips may be formed from the following materials:

- Lead: Only suitable for sheltered locations with a thickness the same as that of the flashing it is fixing.
- Copper: Should be a minimum of 0.6mm thick, and may be thicker for very exposed locations.
- Stainless steel: Should be 22swg or 28swg thick, and is used for very exposed locations or where the fixing point is more than 75mm from the free edge of the flashing.
- Nails and screws: Copper wire nails (with jagged shanks) should be a minimum 25mm long x 10 gauge. Stainless steel annular ring shank wire nails should be a minimum 25mm long x 12 gauge. Screws should be brass or stainless steel, minimum 25mm long x 10 gauge.

7.9.5.5 Mortar

The mortar used in roof construction should conform to the recommendations given in BS 5534. Mortar should typically consist of a cement and sand mix based on sharp sand, with soft sand added to achieve workability. The proportion of sharp sand should not be less than a third of the total sand content.

Alternative proprietary mortar mixes may be accepted if they are shown to have similar strength, durability and workability.

7.9.6 Workmanship

7.9.6.1 Slate and tile fixing

Slate and tile fixing should be in accordance with BS 8000-6.

7.9.6.2 Fixing timber battens

Battens and counter battens should be graded to meet requirements recommended in BS 5534 in respect to timber species, permissible characteristics and defects and preservative treatment. Battens should be at least 1200mm in length and supported at each end and intermediately by at least three rafters, trusses or walls. Stagger butt joints over intermediate supports, splay nail each batten end and nail battens to each rafter.

On trussed rafter roofs for interlocking tiles, allow no more than one joint in any four consecutive battens on the same support. On trussed rafter roofs for plain tiles, allow no more than three joints together in any twelve consecutive battens on the same support. The batten sizes given in Table 2 should be taken as minimum dimensional requirements. Take care that nails used to secure tiles do not penetrate the underside of battens or the underlay.

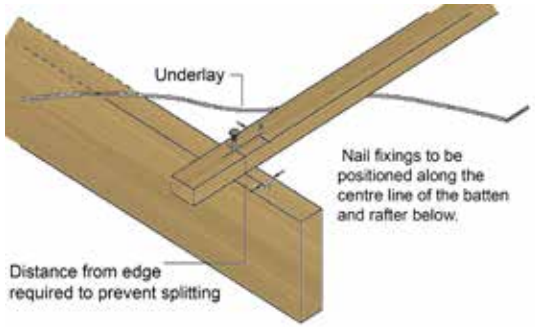


Figure 14: Fixing battens to rafters

Recommended batten sizes for pitched roofs and vertical work (BS 5534 in accordance with clause 4.12.4.1):

Tile type	Basic minimum sizes*			
Rafters/supports	450mm span		600mm span	
	Width	Depth	Width	Depth
Plain pitched / vertical	38	25	38	25
Single lap interlocking tiles / slates	38	25	50	25
Fiber cement Slates	38	25	50	25

* All dimensions subject to re-sawing allowance: width + 3mm depth - 0 or + 3mm based on measurement at a reference moisture content of 20%.

Table 2: Minimum sizes of timber battens

Fixing roof battens

Fix the specified battens up the roof slope on top of the rafters, ensuring a minimum 40mm nail penetration into rafters (smooth shank). Nail counter battens at maximum 300mm centres vertically up the roof slope where boarding is used to coincide with the line of rafters.

Fixing wall battens

Fix the specified battens to boarding/sheathing/sarking in line with vertical supports, or to a masonry wall as specified. Secure counter battens to masonry walls with improved nails or with plugs and screws.

7.9.6.3 Underlays

Lay the specified roofing underlay parallel to eaves or ridge with horizontal overlaps, as specified in Table 3. Vertical side laps should be a minimum of 100mm. Minimise the gap at laps resulting from different tautness between underlay courses. Drape in underlay between supports is to be no less than 10mm and no greater than 15mm. Fix underlay with the fixings specified, keeping the number of perforations to a minimum. Handle and fix underlay with care to ensure there are no tears or punctures, and repair any tears or punctures prior to tiling. Ensure that the underlay does not obstruct the flow of air through ventilators located at eaves, ridge or in the main roof, and appropriately weather all holes formed in underlays for soil vent pipes, etc. Avoid contact between the underlay and the underside of tiles, while to prevent wind uplift, fix additional battens or timber strips where laps occur between tiling battens.

Minimum horizontal lap for underlays (BS 5534 in accordance with clause 6.2.1.1):

Rafter pitch	Not fully supported (mm)	Fully supported (mm)
12.5° to 14°	225	150
15° to 34°	150	100
35° and above	100	75

Table 3: Minimum horizontal laps for underlays

7.9.7 Slate and tile details – key check points

7.9.7.1 Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6)

At the eaves (bottom edge), the batten should be set to provide the required overhang of the tiles, slates or shingles into the gutters. The recommended overhang is 45mm–55mm horizontally, or to the centre of the gutter, whichever is less.

- Ensure fascia board is to correct height so as to prevent tiles/slates kicking up or drooping
- Fit duct trays to retain insulation
- Fix underlay protector trays, fascia vents and comb fillers (profiled tiles)
- Clip eaves course where required
- Ensure vent path to roof space is achieved

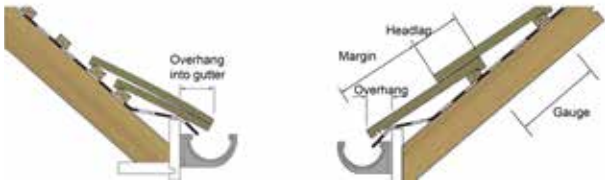


Figure 15: Eaves and bottom edge details

7.9.7.2 Verge (in accordance with BS 5534 and BS 8000-6)

Battens should overlap onto the outer skin of the brickwork or the undercloak material; for plain tiles, the verge should project 38mm–50mm; interlocking tiles can project 30mm–60mm. Where the distance of the nearest batten fixing to the rafter is greater than 300mm, an additional mechanical fixing is recommended.

Note: Where proprietary verge tiles or systems are specified, the detailing should be in accordance with manufacturers' recommendations that are relevant to UK conditions of use.

- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter tiles and slates (clip and/or nail).

Undercloak

Where an undercloak is used, it should comprise plain tiles, slates or fibre cement sheet strip. It is usually fixed at verges beneath the battens and on top of the underlay to support the mortar onto which the verge tiles or slates are bedded.

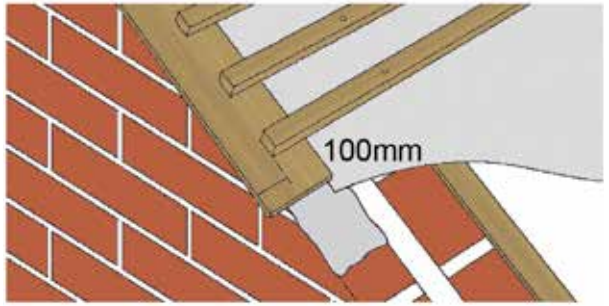


Figure 16: Verge detail

7.9.7.3 Valley (in accordance with BS 5534 and BS 8000-6)

The design of pitched valley gutters is just one roof detail where the latest guidance is much improved over previous Codes of Practice. The valley is the most vulnerable area of a pitched roof in respect to potential water ingress, as it drains all of the water from adjacent roof slopes.

Consequently, the design data is related to the pitch of the roof, the rainfall rate, the length of the valley and the catchment area or area of the roof to be drained. Designers are able to determine the

width of valley trough appropriate for discharging the rain water from the adjacent roof covering to the eaves gutter.

- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure ground work provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay beneath lead sheet valley.
- Keep open gutter width 100mm–250mm (correct width to be determined by reference to Table 14 in BS 5534).
- Keep roof design as simple as possible.
- Avoid discharge of valleys onto roofing wherever possible, but where inevitable use a lead saddle.
- Avoid direct contact with lead when using mortar; provide an fibre cement undercloak or tile slips.
- Do not block tile laps with mortar to avoid water damming.
- Mechanically fix all tile and slates adjacent to valleys.

7.9.7.4 Ridge (in accordance with BS 5534 and BS 8000-6)

The ridge or top course batten should be set to allow the ridge tiles, ridge units or metal ridge to overlap the top course of tiles, slates or shingles by the overlap necessary for the main tiles, slates or shingles. For interlocking tiles, this should be not less than 75mm. For double-lap products, the top batten should be set to allow the ridge to overlap the penultimate course by the required head-lap.

- Check ridge tile is suitable for pitch of roof.
- Edge bed components onto tiles or slates.
- Ensure top course tiles or slates are mechanically fixed.
- Mitre tiles neatly at hip ridge junctions, and use a lead saddle underneath for protection.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- All mortar bedded ridge tiles must also be mechanically fixed by proprietary fixings in accordance with the roof covering manufacturer's recommendations.

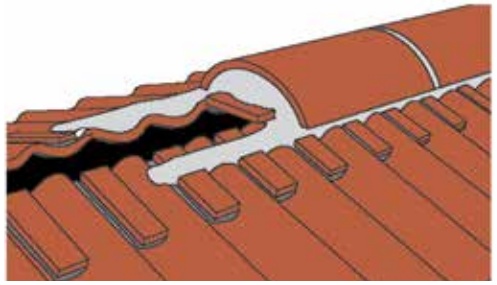


Figure 17: Ridge detail

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

7.9.7.5 Hip (in accordance with BS 5534 and BS 8000-6)

- Check hip tile is suitable for pitch of roof.
- Mitre tiles neatly at hip ridge junctions and use a lead saddle underneath for protection.
- Use the correct hip iron at base of hip.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- All mortar bedded hip tiles must also be mechanically fixed (screws, nails, clips, etc.).

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

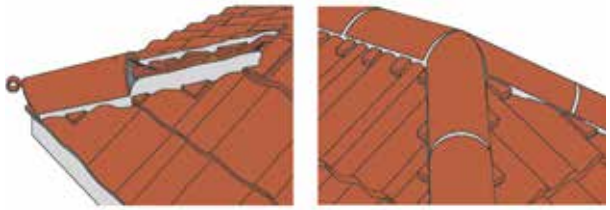


Figure 18: Hips

7.9.7.6 Flashings and weatherings

The following is a brief summary of metal flashing details; for the best advice on the use of lead, reference may be made to the Lead Sheet Association or the metal flashing manufacturer's recommendations.

A coat of patination oil should be applied to lead flashings after fixing. Lead can be used in contact with other metals, such as copper and stainless steel, without risk of bimetallic corrosion, but should not be used with aluminium in a marine or coastal environment.

Lead sheet used for roofs, flashings and weatherings should, in terms of suitability to meet the requirements of the Technical Manual, be in accordance with BS EN 12588 or a valid UKAS (or European equivalent) third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use (see Chapter 2.3.5).

Interlocking tile

Side abutments

There are three common ways of weathering a side abutment with interlocking tiles; stepped cover flashings, secret gutters and a combination of stepped cover flashing above secret gutter.

Side abutment (stepped cover flashing)

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Finish the tiling battens as close to the abutment as possible.
- Lay the tiles to butt as close as possible to the wall.
- Cut a piece of Code 4 lead to form a combined step and cover flashing.
- Flashing should not exceed 1.5m in length, and should be 150mm–200mm in width or wide enough to cover the first roll, whichever gives the greater cover.
- Chase out brickwork mortar joints and push folds of flashing into chases; wedge in with small pieces of lead.
- Dress cover flashing as tightly as possible to tile profile.
- Repoint brickwork.
- In areas of high exposure, or when dressing lead over flat tiles, use clips to hold cover flashing in place; when using this type of flashing with flat tiles below 25°, increase cover of flashing over tile to 200mm.

Side abutment (secret gutter with and without cover flashing)

A secret gutter may be formed as an alternative to a step and cover flashing when using single-lap flat interlocking tiles and slates. In view of the increased risk of water penetrating under the lead, especially on low pitches in exposed locations, maximum security can be achieved using a combination of both secret gutter and cover flashing.

- Form secret gutters before starting tiling.
- Fix a support between the last rafter and the abutment; this should be a minimum of 75mm wide and run the full length of the abutment.
- Fix a splayed timber fillet at the discharge point to raise lead lining to the right height; avoid backward falls.
- Fix a counter batten along the outer edge of rafter.
- Line gutter with Code 4 or 5 lead, in lengths of no more than 1.5m.
- Lap each strip offered over the lower one by a minimum of 150mm, and fix with copper nails at head.
- Turn up lead welts to provide a weather check and exclude birds and vermin from entering tile batten space.
- Gutter should be a minimum of 25mm deep and have a vertical upstand of no less than 65mm above the top surface of the tiles or slates.
- Fit a stepped flashing, chased into brickwork as before and dressed over vertical upstand.
- Turn roofing the underlay up the side of the counter battens and butt the tiling battens up to the counter batten.

- Lay tiles to leave a gap of 15mm by the side of the abutment.
- A lead cover flashing above the secret gutter is advisable for interlocking tiles and slates, particularly in areas of high exposure or on roofs under trees, where the risk of blockage is high. If this is done, the width of the secret gutter may be reduced to 50mm.

Top edge abutment

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Fix the top tiling batten as close as possible to the abutment.
- Complete tiling in the usual way.
- Chase abutment and insert lengths of code 4 lead, no more than 1.5m long; wedge in with small pieces of lead, no less than 450mm apart.
- Lead should be wide enough to give at least 150mm cover to top course of tiles, e.g. below 30° this increases to 290mm at 15° rafter pitch.
- Vertical upstand should be 75mm–100mm.
- Lap each length of lead by no less than 100mm.
- Dress lead to the profile of the tiles.
- Secure lead flashings with copper or stainless steel clips, with frequency dependent on exposure (see the Lead Sheet Association recommendations).

Double-lap plain tiles

Side abutment (soakers and step flashings)
Soakers are used where double-lap plain tiles abut a wall.

- Turn underlay 50mm up the abutment and cut tiling battens 10mm–25mm short of the wall and fix securely.
- Lay tiles close to the abutment with a soaker fitted between each tile.
- Form code 3 lead soakers with an upstand of 75mm to place against the abutment. They should be 175mm wide and 190mm long, allowing a 25mm downturn over the back of the tile. After all tiles and soakers have been fixed, insert a stepped flashing into the abutment wall and dress down over the upturned edges of the soakers.

Fibre cement and natural slates

Side abutment
(step and cover flashing with soakers)

- Continue the underlay across the roof and turn up the wall by a minimum of 50mm. Cut the battens 10mm–25mm short of the wall, and fix securely.
- Finish the slating with alternate courses of slates and slate-and-a-half slates, cut as necessary to maintain the bond.
- Code 3 lead soakers, with a minimum width of 175mm and length equal to gauge + lap + 20mm, are to be interleaved with the slates and turned 75mm up the wall.
- The Code 4 stepped lead flashing should be secured in the brickwork bed joints with lead wedges and dressed neatly over the soakers.

Top edge abutment flashings

- Continue underlay a minimum of 50mm up the wall.
- Position two battens downslope from the abutment, the upper to receive the top edge of the top course slate and the lower the top of the full length slate.
- Head nail the top course slate and use a disc rivet to secure the tail in the usual manner. Centre nail and rivet the full length slate below in the normal way.
- Dress Code 4 lead cover flashing over the top course slates and turn up the wall face a minimum of 100mm, with the top edge turned into the brickwork bed joint and secured with wedges.
- Extend lead down over the slate to lap the surface a minimum of 150mm, and secure the bottom edge with a clip to resist wind uplift.

Dormers
Treat tiled dormer roofs in a similar way to the main roof work. However, single-lap tiling is less suitable for small covered areas, and for a dormer, it is generally preferable to adopt an alternative form of covering.

When dormer cheeks are tile hung, close cut vertical tiles to the roof rake over a flashing fixed to the side of the dormer, and dress well into the adjacent tiles. The formation of a secret gutter is not recommended.

Back gutters
Back gutters may be lead welded off-site and positioned when tiling is undertaken. A gutter should be formed where the bottom edge of tiling meets an abutment. Form the gutter before tiling, but after felting and battening is complete.

- Fix a lay board to support lead lining, with a tilting fillet, close to the abutment to flatten the pitch of the lead.
- Dress a sheet of Code 5 lead (width of abutment plus 450mm) into position with a vertical upstand of at least 100mm up the abutment.
- Dress the extra width of lead around the corner of the abutment after any side abutment weathering has been fitted.
- Dress the upper edge of lead over the tilting fillet and turn it back to form a welt.
- Chase abutment, insert a cover flashing of Code 4 lead and dress it over the vertical upstand of the gutter.

Roof protrusions
The treatment of tiling against chimney stacks, skylights and other similar projections through the roof surface should be similar to that described for abutments where appropriate.

- Make perforations for pipes, chimney stays, supports for ladders, etc. weather tight by dressing over and under tiling with a lead or copper slate to which a sleeve is burned or soldered.
- Boss sleeve around pipe or stay, and seal at top with a collar.

Saddles
The following details can apply to any type of valley or hip/ridge intersection:

- Use Code 4 lead no less than 450mm square and large enough to give a lap of at least 150mm over the gutter lining on each side.
- Saddles should be capable of being readily dressed down when in position.

7.9.7.7 Vertical tiling and slating

Vertical slating with fibre cement slates
Fibre cement slates can be fixed to vertical surfaces and provide an attractive and weather proof cladding on both timber frame and masonry constructions.

The following guidance notes apply to this detail:

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required.
- Slate-and-a-half should be used in alternate courses at internal and external corners and adjacent to openings.
- Use Code 3 lead soakers to weather internal and external corners.
- Fix slates by two nails and one rivet, and slate-and-a-half by three nails and two rivets.
- Code 4 lead cover flashings should be used above and below openings, in accordance with Lead Sheet Association recommendations.

Vertical tiling with plain tiles
Plain tiling is an excellent, weather proof and attractive cladding to the vertical walls of any building. Feature and ornamental tiles may also be used with normal plain tiles to create decorative patterns. Fibre cement slates can also be used for vertical cladding.

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required.
- Ensure tiling details do not interfere with the opening of windows and doors.
- Lead flashings and soakers should be used around openings, in accordance with Lead Sheet Association details.
- Use double course of tiles at eaves, by laying first course of eaves/tops tiles with course of full tiles laid over.
- At the top of a wall or under a sill, use a course of eaves/tops tile laid over a course of full tiles. Dress a Code 4 lead cover flashing over by 100mm.
- Use internal and external angle tiles at all 90° corners. Purpose-made 135° angle tiles are also available. For other angles, close mitre tiles and use Code 3 lead soakers.
- All tiles should be twice nailed.

7.9.7.8 Dry fix systems
Proprietary dry roofing products and systems may be used as an alternative to mortar bedding at verges, ridges, hips and valleys to provide weathering and mechanical resistance properties. Dry roofing products as fitted should not adversely affect the performance of the roof as laid.

Specifiers should seek evidence that this will not be the case, and should use dry roofing products only if such evidence is available.

Note 1: There are no British Standards for these products. Specifiers should seek evidence of third-party testing.

Note 2: Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

Appendix
British Standards:

BS EN 490
BS EN 492
BS EN 1304
BS 5250
BS EN 1990: 2002+A1
BS 5534: 2003+A1
BS EN 1991-1-4: 2005+A1
BS 8000-6
EN 13859-1
BS 6399–2

Further guidance
NFRC Zonal Method User Guide
(available from the NFRC website www.nfrc.co.uk/)

Practical guidance on the application of single-lap and double-lap tiling can also be obtained from CITB/CS Trainer Resource Package for Operatives in the Construction Industry Manuals, Construction Industry Training Board, 2002:

- CTP 036/1 – Roof Slating and Tiling – Common Materials and Methods
- CTP 036/2 – Roof Slating and Tiling – Single-lap, Variable Gauge, Interlocking Tiles
- CTP 036/3 – Roof Slating and Tiling – Double-lap, Variable Gauge, Plain Tiles
- CTP 036/5 – Roof Slating and Tiling – Single-lap, Fixed Gauge, Interlocking and Mitred Tiles

FUNCTIONAL REQUIREMENTS

7.10 ROOF COVERINGS – CONTINUOUS MEMBRANE ROOFING

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

CHAPTER 7: SUPERSTRUCTURE

7.10.1 Definitions

For the purposes of this standard, the following definitions shall apply:

Flat roof: a roof having a pitch no greater than 10° to the horizontal.

Condensation: process whereby water is deposited from air containing water vapour when its temperature drops to or below dew point.

Interstitial condensation: condensation occurring within or between the layers of the building envelope.

Thermal bridge: part of a roof of lower thermal resistance than its surrounding elements, which may result in localised cold surfaces on which condensation, mould growth or staining may occur.

Structural deck: continuous layer of the construction (comprising concrete, profiled metal or timber panel) supported by the building structure and which supports the roof system.

Vapour Control Layer (VCL): construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof.

Water Control Membrane (WCM): construction material (usually a sheet membrane) that substantially reduces the transfer of rain water to the insulation in an inverted warm deck roof.

Protection layer: construction material (usually a geotextile all rigid board) that isolates another construction material from mechanical damage.

Filter layer: construction material (usually a geotextile) that substantially reduces the transfer of mineral and organic material to the insulation in an inverted warm deck roof.

Separation layer: construction material (usually a geotextile) that separates two construction materials that are not chemically compatible.

7.10.2 Design criteria – system type

Warm deck roof

The principal thermal insulation is placed immediately below the roof covering, resulting in the structural deck and support being at a temperature close to that of the interior of the building.

The design should ensure that:

- The structural deck is maintained at a temperature above that which could cause condensation to occur at this level during service.
- A VCL is provided by the deck or by a membrane placed above the deck.
- The insulation has sufficient mechanical characteristics to resist loading.
- The waterproof membrane has sufficient resistance to temperature to suit the conditions created by a substrate of insulation.

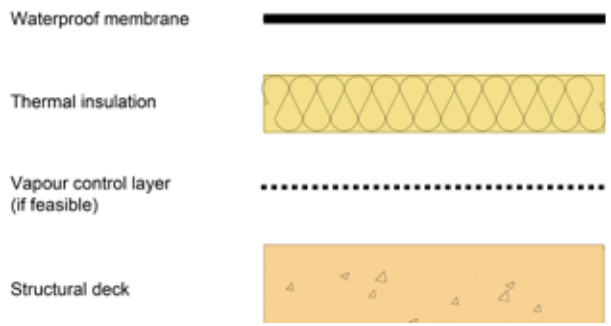


Figure 1: Warm roof (section)

Inverted warm deck roof

A variant of the warm deck roof in which the principal thermal insulation is placed above the waterproof membrane, resulting in the waterproof membrane, structural deck and structural support being at a temperature close to that of the interior of the building. Generally, the principal insulation is secured by separate ballast (paving or stone).

A filter membrane or (WCM) should be provided to control mineral and organic material passing into and below the insulation joints. A WCM is recommended because it will provide improved rain water run off, which may allow for a reduced thickness of insulation and reduced loading of ballast. If a WCM is included, it is essential that the drainage design facilitates the rapid transfer of rain water across the product and to rain water outlets.

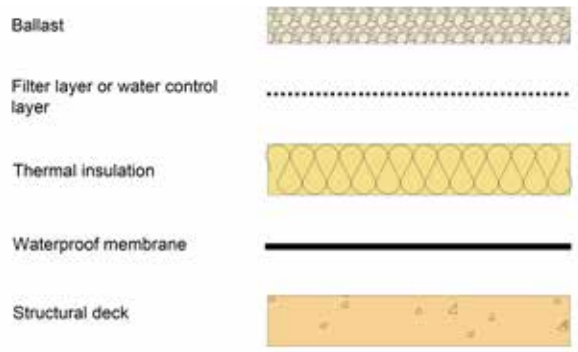


Figure 2: Inverted warm roof (section)

Cold deck roof

The principal thermal insulation is placed at or immediately above the ceiling, i.e. below the structural deck, resulting in the waterproof membrane and structural deck being substantially colder in winter than the interior of the building. The structural support will typically form a thermal bridge between the high and low temperature zones of the construction. It is very difficult to insulate a cold roof system to current mandatory levels without introducing thermal bridges and/or increasing the risk of interstitial condensation in the system. In addition, the mandatory requirement for uninterrupted external air circulation limits the application of the system where abutting elevations or changes in building geometry occur. Therefore, it is not recommended.

If an existing cold deck roof is refurbished, it is important to ensure that the ventilation requirement is achieved, whether or not the level of insulation is to be increased. It is also not feasible to introduce vapour control and insulation below an existing structural deck of concrete, e.g. if during refurbishment, a cold deck roof is converted to a warm deck roof by placing insulation above the deck and closing off the ventilation. It is necessary to provide at least as much thermal resistance above the deck as was previously provided below the deck. A condensation risk calculation should always be carried out in such circumstances to ensure that the deck is above dew point during service.

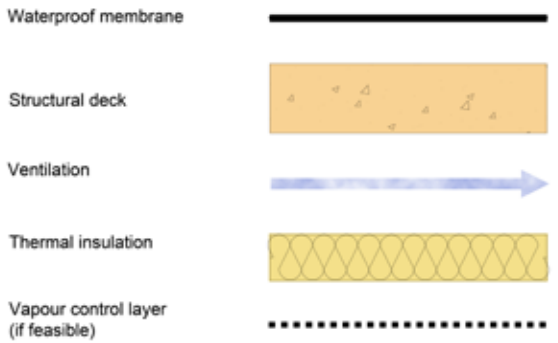


Figure 3: Cold roof (section)

Hybrid roof

Many roofs combine the features of two or more of the roof types previously described. Examples include structural decks of high thermal resistance combined with additional insulation, and existing roofs to which thermal insulation is added. Once assessed in terms of their thermal and water vapour transmission characteristics, such roofs will generally fall into one of the categories described.

In some constructions, the waterproof membrane is placed between two layers of insulation, combining the properties of warm roof and inverted warm roof construction. This form of construction is generally known as a 'duo roof'.

7.10.3 Loading

7.10.3.1 Statutory requirement

Design for loading complies with the current Building Regulations.

7.10.3.2 Resistance to wind load

In all situations, including ballasted, green and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

7.10.3.3 Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential functions of the roof with regards loading with equipment, e.g. air handling, renewable energy capture and the intensity and frequency of foot traffic. This should inform the selection of the deck, insulation, safety guarding and protection.

7.10.4 Falls and drainage

7.10.4.1 Statutory requirement

Design for drainage should comply with the current Building Regulations.

7.10.4.2 British and industry standards

BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved. Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculations, this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%). Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall to ensure that deflection of the deck and/or construction tolerances are overcome. This is particularly important in designing inverted roofs, where calculation of dead loading should be based upon the ballast type and depth to be used.

The manufacturers of certain waterproofing products have certification for their use in 'completely flat' or 'zero falls' applications. For the purposes of this standard, the design conditions of BS 6229 shall be assumed to prevail.

Consideration should also be given to:

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the roof area to be drained.
- Avoidance of ponding behind wide obstructions to the drained slope, such as plant plinths or roof lights.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rain water outlets along a perimeter.

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system.

Ponding on membrane roofs should be avoided because:

- It encourages the deposition of dirt and leaves, which can be unsightly, may obstruct outlets and/or become a slip hazard.
- In the event of damage, the interior will suffer increased water ingress.
- The load may cause progressive deflection of the deck.
- Ice or algae may create a slip or wind hazard, particularly on walkways.

Independent research has shown that roofs with extensive ponding require increased maintenance input.

Waterproof coverings of all types are tested for water absorption and water tightness as part of third-party certification. However, the construction process, including the installation of components and the forming of seams, is clearly facilitated in dry, well-drained conditions.

7.10.4.3 Creation of falls

Roof falls may either be created during the construction of the deck or alternatively by using tapered insulation systems.

The creation of falls in the deck should always be attempted because it has the following advantages:

- There will be a consistent thermal environment across the roof.
- The VCL will also be to a fall, and will act as a temporary line of defence to water ingress during construction.
- If mechanical fasteners are to be used for the waterproof membrane, their length will be constant, which facilitates planning and installation.

Cementicious screeds provide a stable substrate to mitred falls with minimal tolerances, and are recommended. Screeds should be in accordance with BS 8204. Lightweight screeds should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness.

Tapered insulation schemes, suitable for warm deck roofs only, have the following advantages:

- It is possible to create effective drainage layouts to complex plan areas.
- Mitred falls can be easily created to direct rain water to single points where outlets are to be located.

Where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value at any point, required by SBEM or SAP calculation, is achieved.

Where the roof finish is to include paving on access routes, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded or trip hazards created.

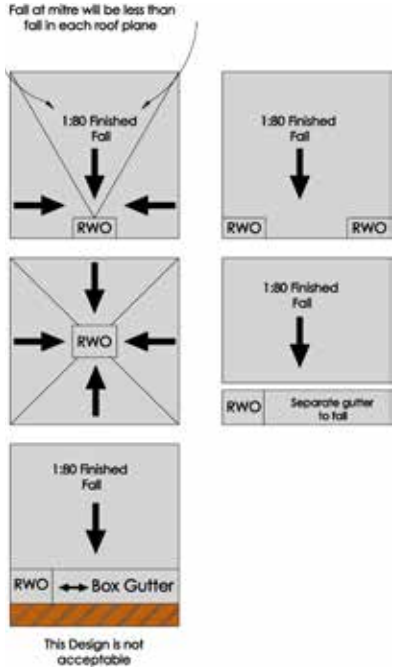


Figure 4: Drainage layout options

7.10.5 Drainage

Drainage design should be based upon calculations in accordance with BS EN 12056 Part 3 given a design head of water (typically 30mm). Rain water outlet capacity should be taken from properly certificated information provided by manufacturers, and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes, such as walkways.

It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets, so consideration should be given to creating these in the structure or insulation. Box gutters are slow, difficult to construct and introduce unnecessary complexity. The need to maintain a fall in gutters and comply with the energy requirements of the Building Regulations may be difficult to achieve.

All waterproof membranes are compatible with siphonic roof drainage systems, which for larger roofs offer many advantages:

- Very high capacity, enabling fewer outlets and therefore less detailing work on-site.
- Smaller bore horizontal collector pipe work, enabling reduced roof void depth.
- Self-cleaning in many situations.

For further information, see www.siphonic-roof-drainage.co.uk

7.10.6 Thermal performance

7.10.6.1 Statutory requirement

Design for thermal performance must comply with current Building Regulations, as appropriate.

7.10.6.2 Thermal transmittance

Design for thermal transmittance should take account of the effect of thermal bridging within the roof field and at interfaces between the roof system and adjoining elements, such as parapet walls or abutments.

In particular, allowance should be made for the effect of:

- Thermal bridging by metal fasteners used to secure insulation and/or membrane. Thermal break telescopic tube fasteners are recommended to avoid this.
- Thermal bridging due to drainage of rain water or snow-melt through insulation in inverted roofs. The use of WCMs beneath ballast to reduce thermal bridging is recommended.
- The locations of above-average thermal transmittance at sumps, gutters or areas of minimum thickness of tapered insulation.

Manufacturers of thermal insulation and WCMs provide calculations of the effects of thermal bridging by fasteners and drainage respectively. Further advice is available in Building Research Establishment BR 262 Thermal insulation: avoiding risks, 2002 edition.

7.10.6.3 Air permeability

Relevant contract drawings should define the position of the component – the air barrier – that determines resistance to air permeability. This may be achieved by an additional, purpose-designed membrane or by an additional function of another component, such as the deck or waterproof membrane.

7.10.6.4 Control of condensation

Any provision required to control interstitial condensation within the roof should be determined to the calculation method defined by BS 5250, but with ambient conditions set in BS 6229. Calculated maximum accumulation of moisture within thermal insulation should not exceed the limits defined in BS 6229.

7.10.7 External fire performance

7.10.7.1 Statutory requirement

Design for external fire performance must comply with current Building Regulations.

7.10.7.2 Certification of system

The manufacturer of the waterproof membrane must demonstrate by reference to independent test certification that the system of waterproofing and insulation (type and thickness) for a particular project meets or exceeds the minimum level of fire performance defined by the Building Regulations.

7.10.8 Provision for access

7.10.8.1 Statutory requirement

Design for access should comply with current Building Regulations.

7.10.8.2 Edge protection

In the absence of suitable parapet walls, permanent edge protection should be provided along roof-level pedestrian routes to equipment that requires regular access for servicing.

7.10.8.3 Protection of roof system

At the earliest possible stage, the anticipated loading of the roof by plant and access during service should be assessed in terms of:

- load, e.g. foot traffic, equipment
- frequency
- risk of impact

The design should include protection to suit the anticipated conditions as appropriate:

- Slip-resistant walkway material.
- Polymeric single ply membranes: compatible sheets or tiles welded to the membrane.
- Reinforced bitumen membranes: heavy-duty mineral surfaces sheets or tiles.
- Liquid-applied membranes: additional coating with textured finish.
- Mastic asphalt: heavy-duty mineral surfaces sheets or tiles.
- Load-spreading materials.
- All waterproof membrane types: paving on paving supports or protection layer.
- Polymeric single ply and reinforced bitumen membranes: galvanised steel sheet with additional covering with slip-resistant finish.

7.10.9 Detailing

7.10.9.1 General principles

At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above the finished roof level.
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum 75mm.
- Construction should achieve independence between different elements and trades.
- Thermal and fire performance should be maintained across the detail.
- A continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection should be avoided.

The total roof zone depth should be assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level.

It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, except at continuous water checks and verges. Balconies are a frequent exception due to the need for level or unobstructed access (see Chapter 7.6 – Balconies). Designers should carefully consider the risks of any departure from this criterion. In the event of this being unavoidable, a written justification should be provided.

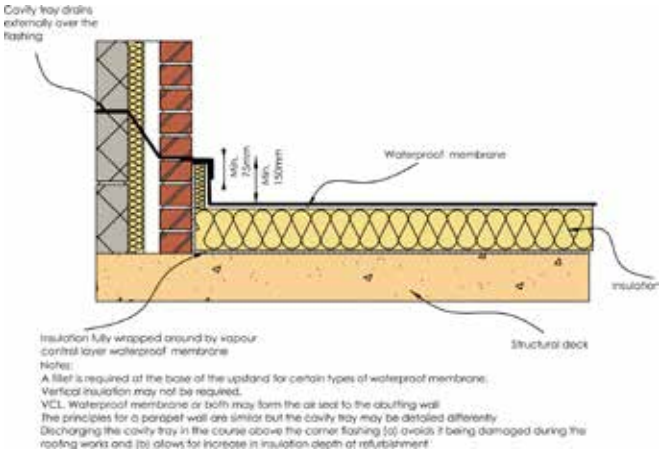


Figure 5: Principles of detailing. An example of warm deck roof at an abutment

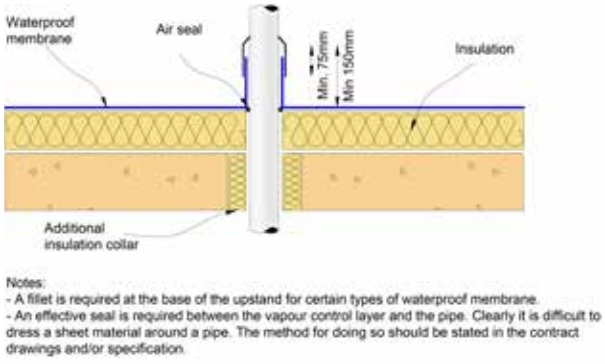


Figure 6: Penetration through roof system

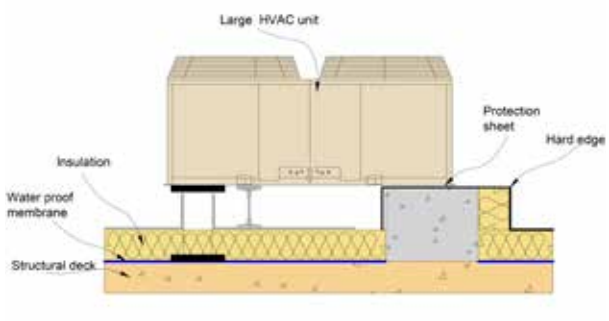


Figure 8: Detail: principles: plant support

Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations.
- Supports.

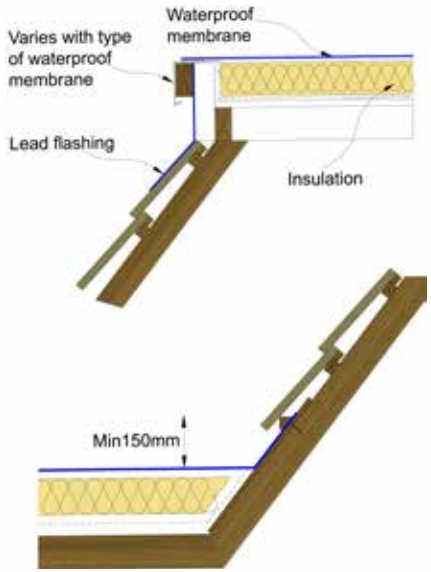


Figure 7: Detail: principles: flat roof interface to pitched roof

7.10.9.2 Renewable energy capture equipment

Renewable energy capture equipment includes photovoltaic panels and multi-panel arrays, solar thermal panels and multi-panel arrays and wind turbines. All such equipment should be secured to a frame and/or posts that transfer their load directly to the structure. The roof system and waterproof membrane should be designed to enable equipment to be demounted without loss of the roof's waterproofing integrity. Support systems based on 'top-fixed' plate and post components should be accompanied by documentation to demonstrate their compatibility with the waterproof membrane.

7.10.9.3 Handrails and balustrades

See Chapter 7.6 – Balconies.

7.10.9.4 Mechanical and electrical services

Detailed design should take account of the installation of such equipment by other (usually following) trades, as follows:

- Services entry/exit points should be suitably weathered to enable connection without loss of integrity of the waterproof membrane.
- The upstand of the waterproof membrane at risers should be arranged to enable a separate downstand or weathering flashing to be formed in ductwork.
- Cladding to insulation placed around ductwork should not be sealed to the waterproof membrane.
- Sufficient clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.

7.10.10 Materials

7.10.10.1 Requirement

General

Materials for use in flat roofing systems are suitable only if the manufacturer has declared compliance with the relevant harmonised European Product Specification and has affixed the CE Mark to the product. Where no relevant harmonised European Product Specification exists, the product should either comply with a relevant British Standard or be independently certificated for fitness for purpose by the British Board of Agrément or other notified body.

7.10.10.2 Structural deck

General

At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed.

Concrete

Precast concrete construction should be designed in accordance with BS 8110. Information on span capability and the installation requirements of precast panels can be obtained from manufacturers. Information on the location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing. Precast panels installed to a fall can provide a simple layout but without cross falls.

In-situ concrete construction should be designed in accordance with BS 8110. It is more difficult to lay to a fall, and it is more common to create falls in the insulation (warm roofs only) or by using an additional screed. Information on compressive strength, resistance to point load and drying periods of wet screeds can be obtained from suppliers and relevant trade associations.

Where structural movement joints are required in large concrete decks, a clearly defined movement joint detail should be constructed to a design and with the materials that afford durability equivalent to that of the roof system.

Profiled metal (steel or aluminium)

Profiled metal decks should have a crown width at least 50% of the profile width. To provide a sound base for the insulation and waterproofing system, and to avoid reduced drainage performance, the mid-span deflection of the metal deck should not exceed 1/200 of the span under uniformly distributed design loads. When considering the deck profile and the necessity for side lap stitching and metal deck closures, reference should be made to the manufacturers of the deck, insulation and membrane.

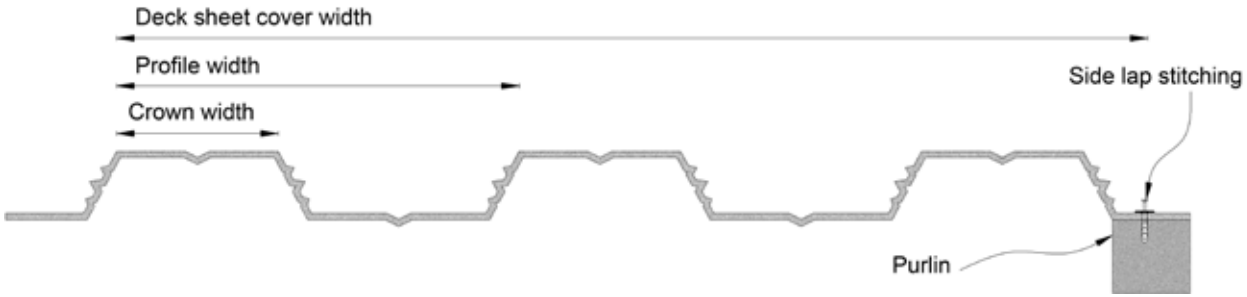


Figure 9: Profiled metal decks: critical dimensions

Profiled metal decks should conform to the following standards:

- Galvanised steel: minimum recommended thickness 0.7mm to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7mm–1.2mm.
- Plain aluminium: minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate.

Timber panels

Roofing grade OSB should be manufactured to BS EN 300 grade OSB/3 and be certificated by the British Board of Agrément. The minimum recommended thickness is 18mm.

Plywood should be minimum 18mm thickness and certificated to conform to BS EN 1995-1-1 Eurocode 5. Design of timber structures, and to BS EN 636 Plywood, specifications minimum service class 2 – humid conditions, or, where required, service class 3 – exterior conditions.

Composite panels (deck/vapour control/insulation)

The suitability of composite panels in providing a combined deck, VCL and thermal insulation in a single component should be assessed with reference to the loading and hygrothermal conditions in the application. There is no relevant British Standard. Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

7.10.10.3 Vapour Control Layer (VCL)

The VCL should be selected with regard to the following minimum criteria:

- Ease with which it can be sealed at laps and at abutments to other elements.
- The method of attachment.
- Condensation risk, expressed as calculated vapour pressure based on notional conditions pertaining to the project building.
- Compatibility with the waterproof membrane and thermal insulation.

The following is a minimum recommended specification. The actual specification will depend on the level of vapour resistance required, based on calculation, and the type of deck.

Roof system type	Deck type	VCL	Attachment
Reinforced bitumen (1) membrane	Profiled metal	S2P3 (2)	Partial bond by 3G or approved proprietary alternative
	Concrete	S2P3	Fully bonded
	Timber panel	S2P3	Partial bond by 3G or approved proprietary alternative
High density polyethylene	All	200µ	Loose laid beneath mechanically -fixed insulation
High density polyethylene and metal foil laminate	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions
Coated metal foil laminate – self-adhesive	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions

Notes:

(1) Reinforced bitumen membranes: minimum recommended specification based on classification in BS8747.
(2) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic). The higher the rating, the higher the performance.

Table 1: Minimum recommended specification for Vapour Control Layer for warm deck roofs.

7.10.11 Thermal insulation

The thermal insulation should be selected with regard to the following minimum criteria:

- Thermal resistance (and therefore thickness) to suit minimum clearances at details.
- Resistance to compression.
- Compatibility with the VCL and waterproof membrane.
- Compatibility with adhesives (if insulation is adhered).
- Contribution to the external fire performance of the system.
- Acoustic properties: resistance to external sound is not currently regulated. However, there may be a need to consider attenuation from balconies (see Chapter 7.6 – Balconies).

Note: The alternative of a separate acoustic attenuation layer should be considered where appropriate.

Roof system type	Insulation type (1) (2)	Insulation code	Minimum compression resistance (3) (KPa)
Warm deck roof	Polyisocyanurate foam	PIR	150
	Expanded polystyrene	EPS	150
	Extruded polystyrene	XPS	200
	Mineral wool	MW	75
	Cellular glass	CG	??
Inverted warm deck roof	As per certification	XPS	200

Notes:

(1) As defined in the appropriate European Product Specification.
(2) Results for composite products should meet or exceed the minimum for each component when tested separately.
(3) Results should be expressed at CS (10), i.e. at 10% compression when tested to BS EN 826.

Table 2: Minimum recommended resistance to compression of thermal insulation

7.10.12 Waterproof membrane

7.10.12.1 Requirement

The waterproof membrane should be selected with regard to the following minimum criteria:

- Anticipated service life based on independent certification.
- Minimum maintenance.
- Ease of adaptation and repair.

7.10.12.2 Polymeric single ply membranes

The manufacturer should declare compliance with the harmonised European Product Specification for single ply membranes, BS EN 13956, which defines requirements for testing and declaration of characteristic values. There is no relevant British Standard. Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

Such certification should be accompanied by full instructions for installation.

7.10.12.3 Reinforced bitumen membranes

The manufacturer should declare compliance with the harmonised European Product Specification for reinforced bitumen membranes, BS EN 13707, which defines requirements for testing and declaration of characteristic values. There is no relevant British Standard.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

In addition, specifications for systems of multi-layer reinforced bitumen membranes for flat roofing should comply with BS 8747.

The following specifications will be acceptable as a minimum:

Roof system type	Deck type	Insulation type(1)	Venting layer(2)	Underlayer(3)	Cap sheet(4)
Warm deck	Profiled metal	Thermoplastic foam	3G	S2P3(5)	S4P4(5)
		Mineral fibre	-	S2P3	S4P5
	Concrete	Thermoplastic foam	-	S2P3	S4P4
		Mineral fibre	-	S2P3	S4P4
	Timber panel	Thermoplastic foam	3G	S2P3	S4P5
		Mineral fibre	-	S2P3	S4P4
Inverted warm deck	Profiled metal	Extruded Polystyrene (XPS)	3G	S2P3	S4P5
	Concrete		-	S2P3	S4P5
	Timber panel	Deck type not suitable for inverted roofs			

Notes:

(1) Insulation type: Thermoplastic foam: PIR, EPS, PF. Mineral fibre: MW.
(2) Venting layer: BS 8747 3G or proprietary equivalent with suitable certification.
(3) Under layer: as defined in BS 8747. SBS-modified products are recommended.
(4) Cap sheet: as defined in BS 8747. SBS-modified products are recommended.
(5) S and P are classifications 1 - 5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic). The higher the rating, the higher the performance.

Table 3: Minimum recommended specification for reinforced bitumen membranes

Bitumen membranes should be protected from solar radiation. This should be by integral protection provided in the product in the form of:

- Mineral granules
- Metal foil

The use of solar reflective paint is not permitted. The use of stone chippings is not recommended unless required to achieve enhanced external fire performance. If used, chippings should be washed, crushed rock, normally 10mm–14mm nominal size aggregate, bedded in a proprietary gritting solution.

7.10.12.4 Liquid-applied membranes

There is no harmonised European Product Specification for liquid applied membranes for roofing. The European Technical Approval Guideline ETAG 005 Part 1 – General gives overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity. The remaining seven parts, known as the Complementary Parts or the ETA Parts, deal with specific requirements for particular families of products, and are the generic types covered primarily by this Guidance Note, shown as follows:

- Part 2: Polymer modified bitumen emulsions and solutions
- Part 3: Glass reinforced resilient unsaturated polyester resins
- Part 4: Flexible unsaturated polyesters
- Part 5: Hot applied polymer modified bitumens
- Part 6: Polyurethanes
- Part 7: Bitumen emulsions and solutions
- Part 8: Water dispersible polymers

The manufacturer of a product for use in flat roofing should declare compliance with the relevant parts of ETAG 005. In the absence of this declaration, the product should have a current certificate of fitness for purpose issued by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

Such certification should be accompanied by full instructions for installation.

7.10.12.5 Mastic asphalt

There is no harmonised European Product Specification for mastic asphalt for roofing. Products used for flat roofing should comply with BS 6925: 1988 Specification for mastic asphalt for buildings and civil engineering (limestone aggregate).

Proprietary grades of polymer modified mastic asphalt are produced for roofing and paving applications. There is no British Standard or European Standard for these products. Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

The separating membrane should be one of the following, and should be laid directly under the mastic asphalt:

- Sheathing felt, comprising a base of flax or jute, or other suitable fibres, impregnated with bitumen.
- Glass fibre tissue.

Bitumen-coated plain expanded metal lathing should be in accordance with BS EN 13658-2.

Stone chippings (bedded) for use as a protective topping should be washed, crushed rock, normally 10mm–14mm nominal size aggregate, bedded in a proprietary gritting solution over the mastic asphalt membrane.

7.10.12.6 Site-applied hot-melt coverings

There is no harmonised European Product Specification for site-applied hot-melt waterproofing systems.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

As these systems comprise a multi-layer application (usually a base coat, reinforcement and top coat), a detailed specification for the system should be available prior to commencement of the works to enable its suitability for the project to be confirmed.

7.10.13 Ancillary components

7.10.13.1 Non-access areas: stone ballast

Stone ballast for inverted warm deck roofs and ballasted warm deck roofs should be clean, rounded aggregate graded 20mm–40mm and as free from fines as practicable. Ballast should be applied over a protection layer or WCM in warm ballasted and inverted warm roofs respectively.

7.10.13.2 Access areas: concrete paving slabs

Concrete paving slabs for use as walkways or as paving on terrace decks should conform to BS EN 1340, and be laid in accordance with the manufacturer's instructions.

7.10.13.3 Access areas: porous concrete tiles (for use on reinforced bitumen sheets and mastic asphalt only)

Porous concrete tiles should be fully bonded in hot bitumen in accordance with the manufacturer's instructions.

7.10.13.4 Access areas: flexible walkway tiles

Evidence of the compatibility of the tile with the waterproof membrane is required. Tiles for walkways or terrace deck paving should be bedded in a bonding compound compatible with the waterproof membrane and fixed in accordance with the tile manufacturer's recommendations.

7.10.13.5 Rain water outlets

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- Integral insulation to avoid condensation.
- Method of attachment.

7.10.13.6 Fall-arrest and edge protection equipment

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Compliance with BS EN 795.
- Method of attachment.
- Compatibility with the waterproof membrane.
- Means of forming a water tight seal to the waterproof membrane.

7.10.13.7 Lightning protection

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Design in compliance with BS EN 62305.
- Method of attachment to the waterproof membrane, including arrangements for self-ballasting of conductors and finials (centres, compressive loads).
- Recommended detailing at penetration of roof system.

7.10.13.8 Support for renewable energy capture equipment

Renewable energy equipment includes photovoltaic panels and multi-panel arrays, solar thermal panels and multi-panel arrays and wind turbines. All such equipment should be

secured to a frame and/or posts that transfer their load directly to the structure. Support systems based on 'top-fixed' plate and post components are acceptable only if accompanied by documentation to demonstrate their dead and live loading capacity and compatibility with the waterproof membrane.

7.10.14 Compatibility of components

The selection of components within the roofing system should be discussed in detail with the membrane manufacturer or appropriate trade association to ensure chemical and mechanical compatibility between components, since the incorrect specification may lead to reduced performance or premature failure of the roofing system. The correct choice of insulation is also important when it is to be adhered to the substrate. In case of doubt, the insulation manufacturer or relevant trade association should be consulted.

7.10.15 Installation

7.10.15.1 Protection of the roof

Temporary protection (during construction)
Responsibility for temporary protection and a method statement for its use should be agreed prior to commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets.
- Rolled recycled thermoplastic or elastomeric sheets.

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

Permanent protection (during service)
Permanent protection should not be laid on routes where access is most likely, and should not be laid on routes where temporary ponding is likely, e.g. near parapet walls in the absence of cross falls between rain water outlets.

It is recommended that concrete paving is laid on support pads, as this allows adjustment, thus reducing the risk of a trip hazard:

- The height of support pads should not exceed the maximum recommended by the manufacturer.
- Paving should not be cut.
- Paving should be firmly butted up against support pad separating pegs.

7.10.15.2 Vapour Control Layer (VCL)

The attachment of the VCL should be designed to resist calculated wind load by a declared margin of safety. All laps should be sealed and the VCL should be sealed to the adjoining element, which forms the continuation of the resistance to air permeability. The VCL should be extended behind all thermal insulation, including insulation placed on vertical surfaces such as parapet walls. Where the roof system is penetrated by a detail such as a pipe or duct, a suitable method for providing continuous vapour control should be provided, and this method should be followed in practice. Where a reinforced bitumen membrane VCL is used, its installation should be in accordance with BS 8217.

7.10.15.3 Thermal insulation

The attachment of the thermal insulation should be designed to resist calculated wind load by a declared margin of safety. This includes consideration of dead loads required in all roof zones in ballasted warm roofs and inverted warm roofs.

Except in tapered insulation schemes, thermal insulation should always be laid in a broken bond pattern. Where two or more layers are laid, the joints in each layer should be offset. On substrates of profiled metal, the short dimension should be parallel to the deck crowns and supported across half the crown width.

Insulation should be lightly butted so as to avoid thermal bridging caused by gaps. If large gaps are created by damaged or undersized boards, any

infill sections should be attached in accordance with the manufacturer's instructions.

Warm roof systems with reinforced bitumen membrane waterproofing
The limiting wind load for the different methods of attachment of insulation is prescribed by BS 8217 as follows:

- Partial bitumen bond: up to 2.4kN/m^2
- Full bitumen bond: up to 3.6kN/m^2

Where the method of attachment is outside the scope of BS 8217, the manufacturer should demonstrate that the method provides sufficient resistance to wind load.

Warm roof systems with mastic asphalt waterproofing
Generally, mastic asphalt on sheathing felt provides sufficient dead load to resist wind load, but this should be demonstrated by calculations in all situations.

Warm roof systems with polymeric single ply waterproofing
Where the insulation is mechanically fixed, the number and arrangement of fasteners required to resist wind load will be prescribed by the manufacturer. This arrangement may vary across the roof according to wind load, but should be followed in all areas.

Where the insulation is adhered, the adhesive should be approved by the insulation manufacturer and should be laid at the coverage rate and pattern designed to achieve calculated wind load. The contractor should allow for temporary loading as required to achieve a suitable adhesion and to achieve the best possible level in the upper surface of the insulation.

7.10.15.4 Waterproof membrane

Polymeric single ply membranes
There is no British Standard for the installation of single ply membranes. Installation should be in accordance with the Single Ply Roofing Association's Design Guide to Single Ply Roofing and with the specific instructions of the membrane manufacturer.

The attachment of the single ply membrane should be designed to resist calculated wind load by a declared margin of safety. This design will normally be provided by the membrane manufacturer.

Whatever the means of attachment, mechanical restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

Perimeter restraint is achieved by several methods, depending upon the manufacturer:

- Individual fasteners, protected by a flashing.
- A linear bar, protected by a flashing.
- Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate).

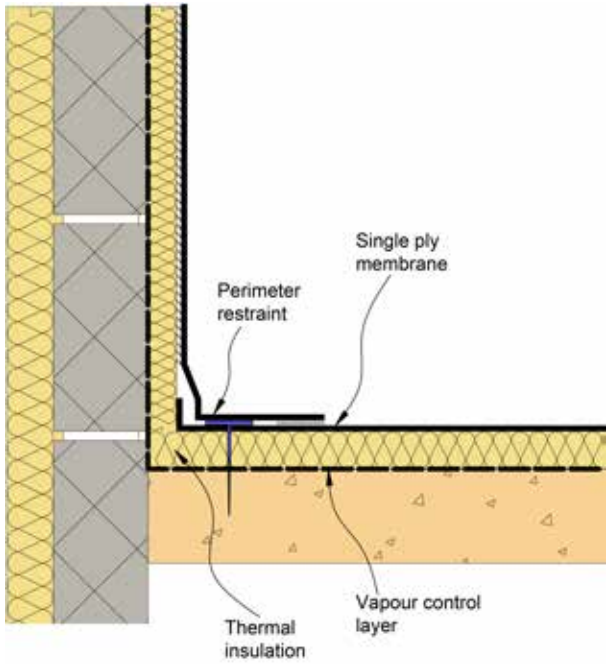


Figure 10: Methods of restraint of single ply membrane at perimeters

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is also achieved for the attachment of these components.

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the insulation boards should always be considered separately, unless specifically sanctioned by the membrane manufacturer. The number and distribution of mechanical fasteners required to fix the insulation boards may vary with the insulation type, geographical location of the building, topographical data and the height of the roof concerned.

The upper termination of the single ply membrane at linear details such as plinths, parapets, abutments and door openings should be secured by one of the following mechanical means:

- Clamping beneath a metal rail, e.g. a parapet capping or roof light frame.
- Welding to a membrane-metal laminate trim (itself mechanically fixed).
- Mechanical fixing using individual fasteners or a mechanically fixed termination bar.

Reinforced bitumen membranes
Installation should be in accordance with BS 8217. In case of doubt, or where the waterproof membrane is beyond the scope of the Standard, the advice of the Flat Roofing Alliance (National Federation of Roofing Contractors) should prevail.

The safe use of gas torches, and the positioning, monitoring and transferring hot bitumen to the work face, should be adopted, all in accordance with the Health & Safety Executive/Flat Roofing Alliance Code of Practice for Safe Handling of Bitumen.

The practice of applying reinforced bitumen membranes by torching onto thermoplastic foam insulation is not permitted, unless the boards are manufactured with a covering of reinforced bitumen membrane.

Liquid-applied membranes
There is no British Standard for the installation of liquid-applied membranes. Installation should be in accordance with the Liquid Roofing and Waterproofing Association guidance, as follows:

- Guidance Note No. 2 – Substrates for Liquid-applied Waterproofing.
- Guidance Note No. 4 – Roof, Balcony and Walkway Refurbishment Using Liquid-applied Waterproofing Systems.
- Guidance Note No. 5 – Health and Safety Provision for LAWS on Roofs, Balconies and Walkways.
- Guidance Note No. 6 – Safe Use of Liquid-applied Waterproofing Systems.

Mastic asphalt
The number of coats should be appropriate to the waterproofing requirements and traffic conditions of the roof. When laid to falls of 1:80 or more, mastic asphalt roofing is laid in two coats to a thickness of 20mm, on a separating membrane of sheathing felt, all in accordance with BS 8218.

On sloping and vertical surfaces over 10° pitch, the mastic asphalt should be laid in three coats to a thickness of 20mm without a separating membrane.

On sloping and vertical surfaces of timber or lightweight concrete, the mastic asphalt should be laid in three coats to a thickness of 20mm on expanded metal lathing over a separating membrane of sheathing felt.

Site-applied hot-melt coverings
There is no British Standard for the application of proprietary hot-melt waterproof membrane systems. Reference should be made to independent certification and the manufacturer's detailed instructions.

7.10.16 Testing

7.10.16.1 Final inspection

At practical completion of the flat roof, all areas should be clear of stored material, other site operations and all protection. A thorough, recorded, visual inspection of all areas, including details, should be carried out with representation from the General Contractor and Roofing Contractor in attendance.

7.10.16.2 Procurement of testing services

If testing to demonstrate waterproofing integrity is required, it should be undertaken by a third-party that is independent of the roofing contract.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.10.16.3 Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is not recommended as a method of demonstrating the integrity of flat roofs. It may be used to test balconies (see Chapter 7.6 – Balconies).

7.10.17 Provision of information

Operation and maintenance manual

The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
  - Thermal insulation: generic type, product(s) and thickness.
  - Acoustic insulation: generic type, product and (as appropriate) thickness.
  - Vapour Control Layer: generic type, product (as appropriate) and thickness (as appropriate).
  - Rain water outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.

FUNCTIONAL REQUIREMENTS

7.11 ROOF COVERINGS – GREEN ROOFING

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.11.1 Scope

This part of the Manual should be read in conjunction with Chapter 7.10 – Roof Coverings. Where appropriate, cross reference will be provided to the relevant section.

This Chapter provides specific advice and requirements in respect of membrane roof systems over which a finish of living vegetation or materials that will support vegetation is to be applied.
The membrane roof systems may comprise one of the following, but the advice of Chapter 7.10 – Roof Coverings applies:

Warm deck, comprising:

- Waterproof membrane
- Principal thermal insulation
- Vapour Control Layer
- Continuously supporting deck (Structural deck)

Inverted warm deck roof systems:

- Ballast
- Water control membrane
- Principal thermal insulation
- Waterproof membrane
- Continuously supporting deck

Cold deck roof systems (not recommended):

- Waterproof membrane
- Continuously supporting deck
- Ventilation externally
- Principal thermal insulation
- Vapour Control Layer

7.11.2 Definitions

For the purposes of this standard, the following definitions shall apply:

Biodiverse roof: a roof that is designed to create a desired habitat that will attract a particular flora and fauna, whether replicating the original footprint of the building or enhancing the previous habitat.

Brown roof: a biodiverse roof where the growing medium is purposely selected to allow local plant species to inhabit the roof over time.

Drainage layer/reservoir board: available in a variety of materials, including hard plastic, polystyrene, foam, coarse gravel and crushed recycled brick, depending on the Functional Requirements. This allows excess water to drain away, thereby preventing the waterlogging of the substrate. Some drainage layers also incorporate water storage cells to retain additional water that can be diffused to the plant support layer during prolonged dry periods.

Extensive green roof: a lightweight, low maintenance roof system, typically with succulents or other hardy plant species (often sedum) planted into a shallow substrate (typically less than 100 mm) that is low in nutrients. Irrigation is not normally required.

Filter fleece/fines layer: geotextile of low resistance to water penetration, which prevents fines and sediments from being washed out of the green roof into the drainage system.

FLL: Forschungsgesellschaft Landschaftsentwicklung Landschaftbau (German Landscape Research, Development and Construction Society).

Green roof: a roof or deck onto which vegetation is intentionally grown or habitats for wildlife are established, including extensive, intensive and semi-intensive roofs, roof gardens, biodiverse roofs, brown roofs and public and private amenity spaces.

Green roof system: the component layers of a green roof build-up.

Growing medium/substrate: an engineered soil replacement that contains a specified ratio of organic and inorganic material, specifically designed to provide green roof plants with the air, water and nutrient levels they need to survive, whilst facilitating the release of excess water.

GRO: Green Roof Organisation, the industry forum for green roof development and promotion in the UK.

Hydro seeding: spraying a specially designed blend of seeds and growing medium.

Inspection chamber: a chamber situated over an internal rain water outlet designed to constrain the surrounding landscaping but allowing easy access for maintenance. Allows water entry, but helps prevent unwanted silt, debris or vegetation from entering and obstructing free drainage.

Intensive green roof: a version of a green roof often referred to as a roof garden that provides benefits akin to a small urban park or domestic garden. Designed primarily for recreational use, intensive roofs are typically configured with 200mm+ of substrate, and often require regular maintenance and irrigation.

Moisture/protection layer: geotextile blanket, available in varying thicknesses (typically between 2mm–12mm), which performs a dual function. Firstly, protecting the waterproof membrane during the installation of the green roof system, and secondly, increasing the water holding capacity of the green roof system.

Root barrier: a waterproof membrane designed to prevent roots from penetrating the waterproofing layer and building fabric. This function may be incorporated in a single membrane waterproofing product.

Sedum: genus of about 400 species of low-growing, leafy succulents that are wind, frost and drought tolerant and found throughout the northern hemisphere. Not all species are suitable for roofs.

Semi-intensive green roof: intermediate green roof type with characteristics of both extensive and intensive green roofs. Typically with a 100mm–200mm substrate depth, sometimes irrigated, occasionally managed and usually planted with a range of species.

SuDS: Sustainable (Urban) Drainage Systems

Vapour Control Layer (VCL): construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof.

Wildlife roof: a version of a biodiverse roof designed to provide a specific habitat to attract a wildlife species.

7.11.3 Design and system types

A green roof essentially comprises an organic vegetation layer and those components necessary to support its growth, which is placed over a membrane roof system. For convenience, green roofs are divided into the following types:

- Biodiverse roof
- Brown roof
- Extensive green roof
- Semi-intensive green roof
- Intensive green roof

The roof system may be of warm deck, inverted warm deck or cold deck configuration (see Chapter 7.10 – Continuous Membrane Roofing). Generally, the warm deck configuration is recommended unless there are specific design circumstances for which inverted and cold roofs are better suited. A technical justification for any departure from warm deck will be required.

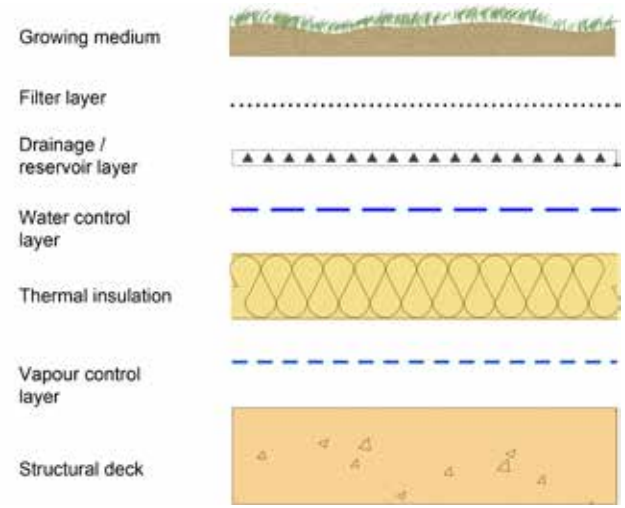


Figure 1: Extensive green roof - warm roof system (section)

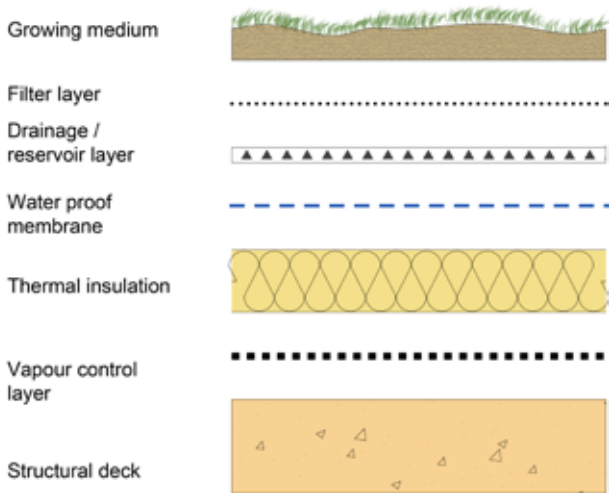


Figure 2: Intensive green roof - inverted warm roof (section)

7.11.4 Loading

7.11.4.1 Statutory requirement

Design for loading should comply with current Building Regulations.

7.11.4.2 Resistance to wind load

In all situations, including ballasted and inverted roofs, a calculation of wind load to BS EN 1991-1-4 should be undertaken by a suitably competent person. Wind load acting on a green roof will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

In biodiverse, brown and extensive green roof systems, the dead load contribution from the growing medium should be calculated on an assumption of dry substrate conditions. Such loadings may be insufficient to restrain the green roof and certain types of waterproof membrane and insulation, necessitating the provision of supplementary ballast or netting restraint. Information on loading is available from horticultural suppliers.

7.11.4.3 Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential imposed loads for which the green roof is to be designed, such as seats, stand-alone planters, storage and public access. In the absence of such a performance requirement, the loading limits of the roof should be defined.

7.11.5 Falls and drainage

7.11.5.1 Statutory requirement

Design for drainage should comply with current Building Regulations.

7.11.5.2 British and industry standards

The relevant requirements of BS 6229 should prevail in respect of green roofs, irrespective of the type of vegetative covering.

Falls are required for green roofs because:

- Standing water will inevitably result from design without falls, due to tolerances and deflection. Standing water, which may become stagnant, is not conducive to plant growth and should not be confused with the temporary retention of water in drainage/reservoir layers.
- Absence of falls will result in ponding, a potential slip hazard and the retention of mineral fines in vegetation-free zones, which in turn may encourage the growth of weeds.

7.11.5.3 Creation of falls

Roof falls may either be created during the construction of the deck or alternatively by using tapered insulation systems (warm deck roof systems only).

Where the roof finish is to include paving with or without paving supports, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded, the minimum height of upstands is not affected or trip hazards created.

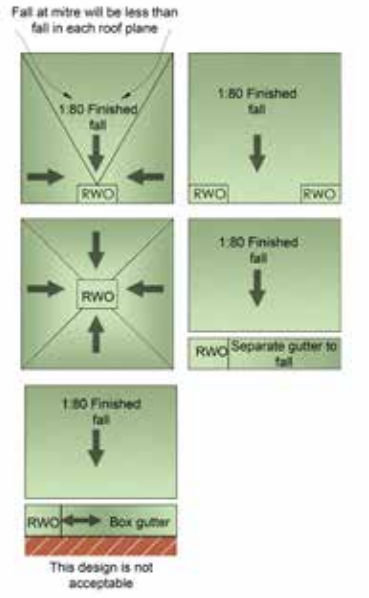


Figure 3: Drainage layout options

7.11.6 Drainage

Drainage design should be based upon calculations to BS EN 12056 given a design head of water (typically 30mm). Rain water outlet capacity should be taken from properly certificated information provided by manufacturers, and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes, such as walkways.

Green roofs are proven to reduce the volume and rate of transfer of rain water-to-rain water goods. This effect is clearly dependent upon many factors, including depth and type of growing medium, type of drainage/reservoir layer, weather conditions prevailing prior to the rainfall event and fall in the waterproof membrane. Due to these variables, it is recommended that the design for rain water drainage in accordance with BS EN 12056 is as follows:

- Brown, biodiverse and extensive green roof systems: no allowance for rain water attenuation.
- Intensive green roof systems: attenuation as advised by the horticultural supplier. If no data is supplied, no allowance should be made.

The UK's National Annex to BS EN 12056 does permit the use of a coefficient to factor down the drainage infrastructure to account for factors such as the additional retention performance of green roofs. However, the coefficient that is used to reflect this reduction would be based on average annual retention, and not on responses to dynamic storm events.

Any drainage infrastructure designed to accommodate this reduced flow rate may not accurately account for seasonal differences or individual storm events. Any reductions in drainage capacity would therefore need to be countered by alternative measures, e.g. appropriate detailing to ensure that any attenuation of water at the roof level will not be detrimental to the building structure or fabric.

Rain water outlets should be readily accessible without disruption to the green roof or pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or Water Control Membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking. Within the area of the green roof, a specific vegetation-free inspection chamber and cover should be provided in order to avoid plant growth obstructing the outlet. Purpose made products are available from suppliers of green roof components and waterproof membranes, and it is recommended that they be used wherever possible.

Rain water goods from higher roof areas or adjacent roof areas should not be designed to discharge onto the green roof. The downpipe should be connected directly to the downpipe serving the green roof.

Green roofs are compatible with siphonic roof drainage systems. In the right circumstances, these can offer the advantages of:

- Very high capacity, enabling fewer outlets and therefore less detailing work on site.
- Smaller bore horizontal collector pipework, enabling reduced roof void depth.
- Self-cleaning in many situations.

However, siphonic drainage should be designed specifically for the green roof system because it must operate siphonically with sufficient regularity to avoid silting-up small-bore pipework.

For further information, see www.siphonic-roof-drainage.co.uk.

7.11.7 Design for irrigation

Rainfall is the typical source of water. However, complementary irrigation options may be required for semi-intensive and intensive systems or those where, for example, the appearance of a grass finish may be important.

Provision may include hoses, sprinklers, overhead irrigation and automated systems that pump from some reservoir storage. The establishment of a need for an irrigation system, and the design of an irrigation scheme, should be in accordance with the principles of BS 7562-3. Where irrigation is required, a frost-protected water supply, rain water or grey water storage facility should be provided at roof level.

7.11.8 Thermal performance

Statutory requirement

Design for thermal performance must comply with current Building Regulations, as appropriate.

7.11.9 External fire performance

7.11.9.1 Statutory requirement

Design for external fire performance must comply with current Building Regulations.

7.11.9.2 Design for resistance to external fire

The design of green roof systems can influence the fire performance of the overall roof system. The rate of growth and moisture content of natural vegetation is unpredictable and determined by irregular weather conditions. The substitution of planted species with others is also unpredictable. Design to minimise fire risk cannot be based on an assumption of regular maintenance or of irrigation during drought. The latter is not relevant with sedum species, which die back, but is important for intensive roof gardens or extensive systems planted with grasses.

The design should not allow the vegetation to grow or propagate towards adjoining elements, such as abutments, eaves or pitched roofs. It should also be kept away from openings, such as roof lights and smoke vents.

This is achieved in two ways:

- A vegetation-free zone of minimum 0.5m width at all perimeters, abutments and openings. This zone should be extended to 1m to separate large roof zones in excess of 40m in length.
- Design of flexible walkways, hard paving and ballasted areas so as to minimise root and plant spread.

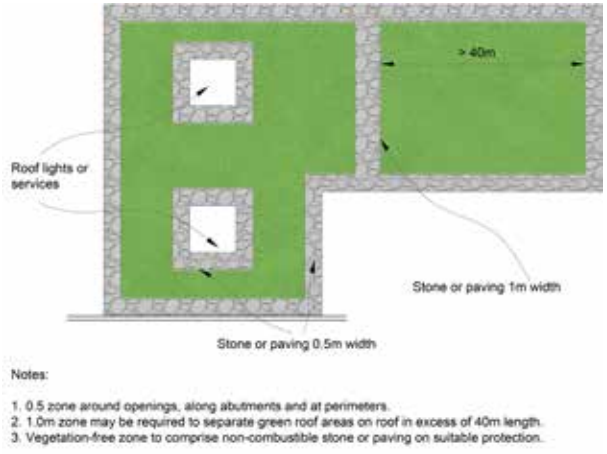


Figure 4: Green roofs: vegetation-free zones plan and zone width (not to scale of building)

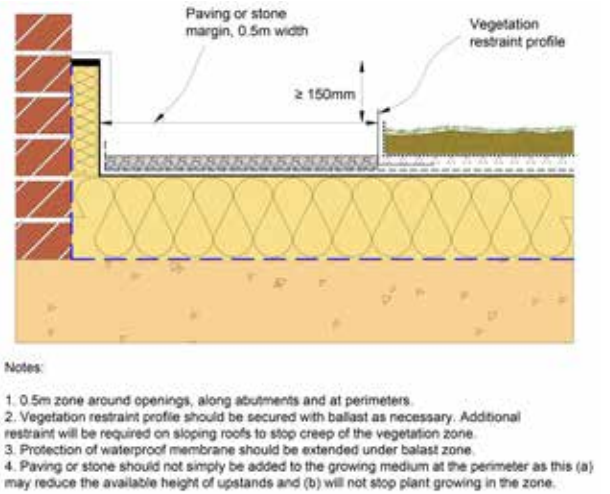


Figure 5: Green roofs: vegetation-free zone: warm roof (elevation)

7.11.10 Provision for access

7.11.10.1 Statutory requirement

The design should comply with current Building Regulations.

7.11.10.2 Temporary provision during construction

At the earliest possible stage, the anticipated loading of the roof system (prior to application of the green roof components) should be assessed in terms of:

- load, e.g. foot traffic, equipment
- frequency
- risk of impact

If such usage is intense or long-lasting during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased, as follows:

- Warm deck roof system: installation of temporary Vapour Control Layer, to be overlaid when remainder of system is installed.
- Inverted warm deck roof system: overlay of completed waterproof membrane with geotextile and continuous temporary decking, such as plywood, Oriented Strand Board or compatible recycled thermoplastic board.

7.11.10.3 Permanent pedestrian access finishes

Pedestrian finishes should be designed to suit the purpose and frequency of access in the context of the intended planned maintenance regime. For example, paving on paving supports may be desirable to allow drainage and to level up the finish, but may be unsuitable if plants could spread beneath the paving. Generally, for amenity access, a finish of porous or hard concrete paving laid directly on a suitable protection fleece may be most suitable.

For service and maintenance access only, a flexible walkway tile may be sufficient (depending on the waterproof membrane and roof system type).

7.11.11 Detailing

General principles

At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above the finished roof level, i.e. top of growing medium.

- Downstands (of separate metal or other flashings) should lap the upstand by a minimum of 75mm.
- Reliance on sealant as the sole means of protection should be avoided.
- Consideration of the effect of vegetation growth on the integrity of the weather proofing.

The total roof zone depth should be measured from the surface of the growing medium and assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the area of the green roof, except at continuous water checks and at verges.

7.11.12 Design for sustainability

As per Chapter 7.10 – Continuous Membrane Roofing.

7.11.13 Materials

As per Chapter 7.10 – Continuous Membrane Roofing.

Note: If the waterproof membrane is also intended to provide root resistance, suitable certification of testing in accordance with BS EN 13948 should be available.

7.11.14 Installation

7.11.14.1 Protection of the roof

Temporary protection (during construction)
Responsibility for temporary protection and a method statement for its use should be agreed prior to commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets
- Rolled recycled thermoplastic or elastomeric sheets

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

Permanent protection (during service)
See 7.11.14.1 (above).

7.11.14.2 Vapour Control Layer (VCL)

As per Chapter 7.10 – Continuous Membrane Roofing.

7.11.14.3 Thermal insulation

As per Chapter 7.10 – Continuous Membrane Roofing.

7.11.14.4 Waterproof membrane

As per Chapter 7.10 – Continuous Membrane Roofing.

Note: Warm roof systems – restraint against wind load. It is unusual for the installation of ballast and green roof components to follow immediately after installation of the roof system. This may be because the roof system and green roof overlay are to be installed by different contractors, or because of site factors, such as limited storage. Unless it is sequenced to do so, the roof system should be installed with restraint against wind load based on an assumption of an exposed waterproof membrane.

7.11.15 Testing

7.11.15.1 Final inspection

A thorough, recorded, visual inspection of all areas, including details, should be carried out, with representation from the General Contractor and Roofing Contractor in attendance.

7.11.15.2 Procurement of testing services

The waterproof membrane should be tested for integrity before the application of any other components above it. Testing should be undertaken by a third-party that is independent of the roofing contract. The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.11.15.3 Methods of test

Low voltage earth leakage
Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge
The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum
Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing
Flood testing is a suitable method of demonstrating the integrity of small areas of roof to which a green roof system is to be applied. However, consideration should be given to the effect of ingress on programme and the risk of entrapped water in insulation (warm deck roofs) and decks (all types). The area under any one test should not exceed 50m^2.

7.11.15.4 Testing after installation of a green roof system

No reliable method is available for testing the integrity of a green roof following application of the green roof components. With extensive greening on certain warm roof systems, it may be feasible to use low voltage earth leakage, but any defects recorded will in any case involve removal of the green roof components. Therefore, it is strongly recommended to ensure the very highest possible standards of protection of the waterproof membrane during the application of the green roof components.

7.11.16 Provision of information

7.11.16.1 Operation and Maintenance Manual
The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
  - Thermal insulation: generic type, product(s) and thickness.
  - Acoustic insulation: generic type, product and (as appropriate) thickness.
  - Vapour Control Layer: generic type, product (as appropriate) and thickness (as appropriate).
  - Rain water outlets: type, product, capacity, location and means of access.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.
- Instructions for irrigation (method/frequency), weed control and application of fertiliser (type/season/frequency).

FUNCTIONAL REQUIREMENTS

7.12 ROOF COVERINGS – METAL DECK ROOFING

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

7.12.1 Introduction

Metal roofing is usually built to a decent standard, but occasionally there are problems, especially where site workmanship has not been up to standard.

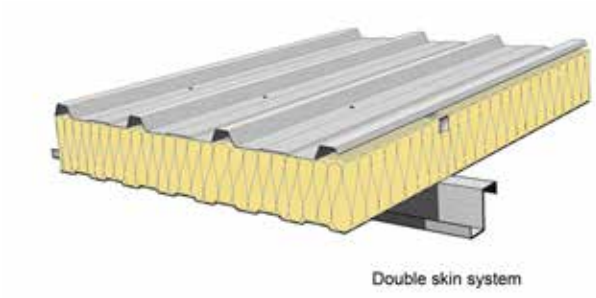


Figure 1: Typical metal double skin insulated roof

7.12.2 Double skin insulated roofs

7.12.2.1 What is a double skin insulated roof?

A double skin insulated roof is made-up on-site from separate components generally comprising: liner sheet, Vapour Control Layer (VCL), spacer system, insulation, breather membrane and finished externally with top weathering sheets. Top weathering sheets are generally secret fixed onto clips or standing seam sheets onto halters, these being machine seamed once fixed. Pierce fixed sheets are still widely used, which are fixed directly to the spacer system with external visible fixings.

Liner sheets can be solid or perforated to give an acoustic, sound-deadening roof. They are fixed directly to purlins, and can act as a VCL if a separate vapour barrier is not specified. If the liner is not used as a VCL, a reinforced vapour control sheet should be incorporated within the roof.

Insulation must be installed between the VCL and the top weathering sheet; some systems may require ventilation above the insulation and others may not; it varies from manufacturer to manufacturer. Where there is no requirement to ventilate, the insulation should be compressed slightly to ensure that there are no air voids where condensation may occur.

7.12.2.2 Workmanship

Top weathering sheets

Ensure that the top weathering sheets are installed in accordance with the manufacturer's instructions.

These must be long enough to discharge into the gutter correctly and allow for an eaves angle if required by the system.

Check that end and side lap tape sizes conform to the manufacturer's requirements.

For pierce fixed trapezoidal sheets, check for tell tales to end laps and side laps for the correct number of rows of tape.

Liner sheets

Where the liner sheet is solid and used as a vapour check, note the following:

- Frequency of main fixings to purlins and frequency of side lap stitchers.
- End laps to be sealed with mastic tape; check the size and that this is continuous. Side laps have a wider 50mm Polyband tape placed from the inside so this is visible from above.
- Check for cuts or splits in this metal liner.
- Ensure that to eaves and ridge the correct filler blocks have been used, bedded in mastic; if necessary, a closure flashing must be used from the crown of the sheet to the wall junction to maintain a vapour check. Check the use of sealant tapes and fire-retardant foam.

Separate Vapour Control Layer (VCL)

This should be a reinforced sheet, and is used to ensure a more positive air seal around the perimeter of the building. The vapour check should be sealed in the field area with the correct tape, with the number of rows dependant on the application. Check the integrity of these tapes and that they are continuous and correctly joined. Where the vapour check abuts the walls to the verge or eaves, it must be properly sealed in accordance with the Architect's detail. Around penetrations, the vapour check must be cut and sealed to any pipes or upstands.

The spacer system is fixed through the vapour check and liner into the purlins. The spacer system will have a soft sealing pad to ensure the vapour check is maintained around the fixing.

Check for punctures of the vapour check by foot traffic or damage, and patch as required.

Insulation
Check the packaging to ensure that the correct thickness is being used if one layer is used, or a combination of thicknesses to give the correct specified thickness. For two thicknesses or more, check that all joints are staggered and check the Lambda value against the specification.

Ensure that no packaging or debris is left in the roof void prior to or during the installation of the insulation. The insulation should fill the void or be compressed into the void; there should be no slumping or gaps and it should be packed into voids at the junctions of the ridge and verge.

With standing seam roofs, a rigid mineral slab insulation should be placed at eaves, ridge and around all penetrations and walkways to support the vulnerable areas of the roof, which will give a solid support to the roof sheet pans. This is easy to see during construction and easily felt on completion. The supported pan of the sheet feels solid to walk on.

Support system
Check the frequency of brackets against the specification and the number of fixings per bracket, and that they are the correct type of fixing.

With standing seam roofs, the halter may be fixed with a stainless steel fixing; check the type and frequency of fixing. Check the orientation of the halter in relation to the lay of the sheet, i.e. will they pick up the seam, as there is a right and wrong way round for halters.

Manufacturers provide halter templates to set out halters, and there must be one on-site to obtain the correct gauging of the halters.

Roof penetrations
These must be sealed to maintain the VCL. Where the liner is used as a VCL, the metal-to-metal junction must be sealed with fire-retardant foam. With a separate VCL, this must be sealed to the upstand or pipes with the appropriate tape. Externally with aluminium roof sheets, the junctions with penetrations should be site welded or weathered using glass reinforced plastic (GRP) in-situ weathering.

Roof lights
Standing seam roof sheets are usually on separate insulated upstands. With pierce fixed trapezoidal roof sheets, roof lights are in line, either factory or site assembled. Ensure that the correct size of tape is used, check the number of rows of tape that are required and that side lap tapes are not twisted by fasteners.

General
Check surface finishes for abrasions, dents and cuts, and that the roof has not been used as a cutting surface for flashings or other metal. Hot swarf from angle grinders burns into the plastisol coating of steel sheets, marks aluminium and rapidly turns to rust. Flashings should have sufficient overlap or butt straps, 150mm wide, and be sealed and supported. Check the frequency of fixings and that they are of the correct type.

7.12.3 Composite panel metal roofing

7.12.3.1 What is a composite panel roof?
A simple sheet roof system with ensured insulation thickness that is delivered with the top weathering sheet, insulation and white liner all in one sheet. With the increase in insulation, thickness panels are being made shorter in length so they can be handled into position. This means that there are more end laps to be checked.

The standard manufacturer's details are to be adhered to, but the following need to be checked.

7.12.3.2 Workmanship and installation

Fixings
There may be a requirement for stainless steel fixings to be used. Check by inspecting boxes and use a magnet; drill points will be magnetic only.

Check fixings are suitable for the purlin type – steel, light gauge cold rolled, heavy gauge or timber – as all fixings are different.

Check the bearing area of the purlin; if the building is not square, the sheets will run out and the end lap detail will not be supported. This can be overcome by using a galvanised support that is fixed to the purlin and which supports the end lap.

Check that the right number of fixings has been used for the panel and the frequency of side lap stitchers; ensure that they are side lap stitchers and not main fixings.

Sealant tapes
Check the number of rows required by the manufacturer of the panel for end laps. Tell tales should be visible at side laps of each sheet. Tell tales are the ends of the mastic tape run that can be seen or must be felt for at the side of each sheet. The same applies to side laps; there should be a tell tale at the end of the sheet. Use the end of a hacksaw blade to locate the rows of mastic tape.

On roof lights, mastic tape is visible; check its location, that its size complies with the manufacturer's requirements and that there are the correct number of rows. Tape should not be twisted by the fixings.

Air tightness
There must be a supply of gun foam, fire rated, at roof level for filling in voids before flashings are fixed. If there is not one on site, air tightness and maintaining the insulation cannot be fully achieved.

The use of foam needs to be inspected during the course of construction, and internal tapes to eaves and ridge purlins need to be inspected for size and position. At the ridge, the gap between panels needs to be filled with foam to maintain the insulation and prevent condensation forming. There also needs to be a suitably sealed inner ridge.

Verge details are difficult and it may be necessary for an internal verge to be cut and sealed around purlins. Check sealant tapes and the use of gun foam to maintain insulation. The manufacturer's details may not be achievable, but an alternative must be devised to maintain air tightness. A degree of confidence in this requirement should be shown on-site as an indication of the importance of air tightness and how this can be achieved.

Gutter junctions
If parapet or valley gutters are being used, check the air seal at the junction of the two. Gutter joints are not always level, and any gaps have to be filled. This will not only prevent wind-driven rain from entering the building, but will also maintain an air seal.

Check that roof sheets are oversailing into the gutter correctly.

Roof penetrations
Penetrations such as flues, vents, upstand-type roof lights and sun tubes need to be sealed internally, the insulation being maintained with site-applied foam. Externally, upstands must be weathered correctly and, with steel composite sheets, this is best achieved using GRP in-situ weathering.

General
Check surface finish for cuts and abrasions.

Check that the roof has not been used as a cutting surface for flashings or other metal. Hot swarf from angle grinders burns into the plastisol coating and rapidly turns to rust.

Flashings should have a sufficient overlap and be sealed and supported. Check the frequency of fixings and that they are of the right type.

Check for closure from gutters and sheet oversails. There should be suitable shrouds to prevent birds or vermin from getting into the building, which can be often overlooked.

CHAPTER 7: SUPERSTRUCTURE

APPENDIX A: INSPECTION CHECKLISTS FOR METAL ROOF COVERINGS

Checklist 1: For double skin insulated roof systems in steel or aluminium

Component / Inspection	Rectification needed		Comments
	Yes	No	
Check bearing width of purlin			
Check minimum overlap of linear decking sheets: 1. Light gauge steel; 2. Hot rolled steel; 3. Timber - check for minimum penetration.			
Check that side laps are stitched at the correct centres			
Vapour control checks using the liner: 1. Check tape to side laps, minimum width 50mm air and moisture barrier tape; 2. Check tape to end laps; 3. Check inner fillers to ridge, eaves and verge; 4. Check for sealing around the perimeter with fire resisting foam.			
Vapour control checks using a separate Vapour Control Layer: 1. Check the minimum overlap is correct; 2. Check for the correct sealant tape; 3. Check for the correct number of rows of sealant tape; 4. Check junctions between Vapour Control Layer and building elements, e.g., upstands, eaves, verge, etc.; 5. Check for puncture and repair where necessary.			
Spacer systems: 1. Check for correct height of bracket or halter; 2. Correct number of fixings per bracket or halter; 3. Check for stainless steel if specified; 4. Check for gauging of halters for standing seam and secret fix roof sheets.			Use a magnet
Insulation: 1. Check that the correct thickness is being used; 2. Check that insulation is the correct type and has the same properties as specified; 3. Check for compression; 4. Check that insulation joints are staggered; 5. Ensure that insulation designed to support load has been correctly installed to eaves, ridge, penetrations and walkways; 6. Ensure all packaging and debris is removed prior to fitting of the roof sheets.			
Breather membranes: 1. Ensure the membrane is laid in the correct direction and in accordance with manufacturer's instructions.			

CHAPTER 7: SUPERSTRUCTURE

Component / Inspection	Rectification needed		Comments
	Yes	No	
Roof sheets - standing seam and secret fixed: 1. Check that sheets are long enough so that water effectively drains into the gutter; 2. Check the direction of lay of sheets in relation to the direction of prevailing wind; 3. Check eaves detail, in accordance with manufacturer's details including eaves drips and fixing; 4. Check ridge detail including turn up fillers and ridge dams, in accordance with manufacturers details; 5. Check verge detail and adequacy of support for cut sheets; 6. Check flashing supports, sheet / verge flashing seals and frequency of fixings.			
Roof sheets - pierced fixed: 1. Check overlap dimension; 2. Check end lap tape and correct number of rows of tape; 3. Check for side lap tape; 4. Check quantity of fixings per sheet per purlin; 5. Check washer size of main fixings and side lap stitchers; 6. Check frequency of side lap stitchers; 7. Inspect for correct tightening of main fixings and side lap stitchers.			
Penetrations for vents, sun pipes, etc. **A - Aluminium sheets:** 1. Check sheets are site welded and area post coated where colour sheets are used; 2. Check that Vapour Control Layer and breather membrane is maintained around the welded area; 3. Check upstands to be at least 150mm. **B - Steel sheets: Ideally use GRP in-situ weathering flashings; however, if folded flashings are used, check:** 1. Overlap; 2. Sealing and fixing of overlaps; 3. If a flat sheet back to the ridge is used, check for insulation under the sheet; 4. Check frequency of fixings; 5. Check sealing of overlapping sheets.			
Flashings: 1. Check end overlap; 2. Check frequency of fixings; 3. Check correct type of fixing is used.			
General 1. Check roof surface for cuts and abrasions; 2. Check for hot swarf damage.			

CHAPTER 7: SUPERSTRUCTURE

Check list 2: for composite panel roofing works

Component / Inspection	Rectification needed		Comments
	Yes	No	
Panel laps to be tight when viewed from inside the building			
Constant straight line on side laps to be achieved			
Fasteners correct for the purlin: 1. Light gauge steel; 2. Heavy gauge steel; 3. Timber.			
Fastener material: 1. Coated carbon steel; 2. Stainless steel.			Check with a magnet
Fastener frequency main roof: 1. Main fixings; 2. Side lap stichers.			
Fastener frequency roof lights: 1. Main fixings; 2. Side lap stichers.			
Bearing area of purlin at end lap is a supporting bearing plate required			Is the building square?
End laps: 1. Correct number of rows of joining tape; 2. Correct size of end lap tape; 3. Correct position of end lap tape in relation to fixing.			
Roof light tape positions: 1. Correct number of rows of joining tape; 2. Correct size of end lap tape; 3. Correct position of end lap tape in relation to fixing.			
Is the roof adequately air tight (visual inspection and air tightness test where necessary)?			
Provision of fire retardant gun foam: 1. Eaves level; 2. Verges; 3. Gutters; 4. Internal verge positions; 5. Foam insulation at ridge.			

CHAPTER 7: SUPERSTRUCTURE

Component / Inspection	Rectification needed		Comments
	Yes	No	
Gutter junctions: 1. Adequacy of seals at gutter junctions; 2. Correct provision of weir overflows to gutter runs; 3. Correct junction detail between gutters and verge flashings; 4. Gaps sealed to prevent vermin infestation; 5. Correct discharge of water from roof sheets into gutter.			
Roof penetrations: 1. Check seals around cut foam insulation internally; 2. Check internal flashing closures; 3. Check weather penetrations externally.			
Flashings: 1. Check end overlaps; 2. Check frequency of fixings.			
General: 1. Check roof covering for cuts and abrasions; 2. Check for hot swarf damage.			

CHAPTER 8: SUPERSTRUCTURE (INTERNAL)

CONTENTS

8.1 INTERNAL WALLS

8.2 UPPER FLOORS

8.3 STAIRS

8.4 FIRE STOPPING AND FIRE PROTECTION TO FLATS AND APARTMENTS

FUNCTIONAL REQUIREMENTS

8.1 INTERNAL WALLS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. Party walls between dwellings must achieve satisfactory levels of sound insulation to meet the relevant requirements of the Building Regulations.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

CHAPTER 8: SUPERSTRUCTURE (INTERNAL)

8.1.1 Internal masonry walls

8.1.1.1 Foundations

Below ground, load-bearing walls must be supported using a suitable foundation. Where there are upper floors, a suitable beam or lintel that can adequately transfer the load to a foundation is required. Structural masonry walls should be provided with foundations.

8.1.1.2 Compressive strength

The varying strengths of bricks and blocks mean that they have to be chosen in accordance with the proposed use of the building. The recommended strengths of bricks and blocks to be used in buildings up to three storeys high are shown in Table 1:

Height of wall	Minimum compressive strength of brick or block unit	
One or two storeys	Blocks	- 2.9N/mm^2
	Bricks	- 9N/mm^2
Lowest storey of a three Storey wall, or where individual storeys exceed 2.7m	Blocks	- 7.5N/mm^2
	Bricks	- 13N/mm^2
Upper storeys of three storey wall	Blocks	- 2.8N/mm^2
	Bricks	- 9N/mm^2

Table 1: Minimum compressive strength of masonry

8.1.1.3 Lateral restraint

Lateral restraint is to be provided for load-bearing walls and separating walls at each floor level and the ceiling level below a roof.

8.1.1.4 Bonding and tying

Where a separating wall abuts an external wall, they may be tied or bonded together.
Tied joints should be formed using expanded metal strip, wall ties or equivalent fixings, at maximum 300mm vertical centres.

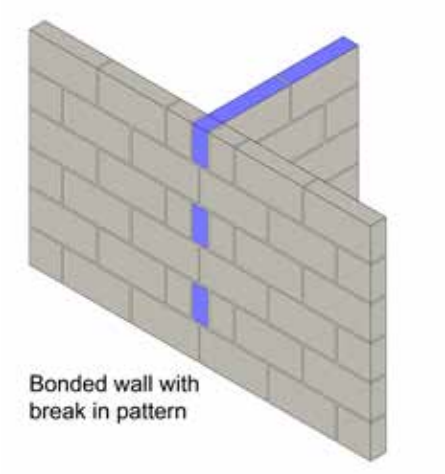


Figure 1: Bonded walls

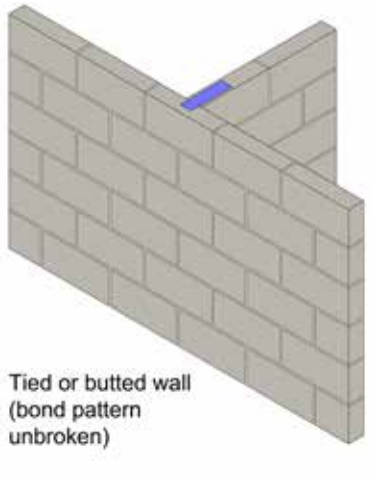


Figure 2: Butted and tied walls

The external wall cavity needs to be closed at the junction with the separating wall with a flexible cavity stop, but not if the cavity is fully filled with built-in insulation (where permitted).

8.1.1.5 Wall ties for cavity separating walls

To provide structural stability, the two leaves of a masonry cavity separating wall should normally be tied together. Sound transmission across the cavity should be limited by the type of tie and spacing. Ties should be specified in accordance with the System Designer's recommendations for timber-framed separating walls. The type of tie and spacing should limit sound transmission across the cavity.

To limit sound transmission, metal tie straps should be:

- No more than 3mm thick
- Fixed below ceiling level
- Spaced at least 1.2m apart horizontally

Thicker ties, fixed at ceiling level or more closely spaced, will increase sound transmission through the cavity.

8.1.2 Load-bearing timber walls and partitions

Load-bearing timber internal walls are to be designed to provide support and transfer loads to foundations safely and without undue movement.

The structural design of load-bearing timber walls should be in accordance with BS 5268.

Structural timber should be specified according to the strength classes, e.g. C16 or C24.

8.1.2.1 Structural elements

Typically, individual studs, sills and head plates are to be 38mm x 75mm. Larger timber section sizes are required to achieve satisfactory levels of fire resistance. Studs should be spaced at maximum 600mm centres.

8.1.2.2 Lintels and studs

A lintel and cripple studs are to be provided to any opening other than where the stud spacing is not affected. Traditionally, multiple studs will be used to support multiple joists.

Where internal walls are made up of panels, structural continuity is to be maintained, for example through the use of a continuous top binder.

Framing joints need to be secured with a minimum of two nails per joint.

8.1.3 Beams and lintels

Beams and lintels shall be satisfactory for their purpose.

Items to be taken into account include:

- Loads and spans are in accordance with the manufacturer's recommendations.
- Wall and cavity thicknesses.
- Bearing capacity of the masonry supporting the lintel or beam.

8.1.3.1 Materials

Concrete or steel lintels are appropriate for use in masonry walls; support for masonry should not be provided by timber lintels.

Lintels should extend beyond each end of openings in masonry as follows:

Span (m)	Minimum length of bearing (mm)
Up to 1.2	100
Over 1.2	150

Table 2: Minimum bearing lengths of lintels

Where structurally necessary, provide padstones under the bearings of lintels and beams.
Non-load-bearing partitions shall have acceptable strength and be adequately supported.

8.1.3.2 Partition construction

The following partition constructions are satisfactory:

- Partitions of brick or block construction.
- Timber stud partitions using studs, sills and head plates nominally 63mm x 38mm. Studs should be spaced to suit the thickness of plasterboard used, as follows:
  - Maximum 450mm spacing for 9.5mm boards.
  - Maximum 600mm spacing for 10mm–20mm boards.

8.1.4 Non-load-bearing timber partitions

Partitions should be robust and form a smooth, stable, plane surface to receive decoration:

- Supporting members should be accurately spaced, aligned and levelled.

- The tolerance of horizontal straightness of a partition should be +/-10mm over a 5m length.
- The deviation in vertical alignment of a partition in any storey height should be +/-10mm.
- Timbers supporting plasterboard should be regularised and have a moisture content not greater than 20% at the time of erection (lower moisture contents can reduce incidents of nail popping and other effects of shrinkage).

Stud partitions should be no less than 38mm wide and no less than 63mm thick (up to a maximum partition height of 2.4m), and 89mm thick up to a maximum partition height of 3m. However, in order to accommodate tolerances for plasterboard fixing, a minimum width of 44mm is recommended.

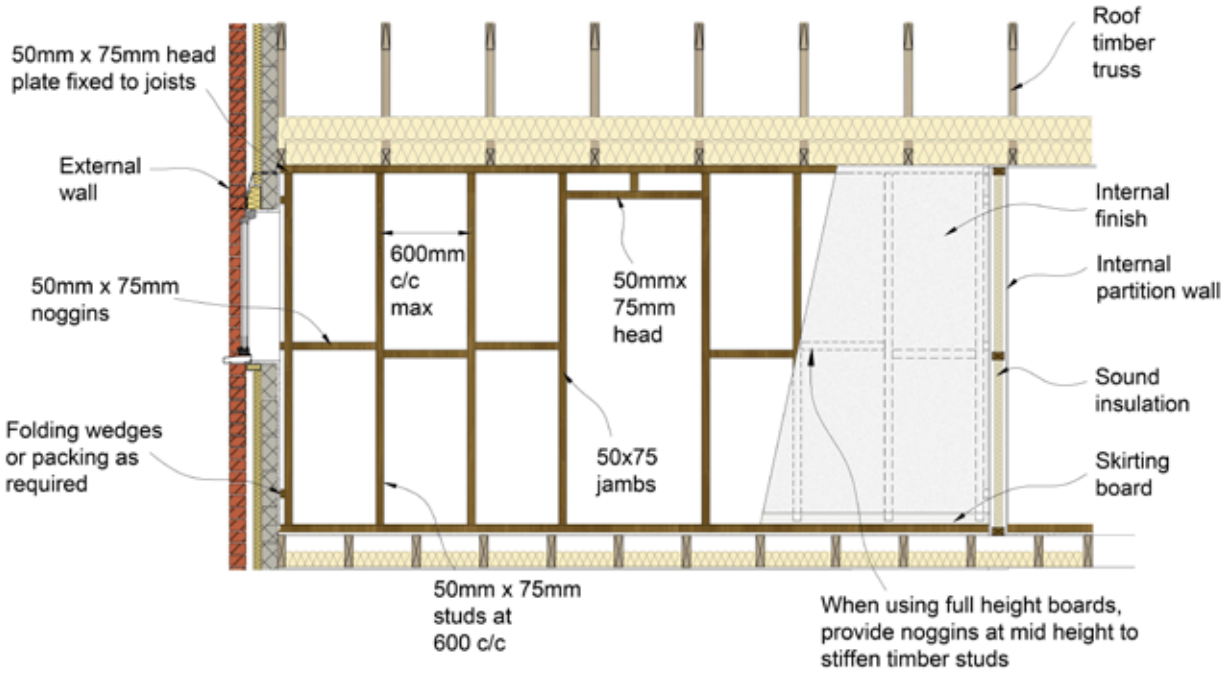


Figure 3: Timber stud partition

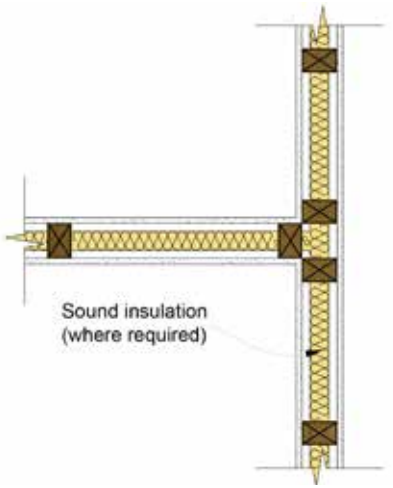


Figure 4: Typical timber stud plan

Head and sole plates should consist of single length members fixed to the building structure at no less than 600mm centres.

Partitions should be located on double joists when parallel to floor joist span and nailed to 50mm x 50mm noggins fixed between ceiling joists at 600mm centres when parallel to ceiling joist span. For short lengths of partitions (1.2m maximum), blocking between joists at 600mm centres may be used. Intersecting head and sole plates should be skew nailed together.

Timber members should be fixed together with a minimum of 2No. 75mm long x 2.65mm diameter nails.

Proprietary partitions of plasterboard, strawboard or other material must be detailed and constructed in accordance with the manufacturer's recommendations.

Where partitions are to support heavy items such as radiators or kitchen cupboards, additional noggins should be provided within the stud partition to accommodate fixings.

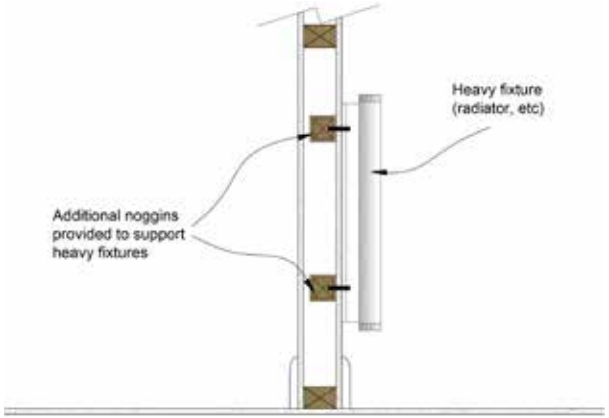


Figure 5: Support of heavy fixtures

8.1.5 Method of supporting partitions

Walls and partitions are to be supported by the structural floor only if the material is specifically manufactured for that purpose; it is not to be supported by a floating floor that incorporates a compressible layer.

Masonry partitions should be supported on:

- Other masonry partitions or walls (wherever conceivable, the design of dwellings should be such that the first floor masonry partitions are an extension of those on the ground floor).
- Concrete floors.
- Steel or concrete beams.

It may be necessary to use padstones at bearings where steel or concrete beams are to be used.

Masonry partitions should not be supported by timber joists or beams. Allowance should be given in the design for the relatively flexible nature of the timber and the rigid nature of masonry.

Extra noggins or joists should be specified where stud partitions or proprietary plasterboard partitions are supported by a timber floor, unless it can be shown that the deck can transfer the load without undue movement.

Allowance for the probable deflection of floors at the head of partitions is required to prevent the partition becoming load-bearing.

8.1.6 Proprietary systems

Proprietary systems are to be specified in accordance with the manufacturer's recommendations.

8.1.6.1 Metal stud system

There are a number of proprietary systems on the market.

This traditionally consists of U-shaped channels that act as ceiling (head), base plates (tracks) and the vertical studs. The advantage of this system is that it is lightweight, versatile and quick to erect.

Installation should always be carried out in accordance with the manufacturer's instructions. Plasterboard coverings are screw-fixed to the metal studs, with the perimeter studs/tracks generally being mechanically fixed to the surrounding walls, ceilings and floors.

It may be necessary to provide earth-bonding to the metal stud system.

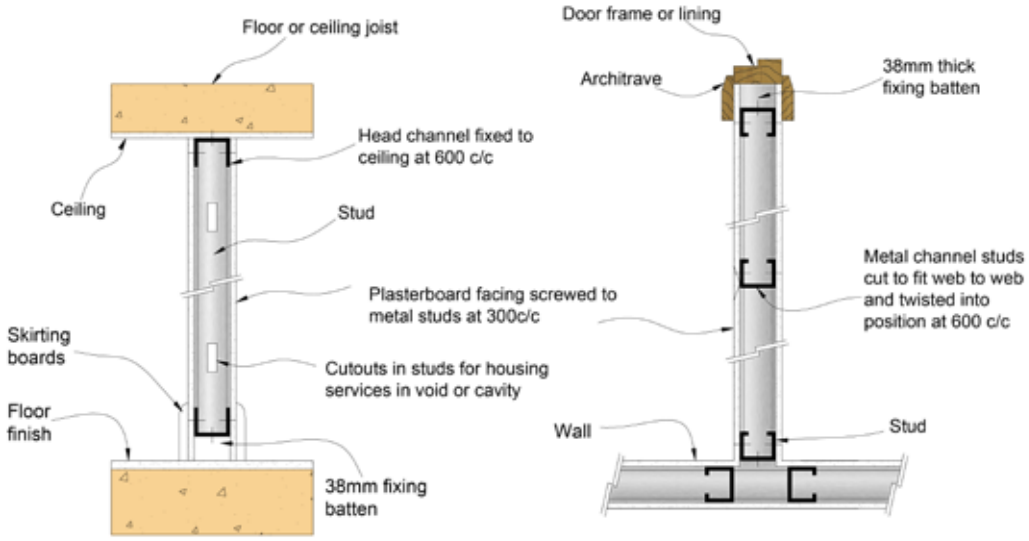


Figure 6: Metal stud partition

8.1.7 Fire resistance

Typically, in dwellings, only a half-hour or one-hour fire-resistance is required to satisfy the Building Regulations with regard to fire separation between dwellings and/or compartments within dwellings.

Material	1/2 hour FR	1 hour FR
Brick	90mm thickness	90mm thickness
Block	90mm thickness	90mm thickness
Plasterboard on timber	12.5mm board on both sides of framing	Two layers of 12.5mm board on both sides of framing or proprietary fire boards (typically 12.5mm - 15mm) on both sides of framing
Plasterboard laminated wall	12.5mm laminated on both sides of 19mm board	Refer to manufacturer's recommendations

Table 3: Minimum periods of fire resistance

8.1.8 Sound insulation

Internal walls shall, where necessary, have adequate resistance to the transmission of sound. All separating walls in England and Wales may be built in accordance with Robust Details Part E Resistance to the passage of sound.
Sound insulation can be complied with by using either:

8.1.8.1 Pre-completion testing

Pre-completion testing (PCT) is required in the following situations:

- To all new-build domestic properties (including rooms for residential purposes), other than when the developer has registered and built in accordance with Robust Details.
- Where the sound insulation construction is in accordance with the guidance given in Approved Document E of the Building Regulations.
- Where the building is not built in accordance with Approved Document E of the Building Regulations.
- The requirements of the robust details system have not been met.

8.1.8.2 Robust details

The use of robust details as a means of providing adequate sound insulation applies only to party walls and floors between different dwellings or flats. It is approved by Robust Details Ltd.

The robust design details are available in a handbook, which can be purchased from:

Robust Details Ltd
PO Box 7289
Milton Keynes
Bucks MK14 6ZQ

Tel 0870 240 8210
www.robustdetails.com

Robust Details Ltd may undertake monitoring to check on the performance achieved in practice.

8.1.9 Internal plastering

Internal plastering should comply with BS 5492. Plasterboard should be to BS EN 520: Gypsum plasterboards – Definitions, requirements and test methods.

Plasterboard thickness should be:

- 9.5mm for stud spacing up to 450mm.
- 12.5mm for stud spacing up to 600mm.

Further guidance on plastering can be found in Chapter 10 of this Manual.

8.1.10 Fire resistance

All internal, separating and compartment walls should have the fire resistance required by the relevant Building Regulations.

8.1.10.1 Fire stopping

Where separating walls and compartment walls meet a roof – see Chapter 7.8.5.

Penetrations in walls that are required to have fire resistance must be designed to meet the requirements of the Building Regulations.

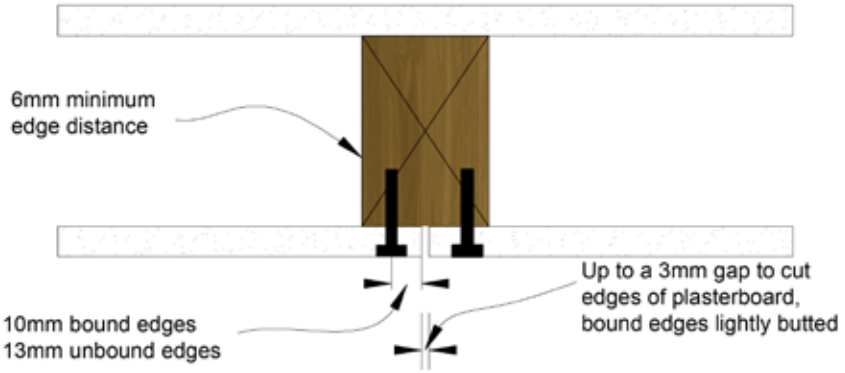


Figure 7: Fixing of plasterboard to studs

FUNCTIONAL REQUIREMENTS

8.2 UPPER FLOORS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Party floors between dwellings must achieve satisfactory levels of sound insulation to meet the relevant requirements of the Building Regulations.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

8.2.1 Floor boarding or decking

Suitable floor boards and decking include: Tongue and grooved softwood flooring with a minimum moisture content at the time of fixing of between 16%–20% and in accordance with BS 1297. All boards must be double nailed or secret nailed to each joist using nails that are at least three times the depth of the board. Boards must have a minimum thickness, as indicated in Table 4.

Finished board thickness (mm)	Maximum centres of joists (mm)	Typical nail fixing (mm)
15	Max 450	45mm lost head nail
18	Max 600	60mm lost head nail

Table 4: Softwood floor boarding: minimum thickness and centres of support

8.2.1.1 Particle boarding

Acceptable particle boards consist of Oriented Strand Board (OSB) or chipboard. Chipboard should be tongue and grooved and all joints glued. The boards should be laid so that the shortest length is laid parallel to the span. OSB boards should be type 3 or 4 to BS EN 300, and should be laid with the major axis at right angles to the joists (the major axis is indicated on the OSB board by a series of arrows).

Particle boards should be either screwed or nailed to the joists at 250mm centres. Nails should be annular ring shanks that are at least three times the depth of the board.

A 10mm expansion gap should be provided around the perimeter of the floor against a wall abutment.

Thickness (mm) (chipboard)	Thickness (mm) (OSB)	Maximum span (mm)	Typical nail fixing (mm)
18 and 19	15	450	60mm annular ring shank
22	18 and 19	600	65mm annular ring shank

Table 5: Particle floor boarding: minimum thickness and centres of support

8.2.2 Floor joists

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 10mm of drying shrinkage in floor joists supported by steel beams. It is essential that joists are not overloaded during construction. Joints in joists, rafters and purlins should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where a 35mm bearing is acceptable (subject to the manufacturer's details). Double joists should be bolted together at 600mm centres using minimum 10mm diameter bolts with large washers that will prevent the bolt head and nut from penetrating the joist. It is recommended that the bolting of double joists is along the centre line of joists. Suitably sized trimmer joists shall be provided around floor openings.

Trimmed openings may be needed around staircase openings and chimneys. Solid trimmed joists may be supported using either joist hangers or a structurally designed connection; timber trimmers around openings should consist of at least two members and be designed by a Structural Engineer.

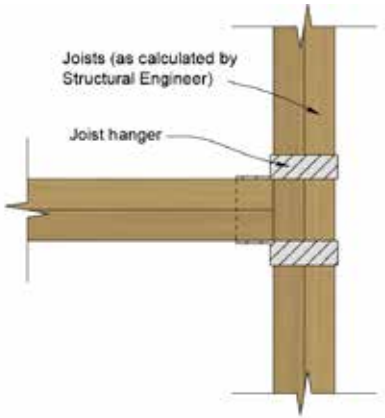


Figure 8: Typical trimming detail (plan)

8.2.2.1 Notching and drilling of joists

Joists can be notched, providing this is in accordance with Figure 9.

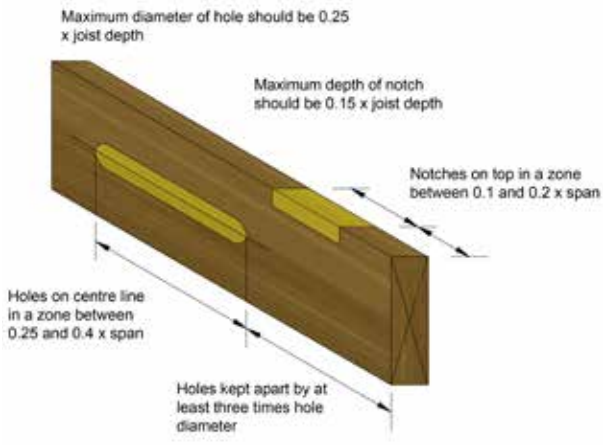


Figure 9: Notching of joists

8.2.3 I-joists

I-joists and metal web trimmed joists should be supported using joist hangers. If an I-joist is used as a trimmer to support another I-joist, backer blocks should be provided on both sides of the web of the trimmer.

Engineered timber I-joists include a timber flange (usually solid timber or laminated veneer lumber (LVL) and a panel product web (usually OSB). They are manufactured in an assortment of depths and flange widths under controlled factory conditions to low and uniform moisture contents.

8.2.3.1 Engineered I-joists

Permanent rows of intermediate strutting are not required.

It consists of parallel stress graded timber flanges joined together with V-shaped galvanised steel webs. The webs are fixed to the flanges via nail plates. The open web design gives great flexibility in running through services.

8.2.3.2 Storage of I-joists

I-joists should be protected from the elements and supported on suitable bearers over a free draining surface. Levels of exposure more severe than those encountered during a normal uninterrupted build programme should be addressed by the provision of suitable protection.

8.2.3.3 Bracing

Large areas of floor joists can be assembled with these products due to their light weight and availability in long lengths. It is of great importance that adequate safety bracing is provided to ensure that the joists remain stable through the construction phase. Joist manufacturers provide simple guide recommendations that allow an installer to facilitate this process with ease and speed.

Unbraced joist layouts are not to be walked on by workers.

Floors should not become overloaded during construction.

Under no circumstances should the flanges of the I-joist be cut, notched or drilled.

8.2.3.4 Building in of I-joists over internal walls

To reduce shrinkage, all mortar should be adequately dry and solidly packed in, but it should not be packed up tight to the underside of the top flange. Before the floor decking is fixed, all continuous joists must be packed down to the intermediate bearing wall.

8.2.3.5 Precast concrete floor units

Precast concrete units and infill blocks are to be carefully stored and handled on-site, preventing damage occurring before, during and after incorporation into the structure. Units should be lifted as near as possible to their ends.

The bearing surface of walls, beams and other supports to receive precast units are to be smooth and level.

Infill blocks and slabs should fully bear onto supporting beams and walls.

8.2.3.6 Precast beam and block floors

Ensure that precast concrete beam and block floors are fully supported by load-bearing walls.

Similar beams of the same size may have differing strength properties because of their varying reinforcement size, so it is important to check beam reference numbers and their layout. It is also essential sometimes to provide two or more beams adjacent to each other where spans are excessive or in heavily loaded areas. Suitable infill bricks or blocks are to be properly bedded on mortar and provided between pre cast (PC) beams where bearing onto supporting walls.

Beams and blocks are to be grouted together with a 1:6 cement to sand mix in accordance with the manufacturer's instructions.

Load-bearing walls are to continue through the beam and block floor.

Holes for service pipes are properly filled by laying non-timber formwork between PC joists and filling with good quality concrete (ST2 mix) prior to screeding.

Beams should bear onto masonry at a minimum 90mm, and steelwork at a minimum 70mm.

Provide restraint straps to walls where the beams run parallel.

Ensure that the blockwork carrying the beam and block flooring has sufficient compressive strength.

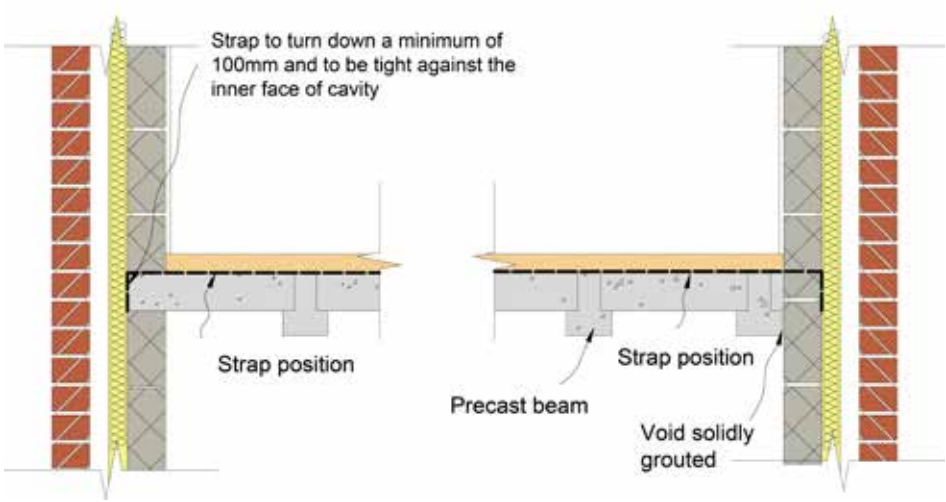


Figure 10: Lateral restraint to walls at floors and roofs (beam and block)

8.2.4 Fire resistance

All floors should have the fire resistance required by the relevant Building Regulations.

To achieve the same fire resistance, I-joists and metal web joists may require a different specification for the ceiling than that for solid timber joists. Holes should not be made in the ceilings, e.g. for down lighters, unless it can be proven that the floor construction achieves the required fire resistance.

8.2.4.1 Fire stopping

Penetrations in floors between dwellings shall be fire stopped. There are to be no holes or gaps for smoke to pass through once the fire stopping has been fitted. Where down lighters are incorporated in a ceiling, they should be fitted in accordance with the manufacturer's instructions.

8.2.5 Deflection of floors

On upper floors (intermediate floors), although the permissible deflection may be in accordance with a relevant British Standard or TRADA recommendation, deflections must be within the tolerances defined in Chapter 1.

FUNCTIONAL REQUIREMENTS

8.3 STAIRS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Stairs and landings must have appropriate guarding to meet the relevant Building Regulations
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The material, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

8.3.1 Stairways

Staircases, newels, balustrades and handrails are to be adequately fixed to avoid excessive deflection. Strings are required on staircases to provide a secure fix to an adjacent wall, and the wall should be of masonry or timber stud construction. The top tread should not be solely relied upon for fixing. It is recommended that stair strings should have fixings at 900mm centres. The fixings should be at least 6mm diameter screws that penetrate into the masonry wall or timber stud by at least 60mm.

Unless it is for a means of entrance/exit within a communal type building, there is no longer guidance given for a minimum width of a staircase. In these circumstances, the width and pitch, etc. will be determined by the use of the building.

Where a staircase serves an individual property, the need is for it to provide a safe means of access between different levels.

All staircases within domestic units are to have a maximum rise of 220mm, with a minimum going of 220mm, although the stair pitch, which is a line connecting all nosings, should not exceed 42°.

The dimensions for maximum rise and minimum going should be:

Type of stairs	Maximum rise (mm)	Minimum going (mm)
Private stairs	220	220
Common stairs	190	250
Access stairs	190	250

Table 6: Minimum rise and going of stairs

At its narrowest point, the minimum width of a winder tread should be no less than 50mm.

The minimum headroom over the flight and landing should be 2m.

Handrails and guarding over the flight and landing should be established at a height of between 900mm and 1000mm. It should be non-climbable, and any gap within a riser or guarding should not exceed 100mm.

Handrail design should ensure:

- A firm handhold.
- Trapping or injuring the hand is prevented.
- A minimum 25mm clearance at the back of the handrail.
- Secure fixing.

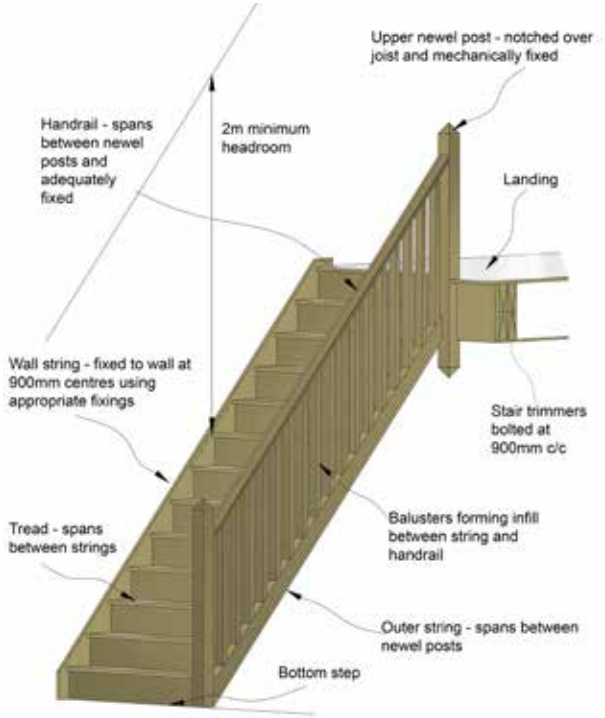


Figure 11: Staircase

Where the staircase is greater than or equal to 1000mm, a handrail should be provided to both sides of the staircase.

8.3.2 Location and fixing

8.3.2.1 Headroom

The overall floor opening is to be checked for the size required to accept the stairs and allow for sufficient headroom.

The minimum headroom above the stairs is to be measured vertically from the pitch line. The clear headroom should be 2m over the entire length and width of a stairway, including landings.

8.3.2.2 Overall vertical rise

Staircases are traditionally manufactured off-site, so the floor-to-floor dimensions should be extremely accurate, although an allowance should be made for floor finishes to structural floors or staircase treads.

8.3.2.3 Pitch

Staircases should be accurately located and fixed with the string at the correct angle, so that all treads are horizontal.

8.3.2.4 Landings

Landings are to be properly framed to provide full support to, and secure fixings for, flights, nosings, newels, apron linings, etc.

8.3.2.5 Floor finishes

Allowance should be made for stair and floor finishes, ensuring that all risers are equal.

8.3.2.6 Pitch

The maximum angle of pitch of a stairway should not exceed:

- 42° for private stairs
- 38° for common or access stairs

8.3.2.7 Lighting

Artificial light sources should be provided to all staircases and landings. Within a dwelling, lighting to stairs should be controlled by two-way switching. Automatic light-sensitive controls may be used in common areas, provided lights can also be two-way switched manually.

Where staircases are lit by glazing, any glass immediately adjacent to the stair should be:

- protected by a balustrade or railing, or
- toughened or laminated glass, or
- constructed of glass blocks

FUNCTIONAL REQUIREMENTS

8.4 FIRE STOPPING AND FIRE PROTECTION TO FLATS AND APARTMENTS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Fire stopping is to be completed by a third-party approved contractor.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.
iv. Fire stopping and fire protection materials are to have relevant third-party certification confirming suitability in its application.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.
iv. Layouts indicating the positions of compartment walls/floors and other lines of fire resistance must be available to the Builder and Risk Management Surveyor.

Limitation of this section

Chapter 8.4 applies to any building that contains flats or apartments with a floor four or more storeys above the ground.

CHAPTER 8: SUPERSTRUCTURE (INTERNAL)

8.4.1 Introduction

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This section assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations in this section, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this Technical Manual.

This section applies to buildings with four or more storeys that contain flats or apartments; however, it is recommended that the guidance is followed for buildings constructed using Modern Methods of Construction and Innovative Materials.

8.4.2 Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification in accordance with section 3 of this Manual, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

8.4.3 Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with the Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification in accordance with Chapter 2 of this Manual, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

CHAPTER 9: BUILDING SERVICES

CONTENTS

9.1 DRAINAGE (BELOW GROUND)

9.2 DRAINAGE (ABOVE GROUND)

9.3 ELECTRICAL INSTALLATIONS

9.4 HEATING AND MECHANICAL SERVICES

FUNCTIONAL REQUIREMENTS

9.1 DRAINAGE (BELOW GROUND)

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

9.1 Introduction

This Chapter provides direction on achieving the technical requirements for internal services.

General

Internal services shall be designed, constructed and installed so that they:

- Conform to all relevant statutory requirements
- Do not adversely affect the structural stability of the housing unit
- Prevent the entry of hazardous ground substances, external moisture or vermin
- Are constructed using non-hazardous materials
- Are durable and robust
- Are safe and convenient in use

9.1.1 Drainage (general)

A trapped gully should be provided where impervious surfaces such as drives, paths and hard standings drain to a rain water drainage system. Impervious surfaces can drain to a permeable area within the garden providing it is free draining.

The drainage system, including manholes, gullies, pipe connections, etc., should be protected from damage throughout the course of the construction works.

9.1.2 Pipework

Where ground movement is likely to occur, flexible drainage systems should be provided, e.g. filled sites, mining areas and sites with shrinkable clay.

Where possible, avoid passing adjacent to tree roots. Adequate precautions should be taken where this cannot be avoided, in accordance with the recommendations of the relevant Building Control body and the Pipe Manufacturer.

Drainage trench excavations should be taken down to solid ground, but when this is not possible, the drainage system should be designed to accommodate any movement and made-up with a well-compacted backfill to the required formation levels.

The depths of drains and the protection provided over them needs to be adapted to the traffic normal for the location, in accordance with the recommendations of the relevant Building Control body and the Pipe Manufacturer. Requirements are as follows:

- Pipes should be laid to an even gradient, and significant changes in gradient should be combined with an access point.
- Pipes should be laid in straight lines, but may be laid to slight curves, providing the length of drain can be effectively cleaned by the use of rods.
- Connections should be to inspection chambers or manholes, but connections to junctions are acceptable if access is provided to clear blockages. In all cases, discharge should be in the direction of flow.
- Bends should be positioned in, or adjacent to, terminal fittings, inspection chambers or manholes, and at the foot of discharge stacks. Bends should have as large a radius as practicable.
- The system should be ventilated at or near the head of each main drain to allow free passage of air throughout; the maximum length of any branch serving a single appliance being 6m, and for a group of appliances, 12m.
- Where appliances are not fitted with integral traps at the point of discharge, a trap must be provided using either a trapped gully or low back trap.

9.1.3 Drainage materials

Drain materials should comply with either:

- BS 1194 – Concrete porous pipes
- BS 65 or BS 1196 – Clayware pipes
- BS 4962 – Plastic pipes

Land drains are to be laid to a uniform gradient with falls of not less than 1:200 and as recommended by the Pipe Manufacturer.

9.1.4 General backfill

In normal circumstances, the excavated material from the trench will be appropriate for backfilling above the chosen material. General backfill materials must be free from:

- Boulders
- Building rubble
- Timber
- Vegetable matter

Backfill needs to be positioned in layers not deeper than 300mm, and must be well compacted. When compacted backfill is at least 450mm above the crown of the pipe, only mechanical compacting should be used.

9.1.5 Drain protection adjacent to foundations

Drains are to be located so that foundation loads are not transmitted to pipes. Where drainage trenches are located near to foundations, foundation depths should be increased or the drain re-routed further from the foundations.

The trench should be filled with concrete to an appropriate level where the bottom of a trench is below foundation level.

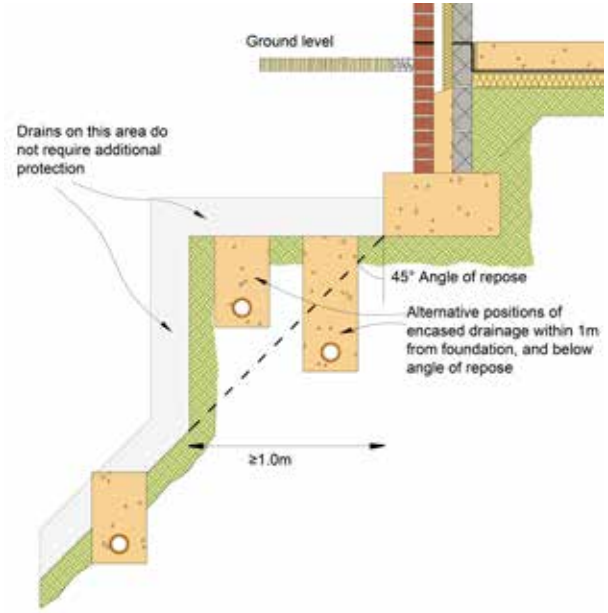


Figure 1: Drainage positions situated within angle of repose and adjacent to foundation by 1m

Walls should accommodate movement where drains pass through substructure by:

- 50mm clearance all round.
- A sleeve with a 50mm clearance.
- (If built in) a connection on both sides of the wall to pipes with flexible joints located no more than 150mm from the face of the wall.

9.1.6 Combined drainage system

A system that carries both foul and storm water from a property will usually be found on older properties where a Local Authority combined sewage system is the only discharge point.

It may be required to install surface and foul water drains independently, even where a site is being assisted by an existing combined sewer. This needs to be confirmed by the relevant authorities prior to design of the drainage.

It is vital that all surface water fittings have an integral trap so that foul gases do not cause problems when a one-pipe system is installed.

A combined drain should be capable of accepting peak surface and foul water flows (BS EN 752). It is also good design practice to guarantee that self-cleansing velocity (0.75l/s) is reached when only foul water is entering the drain.

9.1.7 Foul water drainage system

Foul water drainage systems only take foul waste from a property or properties. Foul waste is the waste water from sinks, toilets, showers, baths, dishwashers and washing machines. These systems discharge into Local Authority sewers, then pass through sewage treatment plants. By separating the foul waste and taking it straight through to treatment plants, you are not treating large volumes of storm water needlessly.

9.1.8 Surface water

Surface water drainage is allowable through the use of one of the following systems:

- An adequate soakaway, or some other adequate infiltration system; or where this is not realistic.
- A watercourse; or where this is not realistic.
- A sewer (this helps minimise surface water arriving into the foul water drainage system, which can often overload the capacity of the sewer and cause flooding).

9.1.9 Provision of gutters and downpipes

If the roof area is greater than 6m², it needs to be provided with rain water gutters and rainwater downpipes (RWP) that meet the minimum size requirements shown in Table 2. Thought should also be provided to the provision of rain water drainage to roof areas less than 6m², such as dormer roofs.

Discharge of gutters into downpipes can be substantially improved by the careful location of downpipes:

- Locating downpipes at end quarter positions will double the flow capacity if more than one downpipe is required.
- The downpipe should be located within 200mm of the change in direction in order to maintain the flow capacity of the gutter where changes in the line of the gutter occur.

Type of surface area	Effective design area
Paved areas	plan area
Flat roof plan	area of roof
30° roof pitch plan	area x 1.29
45° roof pitch plan	area x 1.5
60° roof pitch plan	area x 1.87
70° roof pitch plan	area x 0.5

Table 1: Calculation of roof area

Max effective roof area (m²)	Gutter size (mm diameter)	RWP outlet size (mm diameter)	Flow capacity (litres / sec)
6	-	-	-
18	75	50	0.38
37	100	63	0.78
53	115	63	1.11
65	125	75	1.37
103	150	89	2.16

Table 2: Gutter sizes and outlet sizes

9.1.10 Layout of land drains

Drain runs on sloping sites need to be positioned perpendicular to the fall of the site.

Land drains should be positioned adjacent to paths, drives and outbuildings. The pipe soffit should be positioned at least 400mm below the finished ground level, and the backfill consolidated to the same degree of compaction as the adjacent soil.

9.1.11 Soakaways

Soakaways are a simple way of dispersing surface and storm water in circumstances where connection to the storm water sewer system is not feasible or unnecessary. A soakaway is basically a system that loses water rather than collects water. Soakaways are part of the Sustainable Urban Drainage Systems (SuDS) technologies that handle storm water at the source rather than leading it into the public sewer systems.

Soakaways can only be considered in permeable conditions. A suitable site must be:

- In a location lower than the area being drained.
- At least 5m away from any building (BS 8301).
- Situated so that it will not saturate the foundations of any structure.
- Situated so that the base of any soakaway/ infiltration system is permanently above the water table.
- Situated far enough away from other soakaways/infiltration systems to ensure that the capacity of those other systems and the ground itself is not impaired.
- Situated so that there is no risk of contamination from pollutants.

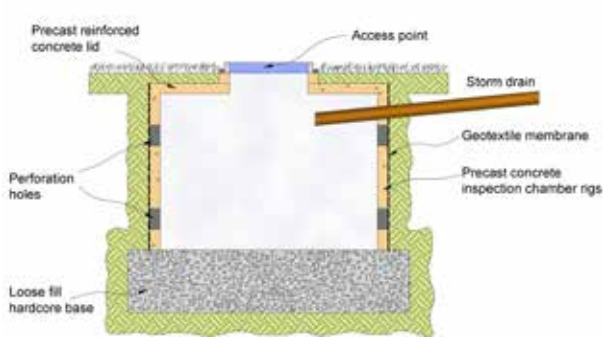


Figure 2: Chamber type soakaway

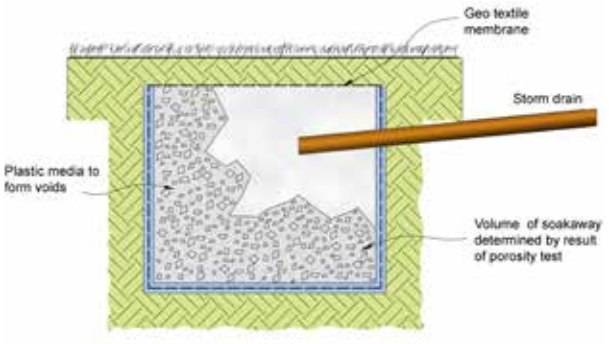


Figure 3: Typical soakaway design

For sites where chalk is prevalent, the CIRIA C574 Engineering in Chalk 2002 publication gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low-density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent, soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations.
- Where the chalk is of low density, or its density is not known, soakaways should be sited at least 10m away from any foundations.
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipe work.
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits.

9.1.12 Septic tank systems/treatment plants/ cess pits

If you are not on main line drainage then you will have a septic tank, treatment plant or cesspit of some description; ordinarily, the foul waste will run to one of the above tanks while the rain water is usually kept separate to help the action of bacteria and enzymes in the tank. The out fall from the septic tank would either run to a soakaway or possibly straight to a river or brook; you will often find the rain water system tapped onto the outlet of a septic tank to help dilute any effluent that may pass through the system.

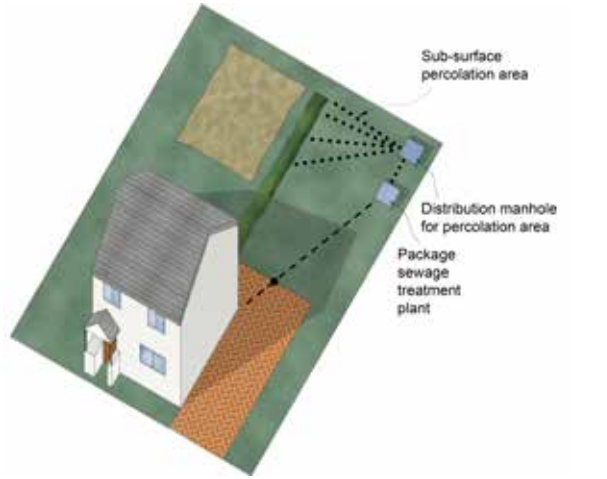


Figure 4: Typical package sewerage plant

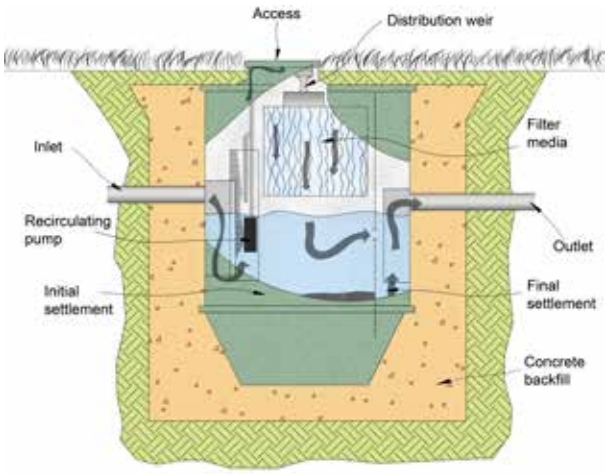


Figure 5: Typical sewage treatment plant

FUNCTIONAL REQUIREMENTS

9.2 DRAINAGE (ABOVE GROUND)

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

9.2.1 Above ground drainage

All above ground plumbing systems need to be designed to allow the unobstructed flow of waste water from an appliance to the underground drainage system. To achieve this, the points below should be noted at the design and installation stages:

- Provide rodding access facilities at all changes of direction.
- Avoid bends and changes of direction in the wet part of the above ground drainage system.
- 75mm-deep seal traps should always be used, except on a WC or where an appliance on the ground floor discharges directly into a trapped gully.
- Pipe sizes should not exceed the dimensions for diameter against pipe length.
- Pipes should be laid at gradient 1:80 or better.
- Any admittance valve fitted to the system should be located above the highest flood level of any appliance connected to that stack pipe.
- Enclosures to air admittance valves should be adequately ventilated.
- The highest point of a drainage system (head of run) should always be vented to the external air.

9.2.2 Soil and waste systems

In all above ground plumbing systems, the unobstructed flow of waste from an appliance to the underground drainage will be allowed. This will be achieved by following the notes below at the design and installation stages:

- Rodding access is to be provided at all direction changes.
- Pipe and gutter sizes are adequate to take the expected rate of discharge, and are laid at suitable gradients with the minimum of direction changes.
- 75mm deep seal traps should always be used, except on a WC where a 50mm depth of water seal can be used on the above ground drainage system.
- Pipe sizes should not exceed the dimensions for diameter against pipe length.
- Pipes should be laid at a gradient of 1:80 or better.
- Venting to the external air will be required at the highest point of a drainage system (head of run).
- At the head of underground drains, ventilation is to be provided, either by a soil pipe or a separate ventilation pipe.
- A soil or ventilation pipe should extend at least 900mm above an opening if it is less than 3m away from an opening into the building.
- The drains are adequately protected from ground loads.

9.2.3 Air admittance valves

Air admittance valves provide a means of ventilation to the drainage system to prevent the loss of water seals in traps.

They are suitable for use in domestic buildings, e.g. bungalows, houses, multi-storey flats, and they only allow air to enter the drainage system. Their use does not avoid the need to ventilate the drainage system adequately.

Where air admittance valves are used to terminate soil pipes they should comply with Building Standards. Valves within the building should be:

- Positioned in areas that are not liable to freezing.
- Positioned in areas with adequate ventilation.
- Accessible for maintenance.

If the discharge stack provides the only ventilation to septic tanks or cesspits, the connecting drain is subject to periodic surcharging or is fitted with intercepting traps, air admittance valves are not suitable for providing ventilation.

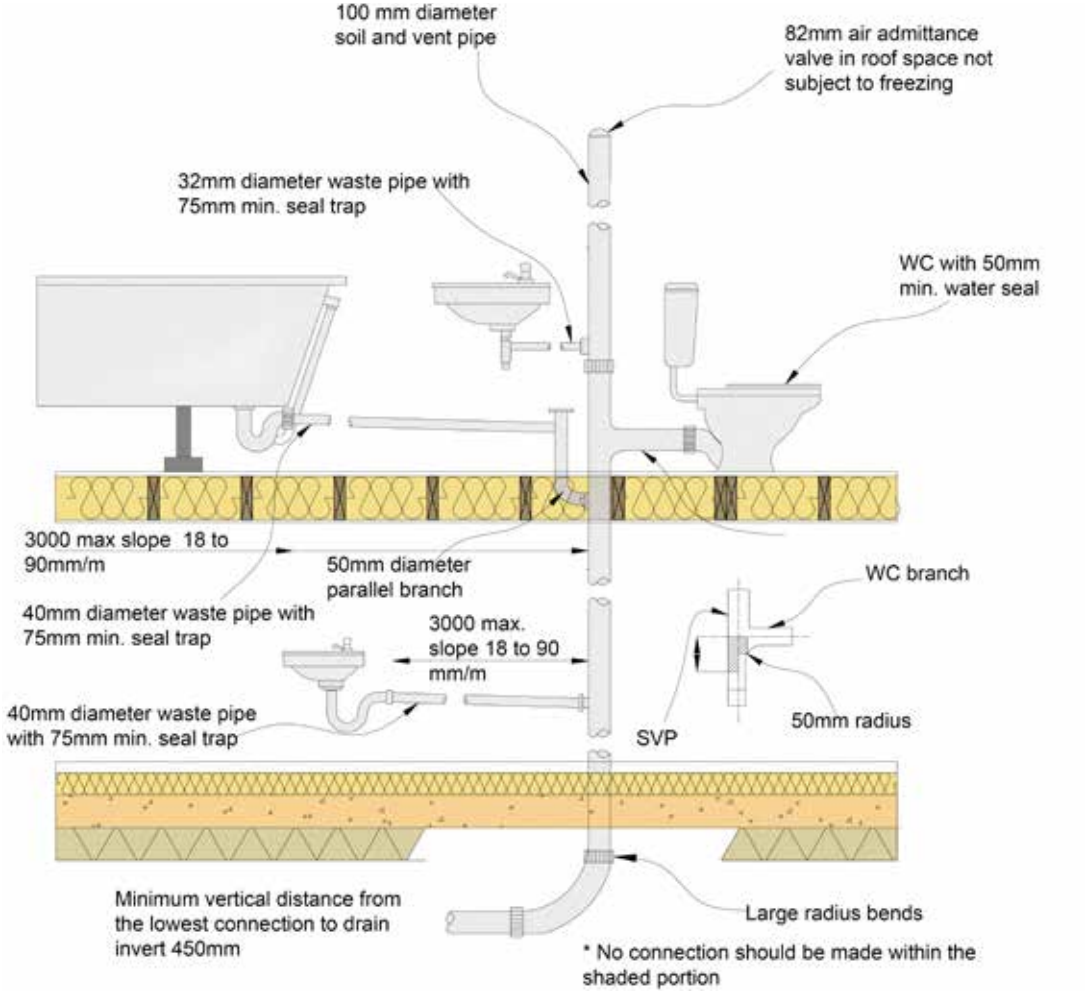


Figure 6: Single stack system: air admittance valves

9.2.4 Provision of information

Design drawings for internal services will need to include:

- Location of sanitary fittings
- Drainage runs
- Location and size of cold water storage cisterns
- Location and size of hot water storage cylinder
- Hot and cold water pipe runs
- Gas supply pipe runs
- Electrical outlets, switches and consumer unit

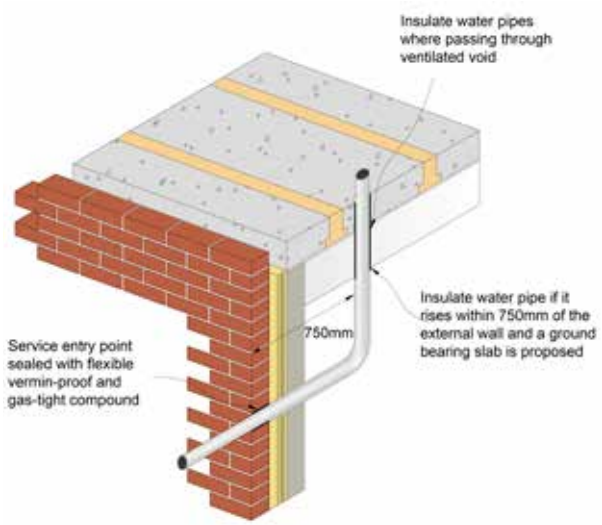


Figure 7: Sealing of service entry points

FUNCTIONAL REQUIREMENTS

9.3 ELECTRICAL INSTALLATIONS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The materials, design and installation must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

9.3.1 General

A suitable electrical service of the appropriate size for normal domestic use shall be provided.

PVC-covered cables should not be in contact with polystyrene insulation.

Electrical cables should not be diagonal, and their locations should be in accordance with Figure 8.

9.3.2 Supplementary earth bonding

For domestic situations, supplementary bonding is required in areas of increased risk, which are rooms containing a bath or shower. It is not required within kitchens, utility rooms or washrooms.

Supplementary bonding is not required to the pipes or metal fitments attached where plastic pipes are used within a bathroom or shower room.

This also applies where short lengths of metal pipes connected to bathroom fittings are attached to plastic pipes.

Supplementary bonding is still required to electrical equipment such as electric showers or electric heaters. This type of bonding must also be connected to the protective conductor of all circuits supplying electrical equipment in the bathroom.

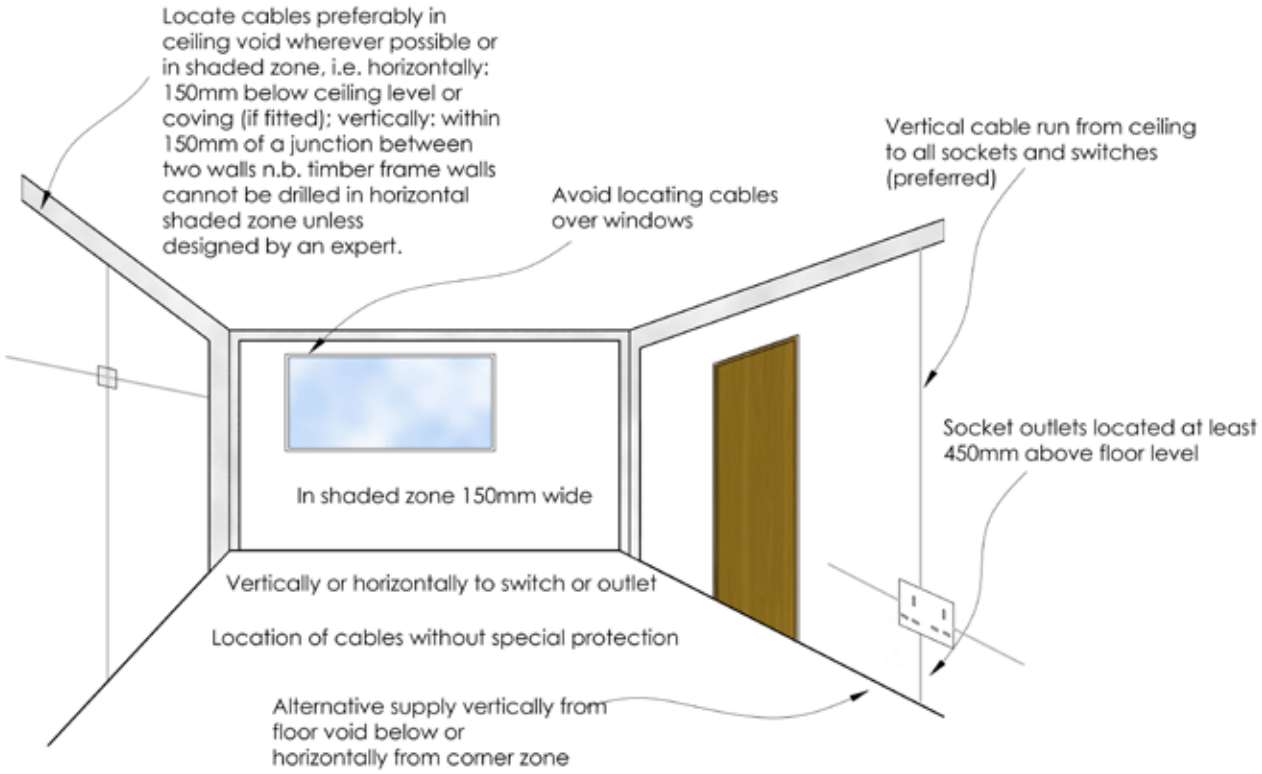
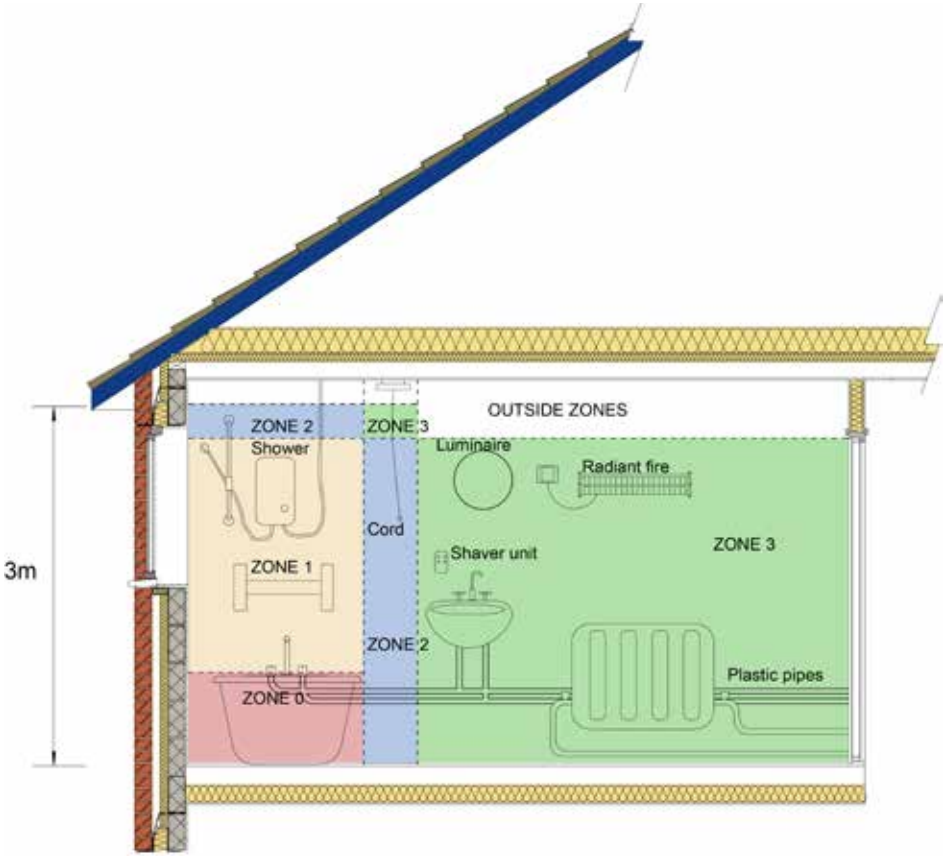


Figure 8: Location of cables without special protection

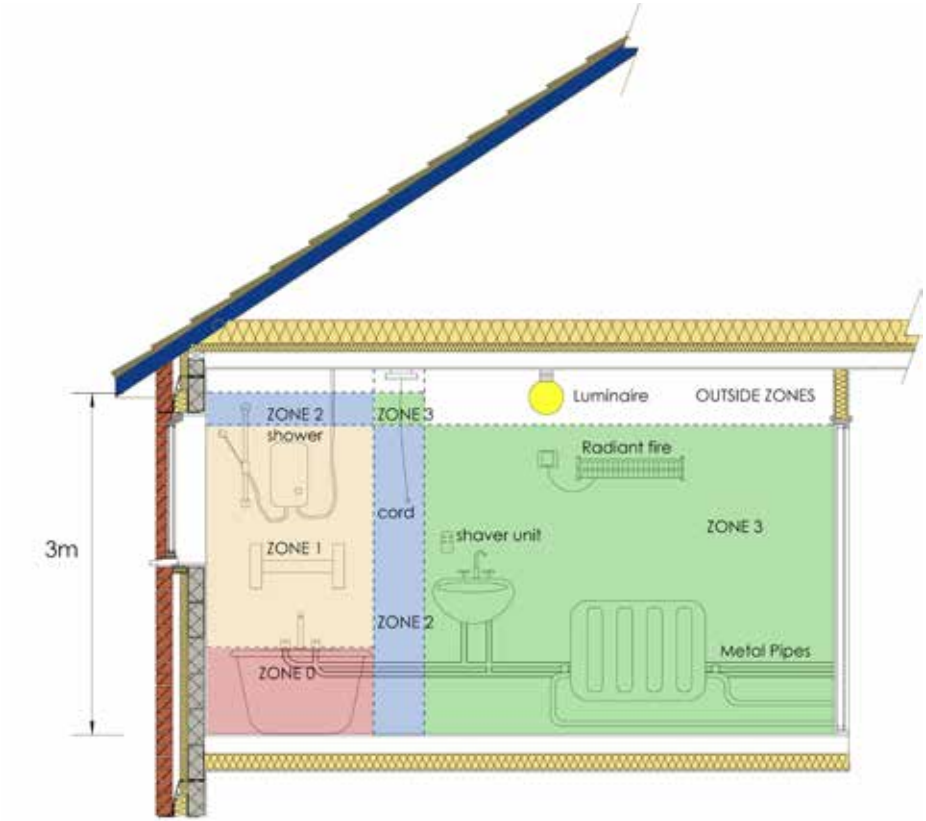


The protective conductors of all power and lighting points within zones must be supplementary bonded. The bonding connection may be to earth terminal of a switch or accessory supplying equipment.

Circuit protective conductors may be used as supplementary bonding conductors.

Supplementary bonding of short lengths of copper pipe installed where the pipes are visible, is not necessary.

Figure 9: Supplementary bonding in a bathroom plastic pipe installation



The protective conductors of all power and metal lighting points within the zones must be supplementary bonded to all extraneous conductive parts in the zones including metal waste, water and central heating pipes, metal baths and shower basins.

Circuit protective conductors may be used as supplementary bonding conductors.

Metal baths not connected to a metal building structure do not require supplementary bonding if all metal pipes connected to them have been bonded.

Connection to pipes to be made with BS 951 clamps (complete with "Safety Electrical Connection" label).

Figure 10: Supplementary bonding in bathroom metal pipes

9.3.3 Socket outlets

Socket outlets are to be conveniently positioned in close proximity to the TV aerial and telephone outlets, thus allowing for electrical equipment including TVs and DVD players. Rooms should be provided with the following 13a outlets:

- Kitchen/Utility – 8 outlets
- Dining Room – 4 outlets
- Living or Family room – 8 outlets
- Bedroom (main) – 6 outlets
- Bedroom (other) – 4 outlets
- Landing – 2 outlets
- Hall – 2 outlets

9.3.4 Cooking

Cooking appliances provided to the cooker space in a dwelling must be suitably switched and terminated with a minimum 30a electricity supply.

If a cooker panel is provided, it needs to be positioned to the side of the cooker space. A 13a socket outlet should be positioned at the cooker space where a gas supply is provided to the dwelling.

9.3.5 Light fittings

At least one fixed lighting outlet should be provided to all rooms. Areas greater than 25m^2 are to be provided with two fixed lighting outlets.

Halls, landings and staircases are to be provided with lighting outlets and two-way switches.

Down lighters and other flush-fitting attachments should not be installed through a ceiling if the ceiling is providing part of the required acoustic insulation or fire resistance to the property.

If down lighters are provided to ceilings below roof voids (excluding thatched roofs), precautions are to be taken to ensure that no fire risk is caused by the proximity of other materials.

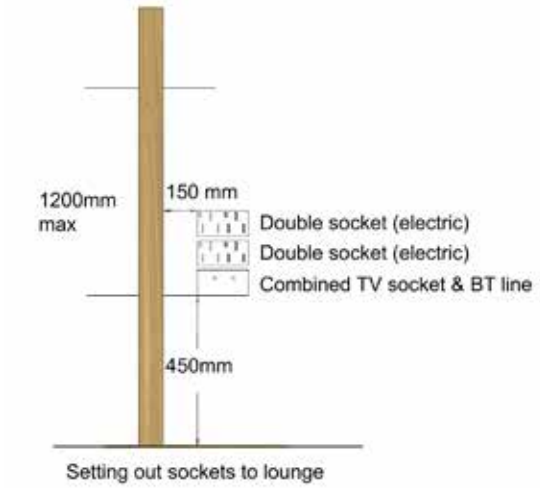
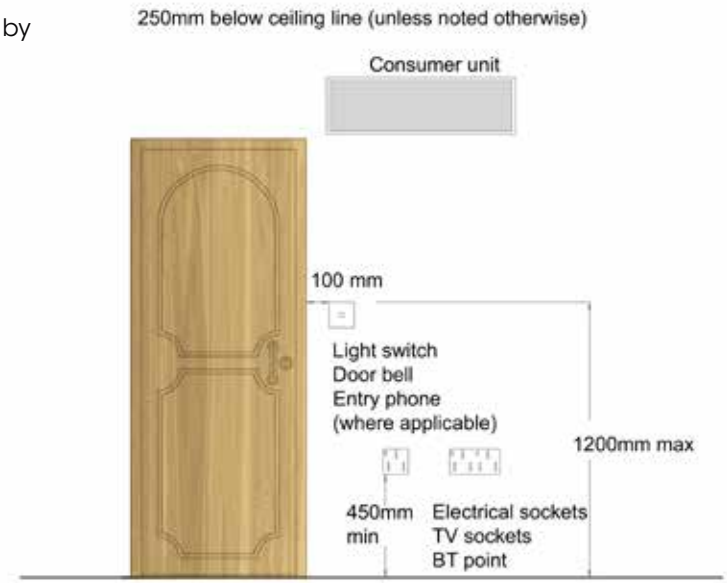


Figure 11: Heights of wiring accessories

Passive infrared (PIR) sensors are to be used in common and external areas.

9.3.6 Positioning of sockets and switches

Sockets and switches should be positioned in accordance with Figure 11.



FUNCTIONAL REQUIREMENTS

9.4 HEATING AND MECHANICAL SERVICES

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The materials, design and installation must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

9.4.1 Gas service

Where provided, the gas service shall be of a suitable scale for normal domestic usage.

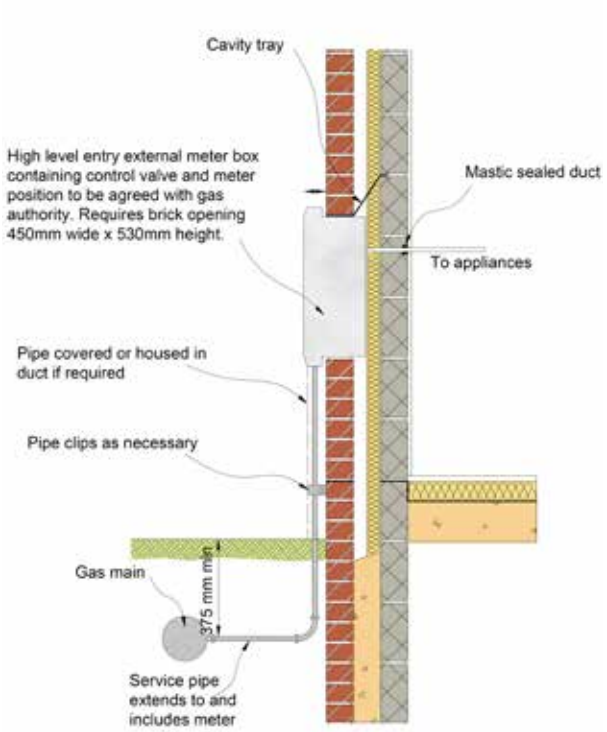


Figure 12: Gas service pipes

A meter control valve is to be fitted on the supply side of the meter.

External meter boxes should be of a type approved by the supply authority and located as close as practical to the main access point to the dwelling.

Domestic meters may be of the following type:

- Built-in to the outer leaf of the wall.
- Surface-mounted on an external wall.
- Semi-concealed: sunk into the ground adjacent to the outer wall.
- Individual, purpose-made compartments, in accordance with British Standards.

All water services are to have precautions against a possible chemical attack.

Corrosion-resistant materials should be used for pipes and fittings for water services. The recommendations of the water supplier should be adhered to.

9.4.2 Cold water services

Each dwelling should have an adequate supply of cold water. The water supply should be fed from below ground and insulated in accordance with Figure 13 to prevent freezing.

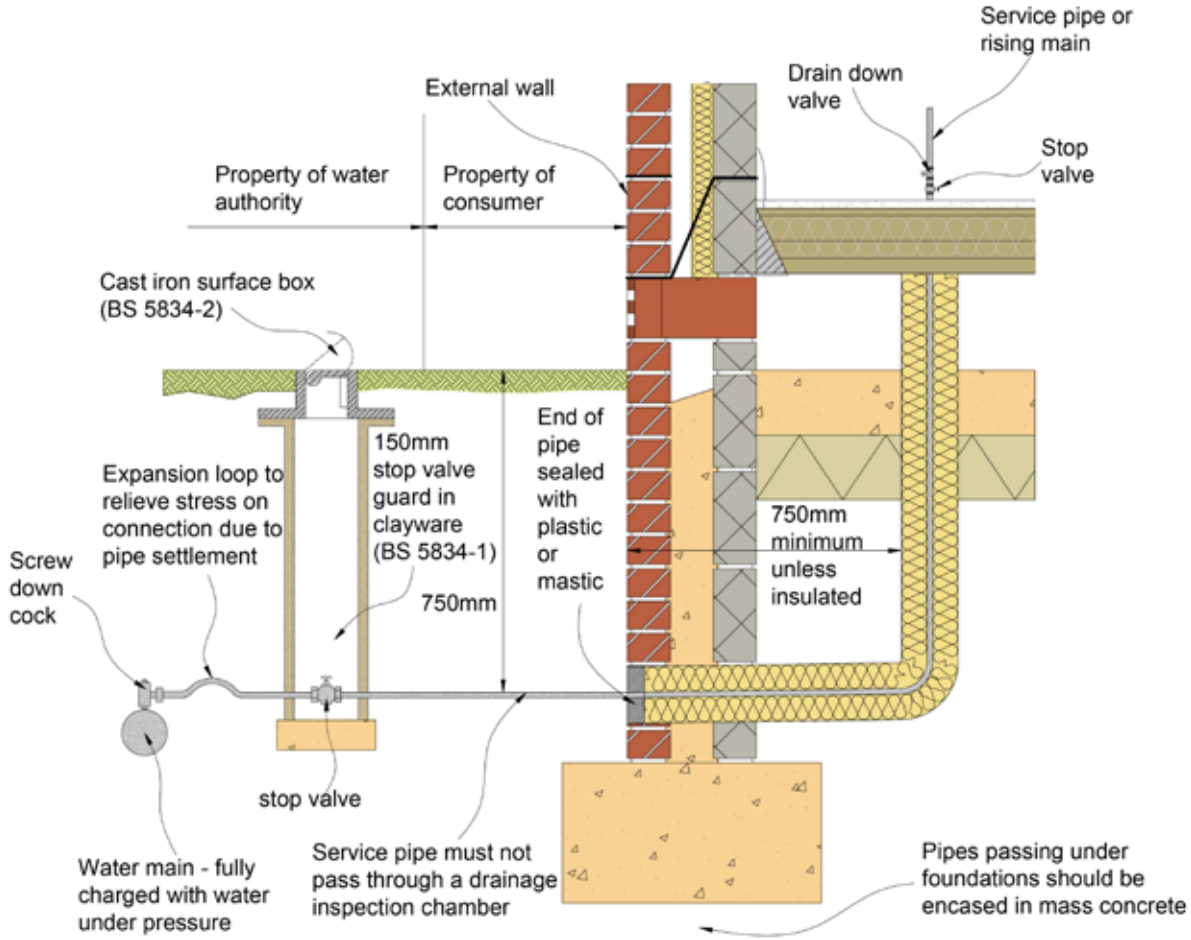


Figure 13: Insulation of incoming services

Cold water systems may have provision for storage or be directly connected to the main supply. Drinking water needs to be supplied directly from the main supply.

Cold water pipes and storage cisterns located in roof spaces and other unheated areas should be appropriately insulated to the relevant standards.

Cold water storage cisterns will require the capacity specified in the design. Suitable support should be given for the cistern filled with water.

To stop the cistern bottom being deformed, permanent support is to be given where necessary. Adequate materials for support platforms are:

- Softwood boarding
- Marine Plywood
- Chipboard Type P5
- Oriented Strand Board Type OSB3 to British Standards

All water tanks should be accessible. Gangway boarding is required to each cistern opening from the roof space access. An area of 1m^2 of boarding is to be provided next to cisterns to permit routine maintenance.

Water storage cisterns should be protected from contamination by a rigid, close-fitting cover (which is not air tight) that excludes light and insects.

Holes should be formed with a cutter in the positions shown in the design.

Overflows in warning pipes should be no less than 19mm diameter and situated 25mm from the shut off water level in the cistern. The pipe may dip below the water level in accordance with water regulations. Alternatively, the pipe should terminate vertically downwards, or a tee should be fitted horizontally at the discharge end.

9.4.3 Hot water services

Hot water systems may have provision for storage or may be of the instantaneous type, e.g. combi boilers.

Vertical installation of cylinders is required with access, and cylinders are to be insulated as specified in the design.

Where an immersion heater is fitted, it should be:

- Appropriate for the type of water supplied to the dwelling.
- Thermostatically controlled.
- Located so that it can be withdrawn for replacement.
- Fitted with an on/off switch.

Cisterns, vent pipes and all water services in unheated spaces should be insulated against freezing as specified in the design. Insulation is not to be placed below a cold waste tank where it can benefit from heat from beneath. Tanks that are raised need to be insulated on all sides in an unheated roof space.

Fully insulated bends and junctions are required, especially near openings to the outside air, such as the eaves. If possible, water pipes should not be located within a loft space where they could be affected by cold ventilation air.

9.4.3.1 Provision for expansion

An expansion pipe is to be provided on vented systems for hot water.

9.4.3.2 Unvented hot water systems

Third-party accreditation is required where an unvented hot water system with a storage capacity greater than 15 litres is required by the design. Installation is to be completed by a competent person.

9.4.3.3 Draining down facility

Hot and cold water installations require the capability to be drained down.

9.4.4 Use of materials

Materials that are safe and minimise the risk of corrosion are to be used for pipes and fittings for water services. The recommendations of the water supplier with regard to materials and fittings should be followed.

It may be necessary to fit aluminium protector rods in areas where the corrosion of copper cylinders occurs. These are to be fitted during manufacture, in accordance with the relevant British Standards.

9.4.5 Space heating

Any whole-house heating system should be designed to meet internal temperatures to the levels set out as per below. External temperature is to be -3°C.

Controls for wet heating systems are to be provided as follows:

Location	Temperature	Air Changes
Living Room	21°C	1 per hour
Dining Room	21°C	1 per hour
Kitchen	18°C	2 per hour
Bedrooms	18°C	1 per hour
Bed-sitting room	21°C	1 per hour
Bathrooms	22°C	2 per hour
Hall and Landing	16°C	2 per hour
Separate WC	18°C	2 per hour

Table 3: Whole house heating system: temperatures

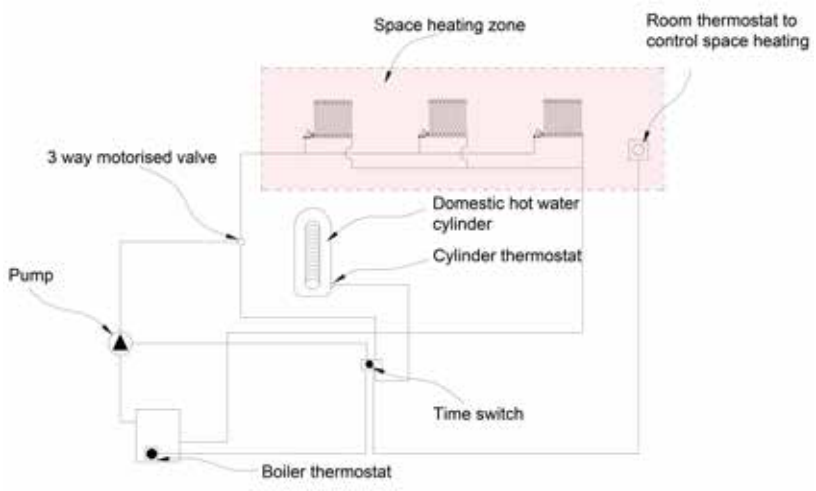


Figure 14: Controls for combined space heating and domestic hot water

- A room thermostat controlling the heater unit.
- A time switch allowing at least two heating periods a day. In the case of electrically heated storage systems (Electricaire), there will normally be a further time switch to control the electrical 'charging' periods to conform within the chosen tariff.
- A programmer to select:
  - Hot water.
  - Space heating.
  - Hot water and space heating.

A thermostat sensitive to the room air temperature should be provided for independent heaters. The boilers chosen for each dwelling should be based on their efficiency within the PCDF list. The efficiency of the boiler should be no less than indicated in the table below.

Central heating system fuel	PCDF% (2009)
Mains natural gas	88
LPG	88
Oil	88

Table 4: Minimum efficiencies of heating systems

9.4.6 Ventilation

Room	Intermittent extract	Continuous extract
Kitchen	30 l/s adjacent to hob Or 60 l/s elsewhere	13 l/s
Utility (access via dwelling)	30 l/s	8 l/s
Bath/shower room	15 l/s	8 l/s
Sanitary accommodation	6 l/s	6 l/s

Table 5: Extract ventilation rates

9.4.7 Extractor fans

Where ductwork from extractor fans goes through unheated spaces such as roof voids, action should be taken to minimise the chance of condensation forming in the ducting and any consequential damage caused to finishes and the fan unit.

- Ensure ducting discharges to the outside air.
- Provide insulation to the outside of the ductwork, and lay to a fall away from the fan.

The system should provide extraction rates in accordance with Building Regulation requirements Approved Document K.

All habitable and service rooms within dwellings should have some form of ventilation as a requirement. It may be permanent background ventilation, mechanical ventilation or an opening window.

9.4.8 Extract ducts

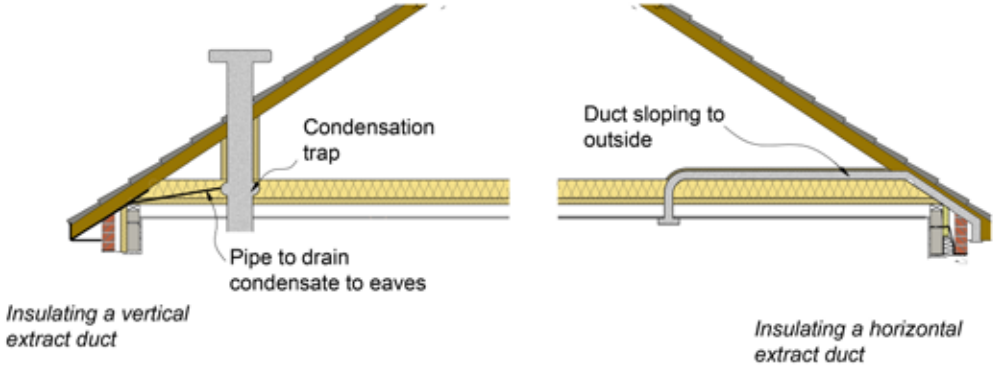


Figure 15: Extract ducts

Adequate support is required for extract ducts, and they also need to have sealed joints where required. Insulation needs to be provided where ducts pass through unheated spaces, such as roof voids, to the outside air, or a condensation drain should be provided in accordance with the design.

Where ducting is part of a mechanical ventilation and heat recovery system, it should be insulated in accordance with the manufacturer's recommendations.

Where a gas appliance requires an electrical supply, a suitably fixed spur or socket outlet should be provided.

A concealed co-axial cable should be provided from the roof void to a terminal outlet within the main living room. Where the co-axial cable is not provided, a conduit and draw wire, or an alternative, should be provided. The provision of an aerial is not required.

9.4.9 Whole-building ventilation

The whole-building ventilation rate for the supply of air to the habitable rooms in a dwelling should be no less than the rates stated in Table 6 below.

Ventilation	Number of bedrooms in dwelling				
	1	2	3	4	5
Whole building ventilation rates (l/s)	13	17	21	25	29

Table 6: Whole building ventilation rates

9.4.10 Passive stack ventilation (PSV)

The system is to meet the relevant third-party accreditation.

The PSV layout should be designed to:

- Avoid cross flow between the kitchen and bathroom/WCs.
- Prevent, as far as possible, air flow in the ducts being adversely affected by the prevailing wind speed and direction, or by sudden changes in these.
- Minimise resistance to air flow by having ducts that are as near to vertical as possible.

To ensure good transfer of air throughout the dwelling, there should be an undercut of minimum area 7600mm^2 in all internal doors above the floor finish (equivalent to an undercut of 10mm for a standard 760mm wide door).

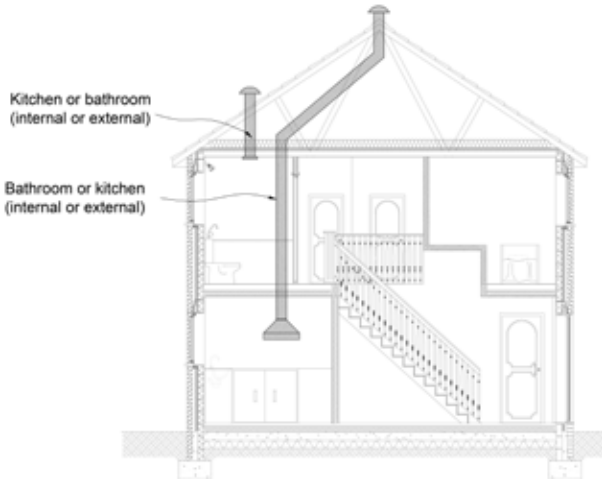


Figure 16: Passive stack ventilation

9.4.11 Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required.Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.

Where copper pipes are permitted in floor screeds, they should be:

- Sleeved or wrapped so that they can move freely along the length and at joints and bends.
- Jointed with capillary joints.

A metallic tape should be applied to the pipework where plastic pipework is hidden within or behind wall surfaces, which would otherwise not be located by a metal detector.

9.4.12 Jointing of pipes and fittings

Proprietary joints should be made strictly in accordance with the manufacturer's instructions.

Only fluxes recommended by the Pipe Manufacturer should be used, and all traces should be removed immediately after jointing. Fluxes containing lead are not acceptable.

Suitable clips or brackets are to be used to secure. Fixings should be installed adequately, and spaced to stop sagging but not restrict thermal movement. Where needed, pipes should have adequate falls.

Sufficient room should be allowed for thermal expansion and contraction to avoid damage and noise from pipe movement.

Holes should be at least three times their diameter apart.

9.4.13 Notches and drillings

Floor joists should not be excessively notched or drilled. Further guidance can be found in Chapter 8 of this Manual.

9.4.14 Concealed services

If the services are hidden in walls or floors, they need to be positioned so that any significant cracking of the surface cannot occur.

9.4.15 Wall chasing

If chases in walls are necessary, their depth should not exceed:

- One-sixth the thickness of the single leaf for horizontal chases.
- One-third the thickness for vertical chases.

Hollow blocks should not be chased unless specifically permitted by the manufacturer.

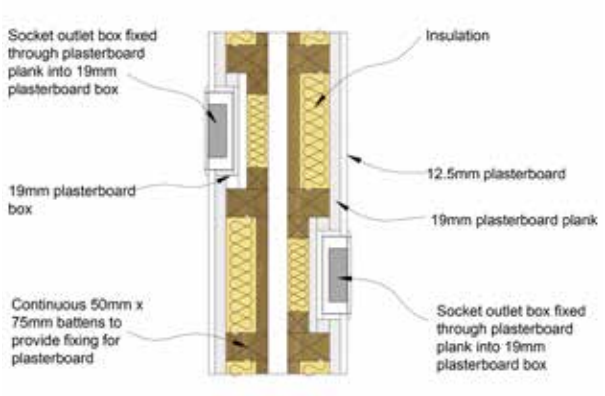


Figure 17: Staggered services on party walls

9.4.16 Services within or beneath floors

Protection through wrapping or ducting is necessary when pipes are situated under floor screeds. Thermal expansion allowances are to be made, especially at changes of direction.

The insulating material around the pipework needs to be a minimum of 25mm in thickness. The screed thickness should still be at least 25mm where pipes cross over.

9.4.17 Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

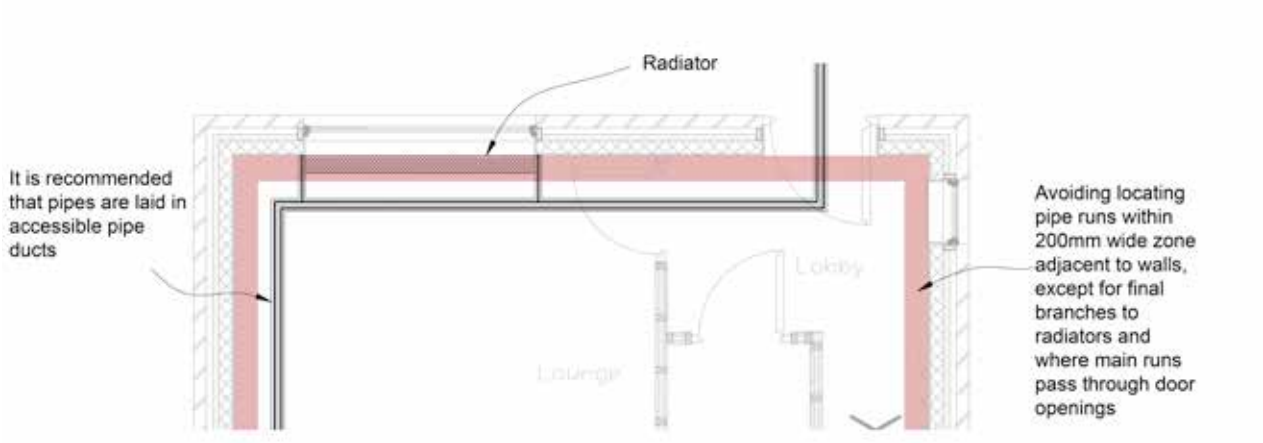


Figure 18: Recommended positioning of pipes in screeds

9.4.17 Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

CHAPTER 10: FINISHES

CONTENTS

10.1 PLASTERWORK

10.2 SECOND AND THIRD FIX FINISHES

FUNCTIONAL REQUIREMENTS

10.1 PLASTERWORK

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Surfaces that will be subjected to water from the use of a showerhead over a bath should be tiled or have an appropriate alternative water-resistant finish.
iii. The materials and construction must meet the relevant Building Regulations, British standards, Eurocodes and other statutory requirements.

CHAPTER 10: FINISHES

10.1.1 Introduction

This chapter covers all plastered finishes to walls and ceilings. Plastered finishes should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

10.1.2 Substrate and background

Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 5492 Code of Practice for internal plastering.

Plaster applied to backgrounds that are susceptible to thermal movement, such as lightweight concrete or aerated blockwork, should be completed in accordance with the block manufacturer's instructions.

Where the background has a mix of varying materials, e.g. blockwork and brickwork, expanded metal should be provided to prevent differential movement in the plaster finish.

10.1.3 Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

10.1.4 Minimum plaster thickness

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified in Chapter 1 of this Manual, and be of a suitable quality so that a decorative finish can be applied. Minimum thickness should be in accordance with Table 1.

Element	Minimum number of coats	Typical thickness
Walls - metal lath	3	13mm (nominal)
Blockwork	2	13mm (nominal)
Brickwork	2	13mm (nominal)
Walls - plasterboard	1	Skim to provide suitable and durable finish
Walls - concrete	1	Minimum thickness to provide suitable and durable finish
Ceiling - plasterboard	1	Skim to provide suitable and durable finish
Ceiling - concrete	2	10mm maximum

Table 1: Thickness of plaster

10.1.5 Plasterboard and dry lining

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded:

Board thickness (mm)	Timber support centres (mm)	Intermediate noggins required	Perimeter noggins required
9.5	400	No	Yes
	450	Yes	Yes
12.5	400	No	Yes
	450	No	Yes
	600	Yes	Yes
15	600	No	No

Table 2: Plasterboard joints and fixings

Fix boards with decorative side out to receive joint treatment or a skim plaster finish. Lightly butt boards together and never force boards into position. Install fixings no closer than 13mm from cut edges and 10mm from bound edges. Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper. Stagger horizontal and vertical board joints between layers by a minimum of 600mm. Locate boards to the centre line of framing where this supports board edges or ends. Plasterboard should be fixed to timber or metal studs using dry-wall screws. When dry lining, plasterboard can be fixed to walls using adhesive dabs or by screwing to metal or timber battens.

Alternatively, a proprietary wall system can be used, providing it has third-party certification. Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve dwelling air tightness.

FUNCTIONAL REQUIREMENTS

10.2 SECOND AND THIRD FIX FINISHES

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

10.2.1 Ceramic wall tiling

10.2.1.1 Introduction

Tiles should be fit for purpose, have a suitable finish and be of an appropriate size and thickness.

10.2.1.2 Background surfaces

Background surfaces should be adequate to support ceramic tiles, and as a minimum should:

- Be even, to adequately support the whole tile.
- Be strong and durable enough to support the tile.
- Have sufficient absorbency to ensure that adhesives will stick effectively or a suitable bonding agent applied.
- Be of the same construction type; where two construction types are present, e.g. blockwork and timber stud, light reinforcing should be provided over the junction between the two types.

10.2.1.3 Fixing

Depending on the background, tiles should be fixed using cement mortar or a suitable adhesive purposely designed for ceramic tiling. Tiles to shower enclosures and other areas that will be exposed to water should be fixed with waterproof adhesive.

10.2.1.4 Grouting

For shower enclosures where tiling can be saturated, grouting should be cement-based, epoxy resin or a proprietary waterproof product. A sealing method should be specified for the joint between sanitary fittings and adjacent tiling. This is particularly important where movement can take place, e.g. where timber floors are used.

Ensure that design and specification information is issued to Site Supervisors and relevant specialist subcontractors and/or suppliers.

10.2.1.5 Ceramic floor tiling

Tile floorings shall provide a suitable surface and be fit for purpose.

10.2.1.6 Background surfaces

Background surfaces should be adequate to support ceramic tiles, and as a minimum should be:

- Level and even enough to provide a plane surface; falls should be specified where required.
- Resistant to ground moisture; a Damp Proof Membrane (DPM) should be provided to a ground bearing slab.
- Adequately dry, i.e. at least six weeks drying out time for concrete base, three weeks for screed.

10.2.1.7 Tiles on wood-based substrate

The floor must be fit for purpose and should have adequate stiffness to support the tiles and adhesive.

For floors supported by joists up to 600mm centres, the floor decking should be:

- 18mm exterior grade plywood screwed to the joists at 300mm centres with all square edges supported on joists or noggins. Plywood should be laid with a 1.5mm–2mm movement gap between boards and at abutments.
- Chipboard floor decking overlaid with a minimum 10mm exterior grade plywood fixed to joists at 300mm centres, or proprietary separating/de-coupling layers, tile backer boards or tile bedding reinforcement sheets used in accordance with the manufacturer's recommendations.
- Tiles should be suitable for laying over a timber base and deformable (flexible) tile adhesive (e.g. C2S1), and grout should be used in accordance with the adhesive manufacturer's recommendations.

10.2.2 Floor finishes

Screeding
Screeds should be fit for purpose, have a suitable finish and be of an appropriate thickness.

Background surfaces
Background surfaces where screeds are being supported should meet the following requirements:

- **Bond**
  Background surfaces for bonded screeds should provide an adequate mechanical key. If necessary, cement grouting or a bonding agent should be specified to provide adequate adhesion.

- **Moisture protection**
  The floor design should ensure that moisture from the ground does not enter the dwelling.

- **Screed mix**
  Cement and sand screeds should have a mix ratio of between 1:3 and 1:4.5.

Proprietary additives should have been assessed and have third-party certification.

Minimum thickness of screeds are as follows:

Surface	Minimum thickness at any point (mm)
Laid monolithically with base	12
Laid and bonded to a set and hardened base	20
Laid on a separating membrane (e.g. 1000g polyethylene)	50
Laid on resilient slabs or quilts (screed reinforced with galvanised wire mesh)	65

Table 3: Screed thickness requirements

Where service pipes are bedded in the screed, the screed should be deep enough to provide at least 25mm of screed cover over service pipes, insulation and reinforcing.

10.2.2.1 Maximum areas of screed
Screeds should be laid room by room. Unreinforced screeds should have a maximum area of 40m^2. Expansion joints should be provided and consistent with joints in the floor slab below.

10.2.2.2 Curing
Screeds should be cured naturally and should not be covered for at least three weeks.

10.2.2.3 Finishing of screeds
Screed should provide an even surface as appropriate, as defined in Chapter 1 of this Manual. Concrete floor slabs may be suitably finished to serve directly as a wearing surface without the need for an additional topping, in accordance with the recommendations of BS 8204. If required, surface sealers or hardeners should only be used in accordance with the manufacturer's instructions.

10.2.2.4 Insulation
Insulation below screeds should have enough compressive strength to support the screed. Damp Proof Membranes should be installed in the correct positions, as indicated by the insulation manufacturer's instructions. Sound insulation should be installed in accordance with the manufacturer's instructions.

10.2.2.5 Building services
Where building services pass through the screed, allowance should be made for thermal movement between the screed and the service, and so that service pipes can resist chemical attack from the screed.

10.2.3 Painting and decorating

10.2.3.1 Timber
Painting or staining of external timber is required to provide protection and stability, even if the timber is preservative treated. Timber with moisture content greater than 18% is not suitable for painting or staining.

The paint and stain systems specified should be compatible with any timber preservatives and timber species used.

Where windows and doors are to be stained, proprietary sealants and beads should be used in glazing rebates in accordance with the manufacturer's instructions as an alternative to linseed oil putty.

Staining
Timber should be stained in accordance with the manufacturer's recommendations.

Painting
Painting of timber should consist of at least one primer coat, one undercoat and one finish coat, or alternatively in accordance with the manufacturer's instructions.

10.2.3.2 Masonry and rendering
External brickwork and render should be dry before paint is applied, and paint systems for external brickwork or render should be applied in accordance with the manufacturer's instructions.

10.2.3.3 Metal
Internal and external structural steel should be protected with at least two coats of zinc phosphate primer. A decorative paint finish may then be applied.

Internal and external steel that has been galvanised to a rate of at least 450g/m2 is acceptable without further protection. Steel galvanised to a rate of less than 450g/m2 should be protected with at least two coats of zinc phosphate primer and a suitable decorative finish, where required.

Intumescent paint coverings must be applied in accordance with the manufacturer's instructions.

10.2.3.4 Plaster and plasterboard
Plaster and plasterboard surfaces should be prepared and made ready for decorating in accordance with the manufacturer's instructions.

CHAPTER 11: EXTERNAL WORKS

CONTENTS

11.1 PAVING AND DRIVEWAYS

11.2 (THIS SECTION HAS BEEN REMOVED)

11.3 OUTBUILDINGS

FUNCTIONAL REQUIREMENTS

11.1 PAVING AND DRIVEWAYS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

Limitations of Functional Requirements

The Functional Requirements for external pathways and drives apply only to the drive and pathway leading to the principle entrance to the dwelling.

CHAPTER 11: EXTERNAL WORKS

Guidance

11.1.1 Preparation of ground

The area to be surfaced should be prepared by stripping away all vegetation and organic material. Land drainage should be considered for ground that is saturated.

Excavation trenches (e.g. service trenches) should be backfilled with granular type material to the required level. The backfill should be compacted in layers no greater than 300mm, and the fill material should at least have the same bearing capacity as the adjacent ground.

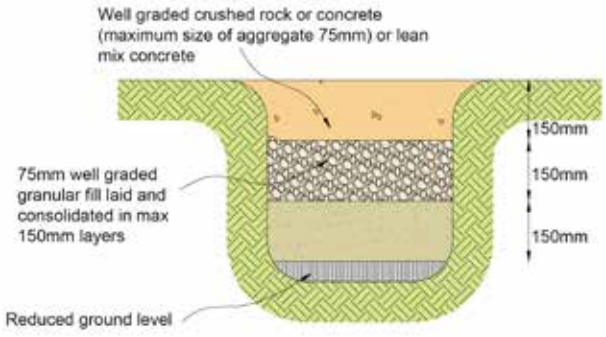


Figure 1: Backfilling of trenches

11.1.2 Laying of paths and drives

Paths and driveways should be effectively drained to prevent ponding of water adjacent to the building. Paths and drives should be laid to fall away from the building. Rain water should either discharge into a trapped gulley or drain to garden land that is well drained. Gullies should be trapped when discharging to a soakaway or combined drainage system (the approval of the statutory sewerage undertaker may be required).



Figure 2: drive and pathway drainage

All paving and drives, with the exception of the principle level access into the dwelling, should be laid at least 150mm below the Damp Proof Course (DPC) of the dwelling.

11.1.3 Sub-base

A suitable sub-base that is capable of supporting the finished surface material should be provided.

Suitable sub-base material is considered as:

- Weak mix concrete ST1 (site mixed acceptable).
- Well graded crushed stone or recycled concrete (minimum aggregate size 75mm).

The minimum thicknesses of sub-bases are indicated in Table 1.

Use of surface	Min sub-base thickness	Comments
Pathway	75mm	
Driveway (light duty)	100mm	Light domestic traffic
Drive (medium duty)	150mm	Suitable for carrying small lorries e.g. refuse, vehicles or fuel delivery

Table 1: Minimum thickness of sub-base

Crushed stone or recycled aggregate sub-bases should be well compacted to adequately support the pathway or drive (see Table 2). Where the ground below the sub-base is weak or soft (typically <10% CBR), the sub-base should be designed by a Structural Engineer.

Compactor type	Compactor size	Minimum number of passes	
		100mm sub-base	150mm sub-base
Vibrating plate	1400 - 1800 kg/m²	8	Unsuitable
	1800 - 2000 kg/m²	5	8
	>2000 kg/m²	3	6
Vibrating roller	700 - 1300 kg/m width	16	Unsuitable
	1300 - 1800 kg/m width	6	16
	1800 - 2300 kg/m width	4	6
Engine driven vibro-tamper	<65kg	5	8
	65-75kg	3	6
	>75kg	2	4

Table 2: Suitable compaction of sub-bases

11.1.4 Edgings

Edgings are to be provided to paths and driveways to prevent movement or displacement. Edgings are not necessary if the driveway is in-situ concrete or for any pathway made of precast concrete paving slabs laid on a mortar bed.

Edgings should be laid to ensure that there are no excessive gaps, and laid with smooth alignment along the top of the edging. Concrete edgings should be bedded on a 200mm wide x 100mm deep ST1 mix concrete base. The concrete should be haunched up the side of the edging to give adequate support.

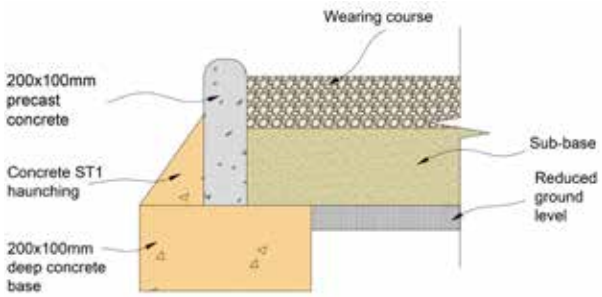


Figure 3: Typical edging detail

11.1.5 Surfacing of paths and drives

Differences in the surface should not exceed +/- 10mm from a 2m straight edge with equal offsets. Some fracturing or weathering may also appear if the material is natural stone because of the natural make-up of the material. This tolerance applies to principle pathways and driveways to the dwelling that are required to meet the standards of Part M (Access to dwellings).

Suitable surfaces for paths and driveways
Suitable surfaces are considered as:

- Block paving
- Precast concrete paving slabs
- Timber decking
- Cast in-situ concrete
- Rolled asphalt
- Macadam

Minimum thickness of surfaces

The minimum thicknesses of surfaces are indicated in Table 3.

Surface type	Material specifications	Minimum thickness (1)		British Standard
		Path	Drive	
Macadam single course	40mm coated macadam	75	75	BS 4987
Rolled asphalt	Coarse asphalt 10mm nominal size	60	60	BS 594
Macadam two course	Nominal 20mm coated macadam	60	60	BS 4987
	Nominal 6mm wearing course	20	20	BS 4987
Block paving	Clay or calcium silicate	50	50	BS 6677
Block paving	Pre-cast concrete	60	60	BS 6717
Concrete	Designated mix	75	100 (2)	
Pre-cast concrete paving	Dense concrete	50	N/A	BS 7263:1

Notes:

(1) Drive minimum thickness assumes standard loadings for a typical family car, additional thicknesses are required where increased loads are applied e.g. LGV vehicles.
(2) Drives increased to 150mm on poor ground or clay.

Table 3: Minimum thickness of surfaces for drives and paths

11.1.5.1 Paving slabs

Paving slabs should be placed on a 25mm bed of sharp sand or a semi-dry mortar mix (sand/cement mix ratio 3:1). Joints between slabs should be no greater than 4mm for straight edge paving slabs, and should be filled with kiln-dried sand. A neat consistent joint should be provided to rustic slabs. Slabs should be cut with a diamond blade cutter or similar to give a neat finish.

11.1.5.2 Block paving

Block paving should be laid on a minimum of 50mm sharp sand, and gaps between blocks should not exceed 5mm. All joints should be filled with kiln-dried sand or similar. Blocks should be cut using a block splitter, and the finished path or driveway should be compacted with a plate vibrator. Care should be taken to ensure that the surface of the paving is not damaged or scuffed.

11.1.5.3 Porous block paving joints

Where paving is designed to allow ground water to drain through the joints, the gaps between blocks and the material within the joints should meet the initial design specification. The joint material should be sufficient to prevent blocking and prevent moss growth.

11.1.5.4 In-situ concrete

In-situ concrete should be laid in areas of 20m^2 maximum to allow for movement. Where abutting an adjacent structure, the concrete should be isolated using a flexible jointing material. Where the sub-base is well drained, it is recommended that the concrete is cast onto a Damp Proof Membrane.

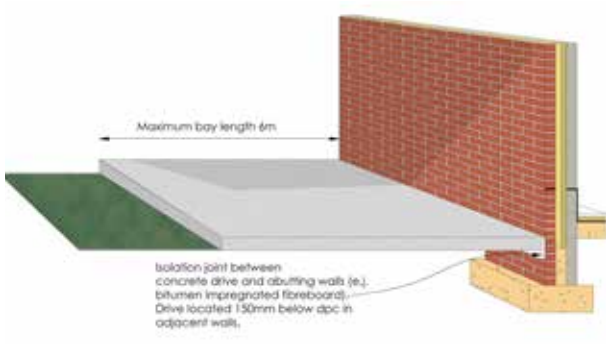


Figure 4: typical cast in-situ drive or path abutting the dwelling

11.1.5.5 Macadam and asphalt

Ensure that sub-bases are dried and primed and that the surface is appropriately rolled with a vibratory roller to the required finish.

11.1.5.6 Timber decking

Only timber naturally resistant to decay, or which can be treated by an industrial process to give long-term protection from decay, shall be used.

Hardwoods: Only use species rated as durable or moderately durable.

Softwoods: Only use species/components with natural durability or which have been treated in accordance with BS EN 335 to a 'Use Class' standard appropriate to their use, i.e. 'Use Class 4' treatment for posts and other structural components in direct ground or freshwater contact, or 'Use Class 3' treatment for all components out of direct ground contact subject to frequent wetting.

Note:

- Whitewood should not be used for posts embedded in the ground or for other elements (joists) in the ground or other non-permeable surface, e.g. concrete slab.
- All crosscuts, notches or large boreholes shall be treated on site with a suitable preservative. For full guidance on wood preservation specification, contact the Wood Protection Association.

Timber grade (strength class): C16 minimum
The grade (strength class) of timber used for structural components such as posts, beams and joists shall be sufficient to cope with the loads placed upon it during its service life. Softwood with a strength class rating of C16 is considered the minimum standard for decks above 600mm in height, and is a requirement of Building Regulations for such raised-level structures. The higher strength classes, typically C18 and C24, should be specified where smaller component sections, longer spans or commercial deck performance design considerations are required.

For decks below 600mm in height, the use of C16 timber is also recommended.

Posts can be made from laminated sections, solid timber or round poles, and should have a load-bearing capability/size/spacing appropriate to the scale and end use of the structure. For extended life, the surface mounting of posts on precast piers or metal shoes is recommended.

Note:

- Do not exceed the recommended load and span for each strength class; for detailed recommendations, refer to span tables in TDA/TRADA Timber Decking: The Professionals' Manual.
- Use 'noggins'/blocking to strengthen frames where appropriate to prevent flexing.
- Timber moisture content at installation: 20% maximum.

To minimise the effects of shrinkage, e.g. cupping, cracking, warping, etc., install timber as close as possible to the equilibrium moisture content of the site. For outdoor wood, moisture content varies from 19% in winter to 13% in summer in the UK. For best results, always install wood with moisture content lower than 20%. The stability of all wood used outdoors can be improved by the use of water-repellent treatments.

Board spacing
When laying timber decking boards:

- Allow for a 5mm minimum to 8mm maximum gap between board lengths.
- where the board abuts a post, allow a 5mm gap.
- where board ends meet, allow a 3mm gap.

Metal fixings
All metal fixings shall be made from corrosion-resistant materials, such as stainless steel, hot dipped, galvanised or other specialist coating. Before use, verify with the manufacturer that the fixings you have chosen are suitable for use with treated timber. Aluminium fasteners should not be used with treated wood. Prevent galvanic corrosion by using the same type of metal for both fixings and connectors.

Screws should be at least two-and-a-half times the thickness of the board being fixed. Ideally, choose screws that are self-countersinking. Pre-drilling pilot holes will help prevent splitting, and always drill pilot holes 2mm oversize when fixing hardwoods.

At all joist crossing points, secure boards with two fixings positioned at the outer quarter points of the deck board, i.e. 25% in from either edge. On grooved boards, fixings should always be at the bottom of grooves. Take care using high-pressure nail guns as they can damage timber.

Fall

To aid drainage, build a gentle fall of 1:100 into the deck, away from any adjacent property. Grooved deck boards are designed to assist the drainage of surface water, so lay them in the direction of the fall.

11.1.6 Further specification references

- TDA/TRADA Timber Decking: The Professionals' Manual – second edition November 2006
- TDA Technical Bulletin TB 02: Statutory requirements
- TDA Technical Bulletin TB 04: Parapet design and construction
- TDA Technical Bulletin TB 08: Metal fixings
- TDA Code of Practice TDA/RD 08/01: Raised timber decks on new homes – desired service life 60 years
- Wood Protection Association: Timber Preservation Manual

British Standards

The standards set out below all have a relevance to the creation of high-performance timber decks.

BS EN 335-1

Use classes of wood and wood-based products against biological attack – Part 1: Classification of Use classes

BS EN 335-2

Use classes of wood and wood-based products against biological attack – Part 2: Guide to the application of use classes to solid wood

BS EN 335-3

Durability of wood and wood-based products – Definition of hazard classes of biological attack – Part 3: Application to wood-based panels

BS EN 350-1

Durability of wood and wood-based products – Natural durability of solid wood – Part 1: Guide to the principles of testing and classification of the natural durability of wood

BS EN 350-2

Durability of wood and wood-based products – Natural durability of solid wood – Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe

BS EN 351-1

Durability of wood and wood-based products – Preservative-treated solid wood – Part 1: Classification of preservative penetration and retention

BS EN 351-2

Durability of wood and wood-based products – Preservative-treated solid wood – Part 2: Guidance on sampling for the analysis of preservative-treated wood

BS EN 460

Durability of wood and wood-based products – Natural durability of solid wood: Guide to the durability requirements for wood to be used in hazard classes

BS EN 599-1

Durability of wood and wood-based products – Performance of wood preservatives as determined by biological tests – Part 1: Specification according to hazard class

BS 8417

Preservation of timber – Recommendations. Guidance for specifiers on the treatment of timber drawing on relevant sections of BS EN Standards

BS 5756: 1985

Specification for visual strength grading of hardwood

BS 6105: 1981
Specification for corrosion-resistant stainless steel fasteners

BS 6399-1: 1996
Loading for buildings. Code of Practice for dead and imposed loads

BS 7359: 1991
Nomenclature of commercial timbers, including sources of supply

BS 5268-2: 2002
Structural use of timber. Code of Practice for permissible stress design, materials and workmanship

BS 6180: 1999
Barriers in and about buildings – Code of Practice

BS 6399-1: 1996
Loading for buildings. Code of Practice for dead and imposed loads

The following diagrams present acceptable provisions to meet Warranty standards:

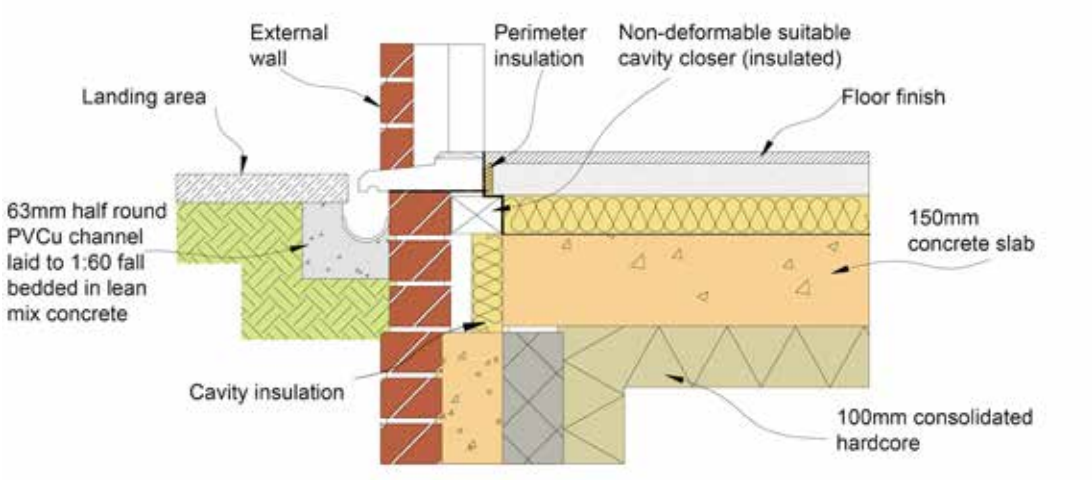


Figure 5: Level thresholds and access to dwellings

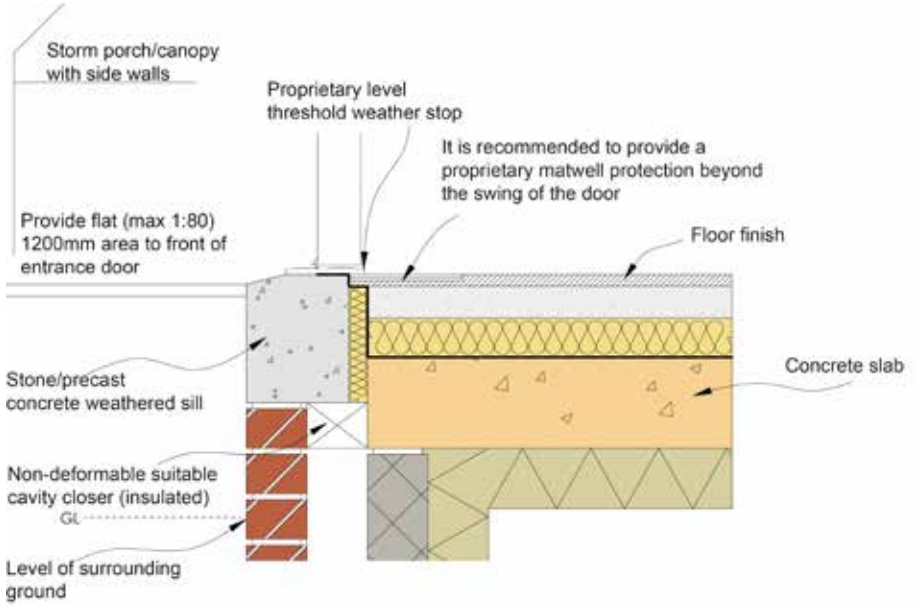


Figure 6: Typical level threshold cast in-situ concrete slab

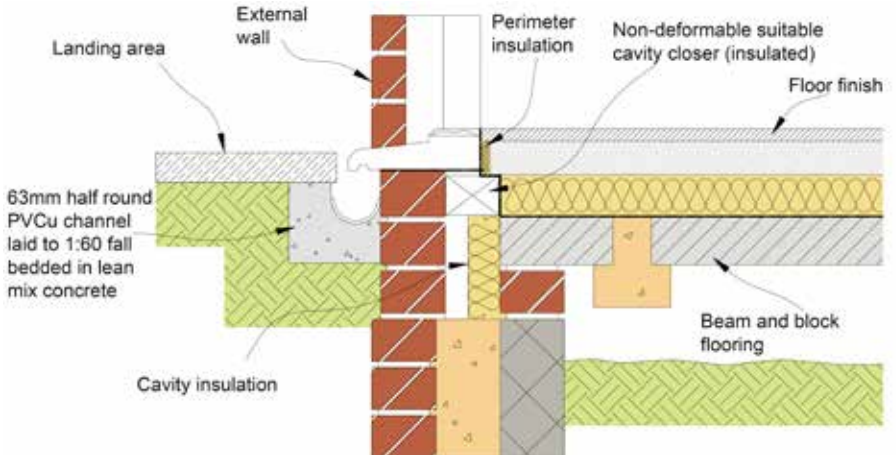


Figure 7: Level threshold: with canopy protection (block and beam floor)

FUNCTIONAL REQUIREMENTS

SECTION 11.2

This section has been removed from the Technical Manual.

FUNCTIONAL REQUIREMENTS

11.3 OUTBUILDINGS

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Outbuildings should be constructed to resist lateral and vertical loads adequately.
iii. Foundations should be designed and constructed to suit local ground conditions and adequately support the weight of the structure and imposed loads.
iv. The materials and construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

11.3.1 Limitations

This section does not apply to outbuildings where:

- The building is heated or protected against frost damage.
- The building is used as a habitable space, including home offices.
- It is essential that the walls will resist wind-driven rain.

11.3.2 Introduction

In order to achieve a satisfactory standard of performance, garages, conservatories, small outbuildings and extensions should be designed and constructed so that:

- They are able to sustain and transmit all normal loads to the ground without affecting their own stability or that of the housing unit (or any adjacent buildings) by excessive deflection or deformation that would adversely affect the appearance, value and serviceability of the building or the housing unit.
- They provide an acceptable and durable external surface and are not adversely affected by harmful or toxic materials in the atmosphere or from the ground.
- They are resistant to moisture and do not allow the passage of moisture to parts of the building that would be adversely affected by it.
- They encourage the rapid discharge of moisture due to rain or snow from their surfaces to suitable gutters and down pipes, or to some other form of collection and discharge that prevents moisture from re-entering the building, where it might have adverse effects.
- In the event of fire, they resist fire spread to the housing unit and to adjacent buildings.
- They are provided with sufficient locks or other devices to resist unauthorised entry.
- Where additional services installations are provided (such as central heating boilers or electrical or plumbing installations), these comply with Chapter 9 of this Manual.
- The risk of injury from accidental breakage of the glazing (where fitted) is reduced to a minimum.

A satisfactory performance for the design and construction of garages, conservatories, small outbuildings and extensions may be achieved by meeting the relevant parts of the Approved Documents.

11.3.3 Foundations

Foundations should be constructed so that loads are adequately transferred; further guidance can be found in Chapter 5 of this Manual.

11.3.4 Floors

Floors should have a minimum concrete thickness of 100mm and bear onto a suitable sub-base. The concrete should be float finished and to at least a GEN3 grade. Further guidance can be found in Chapter 6 of this Manual.

11.3.5 Walls

Single leaf 100mm walls are considered acceptable, providing that the following provisions are met:

- The height of wall does not exceed 2400mm from ground level.
- Intermediate piers are provided, in accordance with Figure 9.
- The wall is adequately restrained at ceiling and verge level.
- The walls are capable of adequately transferring the roof loadings to the foundation.
- Walls are pointed both internally and externally.
- Walls should be provided with a suitable DPC located at least 150mm above ground level.
- Proprietary lintels should be provided over window/door openings.

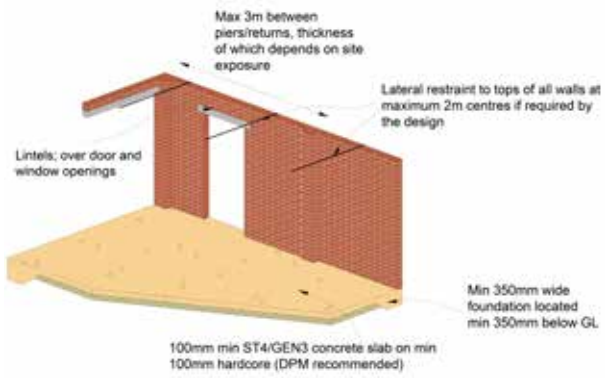


Figure 8: Small detached buildings

11.3.6 Roofs

Roofs should be weather tight and provided with a minimum fall of 1:40. Tiled roofs should be installed in accordance with the manufacturer's instructions, including pitch, fixing and lap.

Roof structures should be durable enough to support roof loadings adequately. Timber trusses should be adequately braced and traditional cut roofs should have timber elements that meet relevant Building Regulations and supporting documents.

Further guidance can be found in Chapter 7 of this Manual.

11.3.7 Walls between outbuildings

Where walls separate outbuildings under two different ownerships or tenancies, the separating wall should be taken up to the underside of the roof and fire stopped.

CHAPTER 12: CONVERSION AND REFURBISHMENT

CONTENTS

12.1 EXISTING ELEMENTS

12.2 NEW ELEMENTS CONNECTING TO EXISTING STRUCTURE

FUNCTIONAL REQUIREMENTS

12.1 EXISTING ELEMENTS

Workmanship

i. All workmanship is to be completed by a technically competent person in a workmanlike manner.
ii. Any new work must meet the tolerances defined in Chapter 1 of this Manual. Tolerances will not apply to existing finishes that have not been upgraded or altered, or where the supporting elements will not allow for the tolerances to be met.

Materials

i. All new materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. Materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure, regardless of whether it is a new or existing element, shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances under 15 years
iv. Existing elements that are to be retained must provide a 'waterproof envelope' to the building and be structurally adequate.

Design

i. The design and specifications should give clear indication of the design intent and demonstrate a satisfactory level of performance with regards the renovation of components and the interaction of new elements.
ii. Specialist reports are required to confirm that existing elements will have an adequate level of structural stability, as defined in the Materials section above; the reports must confirm the adequacy of the existing 'waterproof envelope'.

CHAPTER 12: CONVERSION AND REFURBISHMENT

12.1.1 Introduction

The following guidance has been formulated to assist both Warranty Surveyors and Developers on projects involving either the conversion or refurbishment of existing buildings.

Conversions and refurbishments are projects that involve work to existing buildings or parts of existing buildings. This could include the conversion of industrial or commercial buildings into housing; the conversion of an existing residential building into flats; an additional storey to an existing building; the refurbishment of an existing residential building; or a façade retention project.

The Warranty includes cover for the **retained structural elements and waterproof envelope** of any existing building for the duration of the policy. The Warranty Surveyor will always undertake an initial assessment of the existing fabric to ascertain in general terms if the proposal is capable of representing a standard risk to the Underwriter. If deemed acceptable, the development is then subject to a technical audit process during construction, and the following guidance is intended to assist all parties in ensuring the relevant requirements are met, as well as providing an element of consistency in approach.

Depending on the condition of the original building; an expert survey may be required for the different elements of the building as described in the following sections of this Chapter. If the survey concludes that any of these elements are unable to meet the life expectancy of 60 years for structure and 15 years for non-structural elements, they should be systematically replaced or repaired.

Existing buildings and structures can present particular problems both initially and on an ongoing basis. Therefore, it is essential that thorough and comprehensive survey work is undertaken prior to new works commencing to understand both the current condition of any structure and the impact any proposed works may have. Although initially this may be considered an unnecessary early expense, the savings in reconstruction costs can greatly outweigh the cost of the preparatory work.

Elements of the retained structure and proposed works should not be considered in isolation, as a solution for one problem may cause issues elsewhere. Past performance is no guarantee of ongoing adequate performance because different expectations and changing living conditions can all impact on both the actual and perceived performance of a converted/refurbished structure.

It is not possible to cover every building type within this Chapter; therefore, the guidance is general, and certainly will not apply in every scenario. It is strongly recommended that early discussions are held to determine exact requirements and to enable a full review of the proposed strategy and development.

Where new work is proposed, it should follow the guidance for those elements in this Technical Manual. Where new work is applied to, or meets, existing elements, consideration on how these areas will interact must be made; for example, new cavity masonry that abuts an existing solid wall construction.

Please note that the requirements of the technical audit are quite different from those undertaken for the purposes of compliance with Building Control and planning legislation. If any such bodies have imposed restrictions on the areas above, we suggest that you contact the Technical Services Department before undertaking any works.

12.1.2 Retained elements, foundations and load-bearing structures (including floors, walls and roofs)

Any areas of cracking or suspected movement are to be assessed, and remedial measures provided by an appropriately qualified and experienced Structural Engineer. Any additional loads must be catered for. Consideration of the impact of any landscaping and drainage works is required. Spalling masonry can be locally repaired, with units cut out and replaced, or re-used with sound face showing. Larger areas will require a schedule of repair to be submitted and agreed.

Damp Proof Courses (DPC) and membranes

All walls, floors and basements should include a DPC. Ground levels and ventilation should be checked before any remedial DPC treatments are considered. However, where remedial DPC treatments are required, these need to be appropriate to the type of construction, independently tested/approved and provided with a 10 year insurance-backed guarantee. Installed by a member of the Property Care Association, the guarantees must cover workmanship and materials. The construction of any existing ground floor will need to be assessed, and details provided to the Warranty Surveyor for consideration.

Timber treatment against insect and fungal attack

All retained timbers will need to be assessed, logged and the remedial treatment noted. Timbers that are embedded should be exposed or removed and replaced with masonry. Where this is not possible, core samples should be taken to assess the moisture content, and remedial works considered. Any remedial treatment must be provided with a 10 year insurance-backed guarantee and undertaken by a member of the Property Care Association, where guarantees must cover workmanship and materials.

Roof coverings

Coverings and support systems should be replaced unless a specialist report compiled by an independent, competent and appropriately experienced Chartered Building Surveyor concludes that the system can provide a life span of at least 15 years. This should include the covering, battens, felt, flat roof decking, fascias, soffits, flashings, nails and clips, etc.

Weather resistance of walls, including claddings, render, re-pointing, etc.

The remedial works for the external walls must have regard for the exposure rating provided in BS 5628. Any retained cladding system must be surveyed to determine a minimum 15 year life expectancy. Provision of additional thermal insulation must also be considered.

External doors and windows

A condition survey should be provided by an independent, competent and appropriately qualified Surveyor or Specialist to confirm life expectancy of 15 years. Consideration must be given to improving the thermal characteristics. External and internal services

Any services to be retained should be suitably tested and reported by a Specialist.

Drainage

A CCTV survey should be undertaken to ensure the integrity and design of any retained system. Where the lengths of existing retained drainage do not have rodding access in accordance with current requirements, additional access points should be provided. Inspection chambers and manholes located within habitable parts of the building will not normally be acceptable. Existing interceptors should be removed, and any proposal to retain existing septic tanks/cesspools will normally be rejected.

Where some of the elements are new and replaced as part of the conversion/refurbishment, no report is necessary.

12.1.3 Substructure

12.1.3.1 Foundations

An appraisal of the existing building and its foundations should be carried out by a Structural Engineer.

This appraisal should address:

- Settlement
- Heave
- Foundation depth and type
- Soil type
- Basement walls and floors
- Trees adjacent to buildings

When carrying out the appraisal, the person responsible should take into account any proposed increased loading on the structure and foundations, alterations to existing load paths and any alterations to the existing stability of the building.

Where the existing foundations are inadequate and the building has moved/cracked, and/or the proposals are to increase the load on the foundations, a Structural Engineer should design a suitable solution, which should then be discussed with your Warranty Surveyor prior to implementation.

Proposals for underpinning should be prepared by an expert and be in accordance with BS 8004.

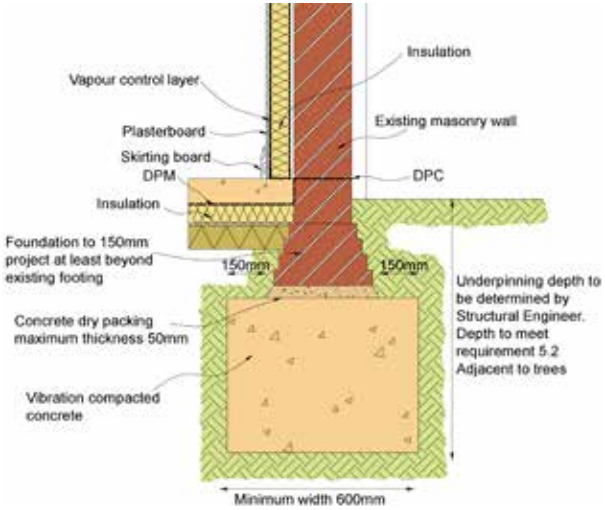


Figure 1: Typical traditional underpinning detail

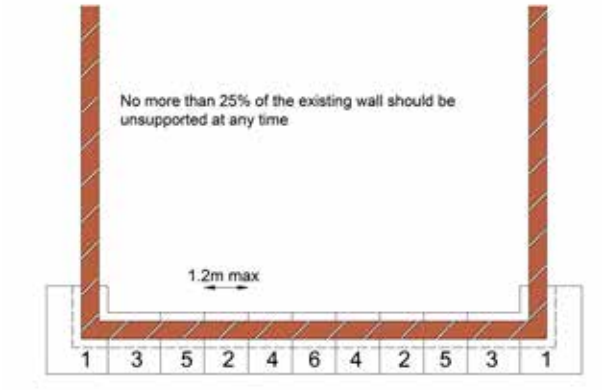


Figure 2: 'Hit and miss' underpinning sequence

12.1.3.2 Tanking of basements

Where it is intended that there will be any useable space below ground level, then the design should be such that adequate resistance to the passage of water/moisture to the inside is achieved, following the guidance in BS 8102: 2009. Please refer to Chapter 6, Section 6.1. in this Technical Manual for our requirements for basement provision.

Relevant matters include:

- Determining the position of the water table.
- Assessing the drainage characteristics of the soil.
- Products used should have independent third-party certificates and be installed by an approved installer.
- Increasing the height of the retaining walls.
- Reducing the ability of the floor above to provide lateral support to the walls.
- Lowering floor levels to increase ceiling heights.
- Alterations to the existing applied loadings.
- Additional loading from adjacent structures.

Existing basement floors may be suitable if it can be shown that the slab is in the region of 100mm thick and is bearing onto a suitable inert hard core. The proposals to tank the basement should address both the walls and the floor, in order to ensure the integrity of the basement area.

It should not be assumed that a wall that is dry at the time of the survey will not cause a problem in future. Existing basements should be provided with a new structural waterproofing (tanking) system designed by a suitably qualified and experienced waterproofing Specialist. The work should be carried out by a competent Specialist Contractor who has been approved by the Warranty Surveyor and is a member of the Structural Waterproofing Group. Land drainage to the external perimeter of the basement must be considered in order to reduce hydrostatic pressure to acceptable levels.

Internal walls will also require tanking if they do not have an effective DPC located at the same level as the floor tanking membrane or if they link with an external wall that is in contact with the adjacent ground.

Built-in structural timbers, such as timber lintels, shall be replaced, e.g. with concrete lintels, if they are sealed by tanking.

It should be ensured that continuity of tanking is maintained around chimney breasts. To simplify the problem, consideration should be given to the removal of the chimney breast in the basement and providing adequate support at ground level to the retained chimney.

In accordance with BS 8102: 2009, adequate provision should be made to prevent surface and interstitial condensation within the basement.

Consideration must be given to:

- Appropriate ventilation
- Adequate heating
- Appropriate insulation
- Avoiding cold bridging
- Treatment of hygroscopic salts contained in walls and floors
- Removal of water vapour from kitchens and bathrooms

12.1.3.3 Damp proofing

Where an existing DPC cannot be identified or is found to be defective, a remedial DPC should be provided; it should have an insurance-backed guarantee and be installed by a Property Care Association Member. A suitable DPC should be provided to existing walls, placed at least 150mm above external ground level to ensure that ground moisture does not enter the inside of the building. Consideration must be given to the height of the ground floor.

Some types of wall are not suitable for treatment by a remedial DPC system. These include:

- Walls of exceptional thickness, i.e. greater than 600mm.
- Rubble-filled walls.
- Random flint/granite walls, or those of other similar impermeable materials.
- Mud walls (cob), wattle and daub.
- Rat trap bond.

Advice should be sought from the Property Care Association Member as to the suitability of their proposed products/system. Products used in chemically injected systems should always hold current independent third-party certificates.

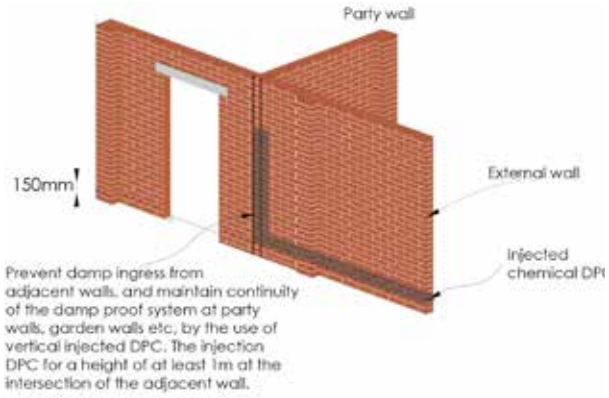


Figure 3: Typical chemically injected DPC

12.1.3.4 Treatment of timbers

Any remedial treatment shall be carried out by registered members of the British Wood Preserving and Damp Proofing Association in accordance with their Code of Practice for Remedial Treatment and associated technical leaflets. **A 10 year insurance backed Warranty** shall also be provided. In order to obtain insurance, it is necessary to undertake detailed investigation of all timber members to identify the presence of any insect or fungal decay, and to treat the affected areas as appropriate. It is essential that the type of fungal attack is correctly identified, as treatment methods vary for dry rot and wet rot.

An alternative method of detecting any dry rot is by seeking the expertise of:

Hutton & Rostron:
Tel No. 01483 203221,
Fax No. 01483 202911
www.handr.co.uk

or

Ridout Associates:
Tel No. 01562 885135
Fax No. 01562 885312
www.ridoutassociates.co.uk

Fungal attack covers wet rot and dry rot. Wood rotting fungi can be divided into two categories according to their effects on the wood. These are:

- Brown rot – causes the wood to become darker in colour and crack along and across the grain when dry. Badly decayed wood will crumble to dust, and the majority of wet rot and dry rot instances fall within this group.
- White rot – the wood becomes lighter in colour, and cracks along the grain. All white rots are wet rot.

The root cause of fungal attack is dampness, which may be caused by the following:

- Rain penetration
- Condensation
- Hygroscopic salts
- Defective rain water goods and roofs
- Bridging of existing DPCs, or no DPC
- Defective renders
- Direct penetration of rain water through solid walls, particularly those facing prevailing winds
- Leaking drains and internal plumbing
- Incorrect external levels

Fungal attack is controlled by two sets of measures, primary and secondary.

Areas that have not been inspected should be clearly identified to enable a subsequent inspection to be carried out when the structure has been fully exposed. This could include rafter feet and wall plates that are particularly prone to rot.

Primary measures

These consist of locating and eliminating sources of dampness and promoting the rapid drying out of the structure. Where the timber becomes wet and remains wet, e.g. the moisture content exceeds 20%, then it is likely to decay; by eliminating the source of dampness and the drying of timbers to below 20%, the fungus will normally stop growing and will eventually die.

Secondary measures
These consist of determining the full extent of the outbreak and a combination of:

- Removing all decayed timbers.
- Treating of walls to contain fungi within the wall (only applicable to dry rot).
- Treating of sound timbers with preservative on a localised basis where required.
- Using preservative-treated replacement timbers (pre-treated).
- Introducing support measures, such as isolating timbers from walls and the provision of ventilation between timbers and the walls.

Dry rot commonly occurs when timber is in contact with damp brickwork and where ventilation and heating are inadequate. Therefore, particular attention should be paid to cellars, basements and sub-floors, and also behind panelling.

12.1.3.5 Existing concrete floors

Where there is an existing concrete ground floor and this is to remain, the following should be identified:

- The thickness and condition of the existing slab. A minimum of 100mm concrete is normally expected, as slabs less than 100mm are more likely to be vulnerable to rising damp, especially if the concrete is of poor quality.

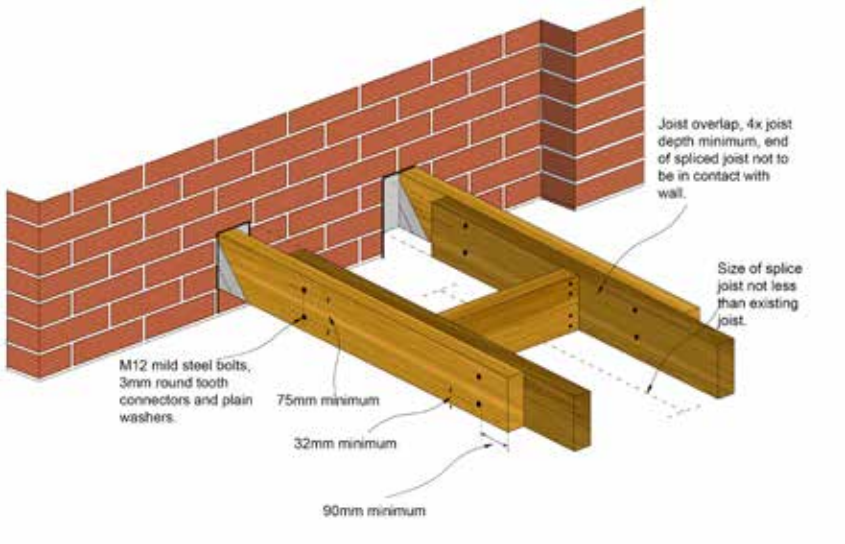


Figure 4: Typical example of repairs to floor joists

- If there are proposals to increase the load on the existing slab, such as building a masonry wall, then the new wall should be built on an adequate foundation or the existing slab proved for adequacy by calculation.
- Are there any gaps between the skirting and floor suggesting settlement of the slab? Is the fill beneath the slab over 600mm?
- Are there any cracks in the floor slab due to settlement? If the slab has settled, it may be practical to re-level the floor with a new screed or self-levelling compound. Before undertaking any works to a settled slab, it must be ascertained whether the settlement has stopped.

- Has the slab heaved? Clay heave can be attributed to the swelling of the clay subsoil when there is a recovery of the desiccated zone following the removal of a tree. Where a slab has heaved, further investigation is necessary to determine the reason for this, and appropriate measures taken to rectify the cause and damage.
- Where it can be shown that the existing ground floor is structurally adequate but does not incorporate a Damp Proof Membrane (DPM), a DPM may be laid over the existing slab, e.g. two or three coats of bitumen paint or 1200 gauge polythene, over which a minimum 50mm, 1:3 screed should be laid. The DPM should lap with the DPC.

12.1.3.6 Existing suspended timber floors

Where it is proposed to keep the existing ground floor, the existing floor boards/finish should be lifted to ascertain the condition of the timber joists/ wall plates. A report compiled by a Structural Engineer must be provided to confirm that the floor construction will be adequate to take the proposed loadings. A Timber Specialist Report will also be required to identify if insect infestation and fungal attack is present and if so, what remedial treatment will be required. (See Timber treatment section12.1.3.4).

When deciding if an existing ground floor is adequate, there are a number of areas that should be addressed, including:

- An adequate DPC to walls/sleeper walls
- All timbers must be free from rot and insect infestation.
- Adequate ventilation to the sub-floor (please note, many sub-floor voids will require cleaning out to achieve ventilation and reduce dampness).
- Adequate foundations supporting sleeper walls.
- Joists are of sufficient size and span.
- Are any load-bearing internal walls built off floor joists?
- Have joists been weakened by excessive notching or drilling?
- Adequate trimming to hearth.
- Adequate strutting of joist.

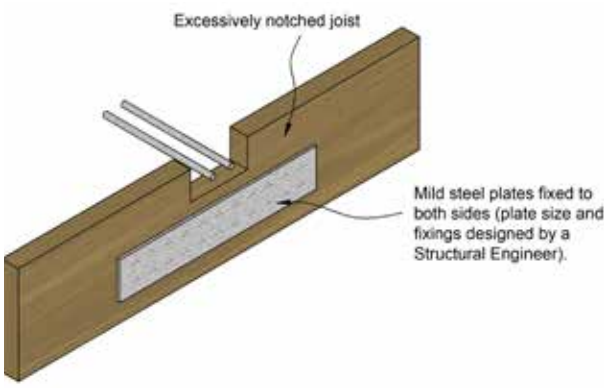


Figure 5: Strengthening an excessively notched joist

12.1.3.7 Drainage

Where it is intended to use the existing below ground foul drainage system, a CCTV survey should be carried out to ascertain the condition of the drains and manholes. The survey should cover size, type of drain, falls and its adequacy to take the proposed discharge. An air or water test could also be carried out.

The use of existing surface water drainage may be acceptable, providing that it can be shown to be carrying the water away from the building.

12.1.4 Superstructure

12.1.4.1 Structural repairs

Prior to undertaking structural repairs, it is essential that the root cause of the structural defect has been remedied by underpinning, addition of adequate lateral restraint, buttressing, etc. Strengthening works to the structure may also be necessary to accommodate increased or modified loads.

12.1.4.2 Masonry walls

To provide an acceptable level of protection against the ingress of rain water, any retained solid masonry external walls should either:

- Be fully lined internally with an independent timber or metal stud wall.

- Be clad externally with a rain screen or other protective measure.
- Comply with the requirements of BS 5628 (as outlined below).

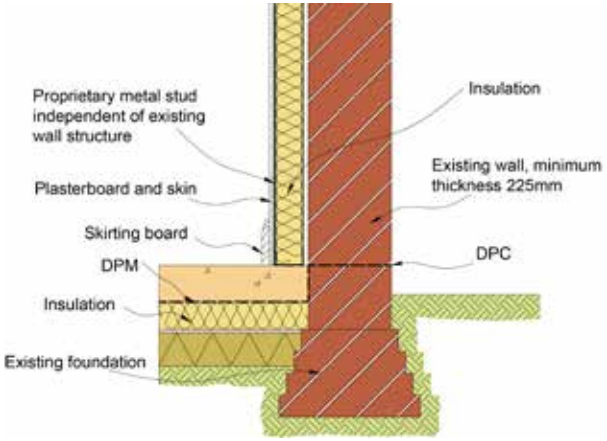


Figure 6: Typical independent internal lining

Where damage has occurred to walls, the cause needs to be investigated.

Likely reasons for the damage include:

- Ground movement – foundation failure, settlement, subsidence, chemical attack.
- Thermal movement – thermal expansion of wall due to temperature changes.
- Roof spread – pitched roofs not properly tied, spreading at eaves.
- External and internal walls not bonded together.
- Wall tie corrosion.
- Lintels inadequate over openings.
- Sulphate attack – water-soluble sulphates attack cement-based mortar, normally in a wet environment, i.e. below ground level and parapet walls.
- Frost attack.
- Bonding timbers present and subject to rot and shrinkage.
- Ineffective or no lateral support at floor and roof level.
- Moisture ingress.

Cracking in masonry walls

Minor cracking can be defined as cracking that occurs in the mortar joints and which does not extend through the masonry components. Providing that the crack is no wider than 4mm, and there has been no lateral displacement of the wall, the wall can be re-pointed.

Major cracking affects the structural integrity of the wall, and investigation should be undertaken to find the cause of the problem.

Walls out of plumb/bulging

Where walls are more than 25mm out of plumb or bulge more than 10mm within a storey height, a Structural Engineer should comment on the stability. The wall may need to be rebuilt or strengthening works undertaken.

Where it is intended to provide buttressing walls to support out of plumb and/or bulging walls, they should be designed by an Engineer.

In raised tie roofs (where no ceiling ties are provided at eaves level), lateral spread of the brickwork just below eaves level may have occurred because the roof has deflected. In such cases, it is necessary to prop the roof and rebuild the affected part of the wall.

Bonding timbers

These are common in Georgian buildings, and were laid in the internal skin of the wall to reinforce it and to provide fixings for panelling, etc. With the low compressive strength of lime mortar and general timber decay, the bond timber compresses under load. As the timber is on the inner skin, the compression causes bulging outwards, which may be apparent on the external face. Normally, bond timbers should be exposed during the conversion and removed in short lengths, and replaced with bonded masonry.

External and internal walls not bonded together

A common defect in properties up to the 1920s is the lack of bonding/tie of party walls to the external wall.

Different bricks and bricklayers were often used, with the poorer quality materials and labour being

used on the party walls. This junction should be exposed when undertaking a conversion and if the bond is inadequate, a suitable stitching detail incorporated. Design by a Chartered Structural Engineer may be required.



Figure 7: Typical examples of rectifying unbounded walls

Arches and lintels

The existing timber lintels can be retained if they support the structural walls and it can be shown that the lintel is adequate for its purpose, i.e. there is no sign of any structural movement, loads will not be increased and the timbers are free from rot and insect infestation.

In order to ensure that a lintel is free from rot, a percentage of all lintels should be exposed at both ends and on the outer face for openings in external walls.

Where movement has occurred and the timber lintel is inadequate, the lintel should be replaced with either a concrete or steel lintel.

Where cracking has occurred in masonry arches, it will be necessary to rebuild the arched construction. In cases where failure has occurred due to the low pitch of the arch, it may be necessary to incorporate a lintel.

Wall tie corrosion

Cavity walls have been constructed since 1850, but it was not until 1920 that this form of construction was widely adopted. It is important when undertaking a conversion to confirm the construction of the external wall. In cases where headers are incorporated into the bond of the external brickwork, the Warranty Surveyor should investigate the wall construction, as many properties in the Victorian period were built with either a 215mm outer leaf and cavity behind, or a 215mm inner leaf, cavity and a half brick outer leaf with snapped headers.

Initial evidence of cavity wall failure can include cracking of bed joints in mortar (typically every sixth course). This is due to the expansion of the wall tie as it corrodes.

Bulging of the external leaf could also indicate that the ties have failed.

Where there is wall tie corrosion or inadequate ties, a specialist company should be employed to provide a report that includes measures to overcome these defects.

Where wall ties have corroded to an extent serious enough to threaten the stability of the wall or building, a Structural Engineer should be appointed to determine the necessary remedial works.

12.1.4.3 Internal walls

Existing masonry

Where a wall is adequately founded or supported on a beam that shows no signs of distress, it can remain providing there is no increase in load onto the wall. Any increase in load should be justified by calculation. However, masonry supported on timber beams should be avoided.

In older properties, it is possible that flitch beams and bessemers may be supporting masonry walls, and these should be examined by an appropriate expert to ascertain their capability to carry the load.

Existing studwork

Many properties built before 1880 have trussed internal partitions, usually located approximately halfway back in the depth of the property. Often, these walls are load-bearing, continue up through the building and carry floor and roof loads onto the foundations.

If a timber partition is load-bearing, providing it is adequate, the loads are not being increased and

the timber is free from rot and insect infestation, it can remain. Where there are defects, i.e. the floor sags on the line of the partition and there is distortion of door heads, then additional strengthening works should be undertaken. New door openings cut into an existing trussed partition should be overseen by a qualified Structural Engineer, as this can adversely affect the triangulation of the truss.

12.1.4.4 Timber floors above ground level

Existing timber floor joists can be retained within the building, providing they are adequate for their purpose.

The following points should be considered:

- Joists are of sufficient size for the span.
- Load on the floor is not being increased.
- Joists have not been weakened by excessive notching and/or drilling.
- Ends of joists are free from rot.
- All timbers to be treated for insect infestation and wood rot.
- No masonry walls are built off timber joists.
- Appropriate strutting is provided.

Alterations to existing openings

Where existing openings are to be filled with masonry, the new work should be adequately bonded to the existing and the weather resistance of the wall maintained. However, if a party wall it should comply with the requirements for sound insulation.

12.1.4.5 Walls of special construction

If it is intended to retain walls of special construction, such as wattle and daub, Tudor, mud walls (cob), etc., they should be altered so as to form a non-structural element, e.g. by the incorporation of an additional load-bearing wall or framing to provide lateral support to the wall and support all structural loads previously supported by the wall. It will also be necessary to ensure that the wall provides an adequate barrier to the passage of rain water into the fabric or the inside of the building.

Unfortunately, due to the inherent risks and planning conditions on these types of developments, it must be noted that it may not be possible to provide a Warranty.

12.1.4.6 Interior

Where the scheme involves converting a concrete or steel-framed building into dwellings, the following guidance is given.

An appraisal of the existing building should be carried out by an experienced and qualified Structural Engineer, taking into account the proposals for the change of use. This will include:

- Condition of the structural frame, including joints.
- Proposals to increase loadings on the structure and foundations.
- Alterations to existing load paths.
- Alterations to stability systems.
- Changes in environmental exposure.
- Recommendations to cover additional reports and testing by Specialists.

The floor loads on the building may decrease, as they will now be for domestic use only where previously they were, for example, offices.

A statement from a qualified Structural Engineer confirming, where appropriate, that the existing foundation design is acceptable for the new loads subject to the building showing no signs of distress, i.e. movement, cracking, etc., will be acceptable in such circumstances.

Where the intention is to increase the load on the existing structure, e.g. by the introduction of an additional floor, then structural calculations should be provided to prove the adequacy of the building and foundations.

Concrete-framed buildings
Where the building is of concrete construction, additional reports are needed for:

- Carbonation
- Chlorination

The two major causes of corrosion in concrete are carbonation, in association with inadequate depth of cover to the reinforcement, and chlorine penetration, due to the de-icing salts and admixtures used to accelerate the setting and hardening of concrete in temperatures at or below freezing point.

Carbonation involves a reaction of carbon dioxide in the air with the free lime present in the concrete. Over a period of time, this reduces the pH level of the concrete.

With a reduction in the alkalinity, and the presence of both water and oxygen, corrosion of the embedded steel will occur.

Visual surveys on concrete structures are a starting point to gather information. However, care should be taken, as although the concrete structure may not show any obvious signs, corrosion of the reinforcement may be occurring.

It is important that a second-stage survey incorporates the following:

- Chemical tests on the concrete structure to ascertain if corrosion of the steelwork is occurring or likely to occur.
- Depth of carbonation can be assessed either on-site or in the laboratory, and the depth of the reinforcement measured. This allows areas of risk to be identified.
- Chloride ion content can be determined by analysis of a drilled dust sample taken from the concrete.

Where concrete repairs are necessary, they should be carried out by a Specialist Contractor.

High alumina cement concrete (HACC)
Where HACC has been used in a building, and the intentions are to keep the existing structure, consideration should be given to:

- The structure being free from obvious signs of deterioration.
- The building being weather tight.
- Structural calculations being provided to show that the floors and roof can solely carry the loads imposed on them.

Alkali silica reaction (ASR)
The ASR occurs when the strongly alkaline cement begins to dissolve susceptible sand and aggregate within the concrete itself. The chemical reaction creates a gel material that absorbs water, expands and in turn creates tremendous pressures in the pores of the concrete surface and subsequent cracking. For a damaging reaction to occur, the following need to be present in sufficient quantities:

- High alkali cement or a high cement content; it may also arise from salt contamination during batching/mixing.
- Reactive aggregate – siliceous materials such as flint and quartz, as well as recycled aggregates.
- Moisture, through exposure to rain or condensation.

If any one of these factors is absent then the ASR cannot take place. Once cracking occurs, the structure can deteriorate further as water entering the cracks generates reinforcement corrosion and this, in conjunction with the freeze/thaw cycle, can result in additional cracking and so on.

Affected concrete often exhibits surface cracking in the pattern of a star, and heavily loaded sections may exhibit cracks along the line of the main reinforcement.

Defects in structures attributable to the performance of concrete are relatively rare in the UK. Increased awareness of ASR, and the publication of guidance on avoidance, have reduced the risk of problems in new buildings to very small proportions.

Consequently, on any refurbishment project where the existing structure is concrete-frame, the Warranty Surveyor will request copies of the following to identify the presence or otherwise of ASR:

- Desk studies undertaken to identify materials used in the original construction.
- Core sampling and detailed chemical testing.

If ASR is identified, the following possible remedial works will need to be assessed by the project's Design Engineer, and the details put to Warranty Surveyors for consideration:

- Critical examination of the robustness of the reinforcement.
- Measures to the amount of water available to the structure – any weather proofing or cladding should not impair the ability of the structure to dry naturally.
- Limited strengthening of the structure.
- Partial or full demolition, followed by rebuilding.

Furthermore, any alterations to the weather proof envelope will need to be considered to ensure that the concrete elements are not exposed to additional sources of moisture.

Steel-framed buildings
In addition to any structural reports, a visual inspection of the steel frame should be carried out to assess the extent of any corrosion of the framework.

Where corrosion is present, accurate measurements can be made using an ultrasonic gauge. Data collected can then compare the thickness of steel sections against the original steelwork drawings, British Standards and the Historical Structural Steelwork Handbook to ascertain if the structural frame is adequate for the proposed loads.

Exterior steelwork: should be inspected; where corrosion is visible, the steel can be grit blasted, cleaned and recoated.

Perimeter steelwork: in direct contact with the outer leaf of the building can be prone to corrosion, particularly in older properties. A sign indicating that this has happened is the displacement of the external masonry due to the expansion of the steelwork caused by corrosion. During the conversion process, the appropriate repairs/replacement should be carried out.

Interior steelwork: normally, corrosion of unprotected steelwork within the interior of a building is low, with only superficial rusting. Providing that a visual inspection confirms this, and the environment intends to remain dry, no further treatment of the steel will be required. Where the proposals involve the steelwork in a 'wet' environment, such as kitchens and bathrooms, it should be adequately protected.

Bimetallic corrosion
This should be considered in the existing and proposed structure.

Bimetallic corrosion occurs where two different metals are in electrical contact and are bridged by water or water containing other chemicals to form an electrolyte. A current passes through the solution from the base metal to the noble metal and, as a consequence, the noble metal remains protected and the base metal suffers increased corrosion.

Where there is a possibility of this occurring, or if it has already occurred, advice should be taken from a Specialist on how to deal with it.

Cast iron, wrought iron and mild steel structures
Many older buildings that are converted into dwellings, e.g. warehouses, cotton mills, etc., were built using cast iron, wrought iron or mild steel.

When the intention is to keep the existing structural elements, an appraisal of the existing building is necessary.

In addition to this, the Engineer should comment on the following:

- Determine the age of the building and the materials used.
- Assess how its construction has fared.
- Justify the loadings by calculation.
- Identify areas where additional testing and/or opening up is necessary.

If the proposed loads remain unchanged or are reduced, as will probably be the case, and it can be shown that the existing structure has not suffered any deterioration due to corrosion or deflection of structural members, etc., the building may only require localised structural alterations. Where the intention is to increase loads, carry out major structural alterations or the existing building is under-designed, a Structural Engineer should comment on this and provide calculations to justify the proposals.

12.1.4.7 Filler joist floors

Many buildings of the late Victorian and Edwardian periods were built with floors constructed of clinker concrete supported by embedded iron or steel joists. The concrete produced with clinker aggregate was porous, and therefore provided poor corrosive protection to the metal.

The clinker also contains particles of un-burnt or partially burnt coke or coal, which contain substantial proportions of sulphur. As the concrete is porous, the sulphur oxidises to form sulphur dioxide (SO_2), and if moisture is present, this then forms sulphuric acid (H^2SO^4). Where floors have been subject to the weather for any length of time, severe corrosion of the embedded iron or steelwork is likely to have occurred.

When considering a conversion in a building with filler joist floors, it is important to first investigate whether the floors have been subject to damp conditions and whether any significant corrosion has taken place.

Particular attention should also be paid to ensuring that the floor remains dry during the conversion, and this could include providing a temporary covering if removal of the existing roof is necessary.

12.1.4.8 Timber roofs

Surveying roof timbers

All roof timbers should be surveyed by a Specialist, and any necessary treatment carried out. Particular attention should be given to rafter feet, wall plates and valley timbers, as these often show signs of rot.

Roof structure

It is essential that the roof structure has adequate strength, stiffness and dimensional accuracy appropriate for the new roof covering. All strengthening work should be designed by a Structural Engineer.

Common problems encountered include:

- Excessive spans of rafters, purlins, binder and ceiling joists.
- Inadequate ties between rafters and ceiling ties.
- Insufficient number of collar ties at purlin level.
- Decay of rafter feet and valley beams.
- Settlement of purlin supports.
- Lateral spread of raised-tie roofs.

Roof coverings

Systematic replacement of all roof coverings, including associated support systems such as battens, felt, flat roof decking, fascias, soffits and flashings, should be carried out, unless it can be shown that the existing roof covering is adequate. Fixing of slates, tiles and the condition of existing fixings, e.g. nails and clips, should be examined if the intention is to keep the roof covering.

A Specialist's report (See 12.1.2) will be required to confirm the adequacy of the existing roof covering and to determine whether timber treatment is required. Adequate ventilation should be provided as appropriate.

Where it is intended to re-use existing roofing tiles or slates, they should have a life span of at least 15 years.

In the case of replacement roof coverings where no extra load is incurred, it may still be necessary to strengthen the roof structure if the roof has deflected.

12.1.4.9 Claddings

Weather resistance of walls and cladding
Existing solid brick or stone walls are unlikely to be acceptable as weather-resisting, although consideration of the exposure category of the building and porosity of the masonry will be given, i.e. do existing non-gypsum-based internal linings allow for greater insulation and evaporation than gypsum plasters alone? It is anticipated that in all buildings, at least one of the additional treatments noted below will be required, and this must include appropriate insulation.

However, all solid masonry wall situations will require a Specialist's report to identify the extent of any necessary remedial treatment.

External treatments
Existing claddings can be retained if it can be shown that:

- The system is maintaining the integrity of the building.
- It is adequately fixed and the expected life span of the fixings, where appropriate, is in excess of 15 years.
- The cladding material is free from any defects.
- Adequate provision for movement has been allowed.

If the above situations cannot be satisfied, a new external cladding or render system will need to be installed.

Internal treatments
An alternative to preventing moisture penetration by using externally applied claddings and renders is to adopt internally applied methods.

Systems are available that are installed on the inside of existing walls to prevent moisture penetration reaching the internal accommodation.

These include:

- **Independent metal or timber framed systems:** these should not be fixed to the existing masonry walls, but fixed at the 'head and base' to avoid direct contact. Ventilation should be provided to avoid a build-up of condensation between the masonry and the inner lining system

- **New internal walls:** these would normally be formed in blockwork, must be adequately founded and, where necessary, tied to the retained and new elements of structure

Control of damp penetration
Measures should be taken to ensure that thermal insulation in cavities does not encourage the passage of damp from the ground or from the exterior of the building to the inside of the building.

Thermal insulation of walls and claddings
Various methods exist to upgrade the thermal insulation of existing walls and floors. Regardless of the methods adopted, it is essential that risks associated with increased thermal insulation are minimised, including:

- Surface condensation caused by improvements to draught proofing of the building.
- Interstitial condensation caused by moisture-laden air passing from the dwelling to within the fabric of the structure and condensing on cooler surfaces.
- Increased risk of damp penetration caused by the filling of cavities with insulation.
- Maintaining the robustness of the external and internal wall surfaces by the provision of adequate mechanical protection over insulation materials, e.g. externally applied insulation systems with render coat mechanical protection.
- Avoidance of cold bridges around openings and where structural elements extend through the thickness of the building envelope.
- Repeating thermal bridging must be considered, e.g. internal metal-framed walls should be used in conjunction with thermally insulated plaster board.

12.1.4.10 Render application finishes

Plaster for conversions/refurbishment

Where the condition and bond of the existing plaster can be shown to be adequate, it can remain, with the exception of the following:

- Where rising damp is present.
- Where a chemical DPC is installed.
- At the junction of external walls and party walls to see if they are properly bonded.
- Above openings to examine the make-up and condition of lintels.
- Where there is a possibility that bond timbers may have decayed.
- Where the wall is solid and the plaster is gypsum-based.

Where a chemically injected DPC is installed, it is necessary to remove the plaster one meter above the DPC level or 600mm above any apparent salt line/dampness, whichever is higher.

Re-plastering work should be delayed as long as possible in order to encourage rapid evaporation of residual moisture, and the building should be well ventilated during the drying period.

Plastering work must comply with an independent third-party, and the chemical DPC must meet the manufacturer's recommendations. Recommended plasters usually incorporate adhesives to increase resistance to the passage of hygroscopic salts from the wall into the plaster. They should not, however, act as a vapour barrier. Gypsum plaster should not be used in conjunction with chemically injected DPC.

The plaster should not bridge the DPC or be in contact with the ground floor slab.

Final redecoration should not be carried out until residual moisture has disappeared. Matt emulsion paint is recommended for use during this period.

Internally drilled holes concealed by skirting boards, etc. should not be plugged. Other visible holes and external holes should be plugged.

Rendering for conversion/refurbishment

Where the condition and bond of the existing render can be shown to be adequate, it can remain, subject to the following exceptions:

- If the render bridges the DPC.
- Above door and window openings where it is necessary to examine the type and condition of the lintels.
- Where there are signs of structural movement in the building, and further investigation is required.

FUNCTIONAL REQUIREMENTS

12.2 NEW ELEMENTS CONNECTING TO EXISTING STRUCTURES

Workmanship

i. All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
ii. All work is to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.

Design

i. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. There should be a Party Wall Agreement in accordance with the Party Wall Act (please note that this requirement will be relevant where the applicant is not the owner of the adjoining property).
iii. The separating wall between the new and existing building must meet the relevant requirements of the Building Regulations.
iv. The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new dwelling.
v. The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new home or the existing home.
vi. An effective Damp Proof Course should be present in the existing wall, linked to the new Damp Proof Course and damp proof membrane of the new home.
vii. At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm–3mm, which would not normally adversely affect the roof covering.
viii. The materials used for construction must meet the relevant Building Regulations, British Standards, Eurocodes and other statutory requirements.

12.2.1 Introduction

A number of residential developments are attached to existing buildings, and the existing elements that form part of the new structure must meet the Functional Requirements of the Warranty. The details below give some guidance on the minimum information and standards required to meet the Functional Requirements.

12.2.2 Party Wall Agreement

There should be a Party Wall Agreement in accordance with the Party Wall Act (please note that this requirement will be relevant where the applicant is not the owner of the adjoining property).

It is highly likely that improvements to an existing wall are necessary to meet the requirements of the Warranty. This may include underpinning, injected DPC and internal linings. A signed Party Wall Agreement provides evidence that the adjacent building owner consents to any potential alterations.

Further guidance on the Party Wall Act can be found on the Planning Portal website www.planningportal.gov.uk

A Party Wall Agreement is not required if the Developer owns the adjacent building that will be connected to the new development.

12.2.3 Separating walls

The separating wall between the new and existing building must meet the relevant requirements of the Building Regulations.

Confirmation should be provided where the existing wall is to be upgraded to meet current Building Regulations, particularly in meeting the relevant sound insulation and fire separation requirements. The structural integrity of the existing wall and its resistance to ground moisture should also meet current standards.

12.2.4 Existing foundations

The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new dwelling.

Foundations to the existing wall should be exposed and assessed for suitability to support additional loadings. It is important to protect existing foundations at all times, and care must be taken not to 'undermine' existing foundations when clearing the site or reducing levels.

Where existing foundations require underpinning, a design by a Chartered Structural Engineer should be provided and approved by the SWarranty Surveyor prior to work commencing on-site.

The existing wall should also be appraised to determine whether it is structurally stable and suitable to support additional loadings.

12.2.5 New wall junctions

The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new home or the existing home.

The detailing of this junction is critical to ensure that moisture ingress does not occur between the new and existing walls. Typical acceptable details are indicated in Figure 8 and Figure 9.

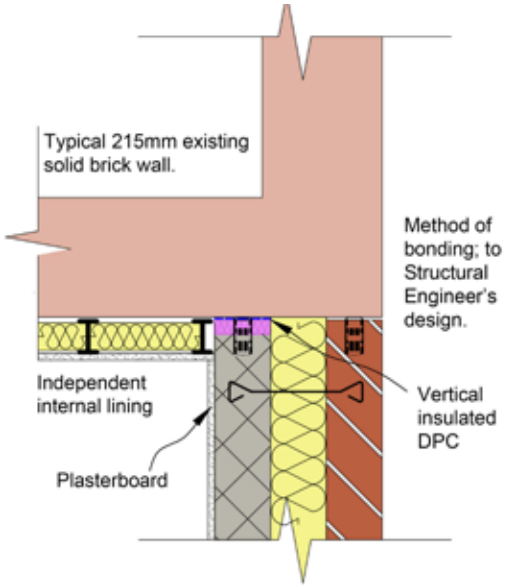


Figure 8: Bonding new walls to existing solid masonry wall

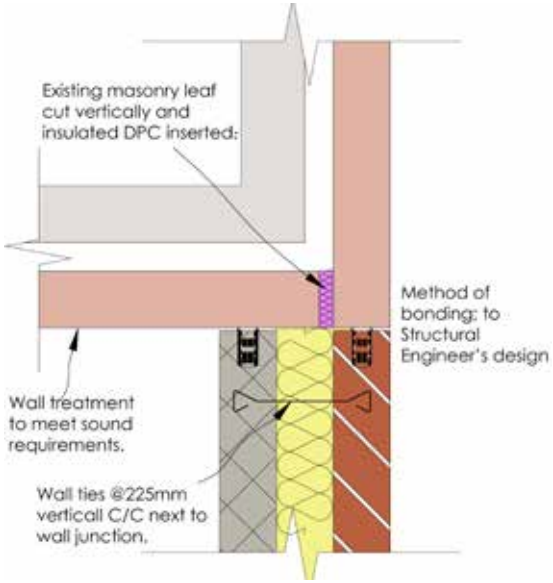


Figure 9: Bonding new walls to existing cavity masonry wall

12.2.6 Damp Proof Course (DPC)

An effective DPC should be present in the existing wall, linked to the new DPC and Damp Proof Membrane (DPM) of the new home.

Acceptable existing DPCs are considered as:

- A continuous felt or proprietary DPC material
- A chemically injected DPC supported by an insurance-backed guarantee
- A slate DPC is considered acceptable if the existing wall incorporates an independent wall lining system to the inner face of the new dwelling

The new DPC should lap the existing DPC by at least 100mm.

12.2.7 Existing and new structure junctions

At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm–3mm, which would not normally adversely affect the roof covering.

Typical details of bonding new walls to existing are indicated in Figure 8 and Figure 9.

In order to prevent excessive differential movement, the new dwelling should have the same foundation type as the existing dwelling. Where the foundation types are different, e.g. new dwelling pile and beam, existing dwelling traditional strip foundation, the new dwelling should be completely independent of the existing dwelling.

CHAPTER 13: SUSTAINABILITY

This chapter has been removed.

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