LABC New Home Warranty

GROUND WORKERS HANDBOOK

Foundations and Substructures

INTRODUCTION

The Ground Workers Handbook gives guidance to site managers and site staff on any particular issues on your site for traditional forms of construction. Rafts, piles, ground beams and suspended reinforced concrete floors are not covered by this guide. For these types of construction, a structural engineer should be consulted.

Ground and site conditions can vary significantly and although this guide gives examples of the most commonly occurring issues, LABC New Home Warranty recommend early contact with our surveyors to help give guidance on how to avoid particular circumstances on your site.

Please refer to the LABC New Home Warranty Technical Manual for the Functional Requirements, Principal Performance Standards / Requirements for the design and construction of Housing units using LABC New Home Warranty.

Please note: there are 'Statutory' variations to the information shown in this publication in respect to:

- England and Wales: The Building Regulations 2000 (as amended) and Approved Documents.

Please refer to your LABC New Home Warranty Site Audit Surveyor for further advice.

Your LABC New Home Warranty Site Audit Surveyor contact is:

CONTENTS

FOUNDATION EXCAVATIONS

SUBSTRUCTURE

KEY TO SUCCESSFUL FOUNDATION CONSTRUCTION

Site investigations must be undertaken to reveal the likely ground conditions of a site. These findings assist the Architect and Engineer to design the most appropriate foundation for the building.

To avoid damage to the building, the foundation design will have to take account of:

- Soil types. Clay soils and the potential for movement caused by shrinkage and swelling is a particular problem near trees (1) and also preventing damage due to frost or prolonged periods of hot weather. (2)

- Movement due to the presence of made ground or consolidation of poor ground. (3)

- Movement due to nearby excavations. (4)

- Erosion of the soil particles due to water in the ground e.g. leaking drains. (5)

- Underlying strata e.g. thin bands of sandstone with weak mudstone under. (6)

Case Study:

Movement due to nearby trees

Trees were removed at the time of development, including a row of conifers 6m away from the elevation shown. Other unspecified tree(s) were also removed from within the building footprint. Re-hydration of the clay is now occurring, causing 'heave' movement.

A site and ground investigation is required for warranty purposes to identify any geotechnical or contamination hazards present on or adjacent to the site that might adversely affect the housing unit. The investigations will also alert the design team to:

- Past use of the site.
- Instability of sloping ground.
- Mining subsidence.
- Chemical attack on the foundation concrete.
- Contamination hazards.
- Methane and landfill gases.
- Radon.

Natural soils encountered usually fall into one of the following categories:

Fine grained 'cohesive' soils, (clay and plastic silts)

Changes in the moisture content of cohesive soils commonly occurs as a result of seasonal changes in the weather or from the influence of existing or removed trees. This can result in shrinkage or heave in the ground. If foundations are not deep enough or anti-heave measures are not adopted, movement of the foundations and floor slabs may take place.

Course grained 'granular' soils (sand, gravel, and non-plastic silts)

Granular soils usually provide a good founding medium and in their dense state can accommodate heavy foundation loads from large structures. However, problems can arise when they are encountered in a loose condition or where high groundwater levels are present. In these cases a structural engineer should be consulted.

Rock (chalks, sandstone, shale and other natural bedrock)

Rock strata can provide a good founding medium and may accommodate very high foundation loads. However, hazards may exist and a thorough site investigation should be undertaken to identify these in advance. Such hazards include:

- Natural or man-made cavities. e.g. mine workings.
- Thin layers or 'crusts' of rock strata may be overlaying a weaker ground.

Note: where proposed building works are to be founded on chalk, a structural engineer must be consulted to fully investigate the ground conditions, in particular for susceptibility to dissolve into solution by groundwater with the resultant voids.

It is also common to encounter more than one soil type. Soils can vary both across the site and also with depth. Such circumstances will require special foundation measures to be taken and a structural engineers design should be used.

FOUNDATION DEPTHS

The required depth of the foundations can be influenced by a number of factors. However, in general terms, the minimum depths should be the greatest of the following criteria:

- The depth to the selected bearing stratum.

- In clays which are subject to seasonal moisture movement, not less than 1.0m in depth (see also BS 5837).

- In clays and in close proximity to trees and shrubs (see sections on Soils and Tress and Hedges).

- In sands, chalk and other frost susceptible soil, a depth below the zone of frost action and not less than 450mm (on exposed sites subject to long periods of frost, an increase in depth will be required).

For internal load bearing walls, foundations must be provided to the same depth as the external walls.

For minimum widths of strip foundations refer to Building Regulations.

Not all natural soils lend themselves to conventional spread foundations. Also, spread foundations may not be the most cost effective solution. Other foundation methods may be appropriate and should be determined by an Engineer. These may take the form of one of the following:

- Pile and ground beam.
- Pad and ground beam.
- Rafts.
- Vibratory ground improvement.
- Engineered Fill.

On Brownfield sites, natural soils are often concealed beneath man-made ground or ground that has been reworked. Care therefore needs to be taken to ensure that the level of the natural soils (i.e. virgin strata) is correctly identified for foundation purposes. Man-made ground may also pose a risk from contamination.

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Detection of Japanese Knotweed must be undertaken before any site clearance is undertaken on a new development (or an existing site subject to refurbishment).

Japanese Knotweed forms in dense clumps up to three metres in height. It has large, oval green leaves and a stem that is hollow and similar to bamboo. This plant can grow as much as 2cm per day and will grow in any type of soil, no matter how poor. Clusters of cream flowers develop towards the end of August.

The plant is hazardous to building works and due to the depth and virulence of the roots, has the potential to cause structural damage. All Developers should seek specialist advice before attempting to remove the vegetation. For further information refer to:

> Environment Agency publication 'The Knotweed Code of Practice' on www.environment-agency.gov.uk

TREES AND HEDGES

Regardless of whether the trees, hedges or large shrubs are within the site boundary or on adjacent land, if they are young or mature in age or have been recently removed; it is likely that they can have an influence on clay soils about the new building.

Trees extract moisture via the root systems from depths typically greater than 1.5m and potentially to 5m.

Where buildings are to be constructed on clay soils, within the influence zone of the trees (or removed trees) piled and beam foundations are recommended. However deepened trench fill foundation may be used subject to careful design which takes account of the swelling of the soil.

A structural engineer should be engaged to provide a specification for foundation depths based on the tree varieties and the soil types. This may influence your choice of foundation design.

Consideration must also be made for:

- Underlying clay soils existing below a sand / gravel soil dig level.
- Potential effect on buildings from new tree planting on site.
- Location of former trees and shrubs.

To establish the correct depth of foundations, the following documents should be referred to:

- BSEN 1997-1 :2004 Geotechnical design. General rules / BS 8004: Code of practice for foundations.
- BS 8103: 1995 Part 1 Code of practice for stability, site investigation, foundations and ground floor slabs for housing.
- BS 5837; Code of practice for trees in relation to construction.
- BRE Digests; 240, 241, 251 and 298.

Case Study:

It is not just trees that require careful consideration near the building works; hedgerows particularly confers, can have an adverse effect on the ground adjacent to the building works.

Case Study:

Tree roots found in the bottom of the trench indicate the excavations are not deep enough to avoid the potential for causing movement and subsequent damage to the building.

HEAVE PRECAUTIONS

Deep trench fill foundations in clay soils within the zone influence of trees will require protection from vertical and lateral clay movement on the sides of the foundations, substructure walls and under the ground floor construction - even if the trees have been removed.

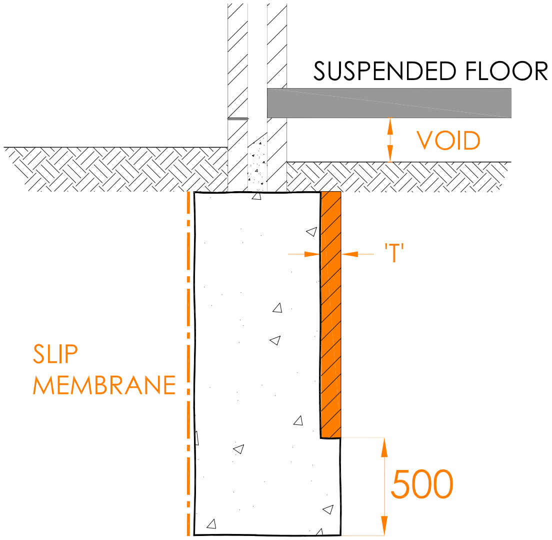
- Compressible materials or void formers should be correctly placed to absorb the swelling of the clays. Only products with third party accreditation should be used.

- The thickness of the vertical compressible material `T' must be sufficient to absorb the expected swelling of the soil (to be determined by the Structural Engineer).

- The sides of the foundation must be vertical and not battered at an angle.

- Floors; where clay soil movement is likely, a suspended ground floor construction should be used with a void formed under (Note: The depth of void must not be less than 150mm to accommodate the heave potential of the soil, seek advice of a Structural Engineer).

Note: Polystyrene sheet should not be used under a cast in situ concrete floor as it may transmit the swelling pressures to damage the floor.



- The compressible material must be positioned and held in place on the vertical inside face of the foundation starting 500mm above the bottom of the trench and for the full length of the affected foundation.

- A Polythene slip membrane is recommended to the vertical outside face of the foundation to reduce uplift forces caused by swelling soil.

Case Study:

Heave precautions to the inside face of the foundations should have been incorporated prior to concreting.

- Excavations must be kept straight and level.

- Check that the designed thicknesses of leaves of walls and correct cavity width will be provided.

- The substructure will be constructed centrally on the foundations.

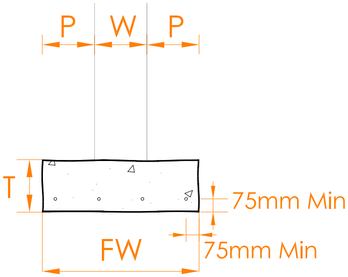
- Check diagonals and all structural measurements carefully.

- Check latest plans for correct specs and planning approvals for any conditions attached relating to positioning of buildings. This includes; finished floor levels, ground levels and correct construction of entrance ramps and driveways. Also positions in relation to tree preservation orders.

FOUNDATION EXCAVATIONS

FOUNDATION DIMENSIONS

Concrete `Strip' Foundation



- Wall to be central on foundation.

- Minimum thickness of foundation concrete (T) to be (P) or 150mm which ever is greater.

- Foundations must be widened at piers and chimneys to maintain a projection dimension (P).

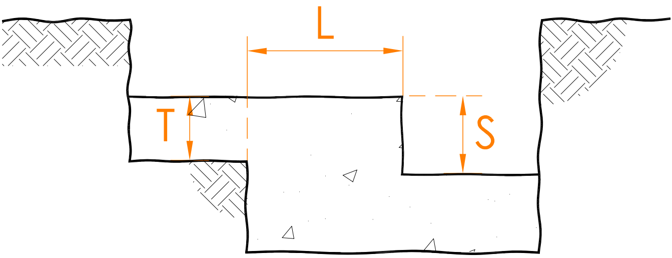
- Foundation width (FW) to be not less than the recommendations in the Building Regulations Approved Document.

- Unless structurally designed, where concrete is cast directly against the earth, any reinforcement used must have at least 75mm nominal cover.

- The trench bottom of each foundation length must be horizontal (and to each stepped length).

- The face of each step where provided, must be vertical.

STEPPED 'STRIP' FOUNDATION

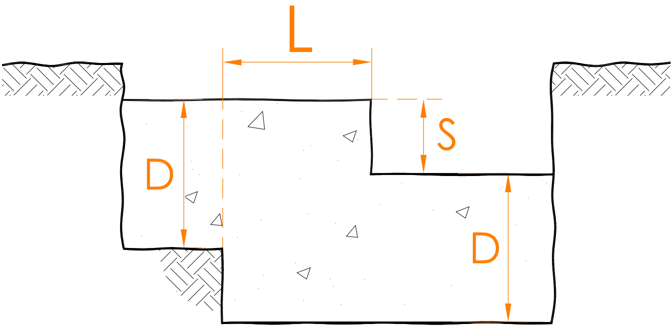


- Minimum overlap L = 2 x S or
  = thickness of foundation or
  = 300mm

  Which ever is the greater

- 'S' must not be greater than 'T'

STEPPED 'TRENCH FILL' FOUNDATION



- Minimum overlap L = 2 x S or
  = 1 metre

  Which ever is the greater

- D to be 500mm minimum

Case Study:

Seemingly good virgin sites (same site as previous picture) can have hidden pockets of fill / ash pits /soak ways. The foundation excavations must be stepped down to at least 300mm below the invert of the fill on all lengths of trench likely to be effected.

Case Study:

Evidence is available to be seen in the sides of an excavation to alert the presence of filled ground and drains. This excavation had to be deepened by a further 1.2m due to an existing drain below.

WATER AND DEBRIS IN TRENCHES

Case Study:

Any water and loose material collecting in the trench bottom must be removed.

- Sumps should be formed (not located at returns) and the water pumped away from the excavation area.

- Immediately prior to concreting, the trench base must be scraped to remove any softened clay / slurry to ensure the concrete is placed on 'firm as dug material'. This is particularly important where the mechanical excavator with a toothed bucket has been used. Standing water between the grooves in the trench bottom can potentially soften the clay.

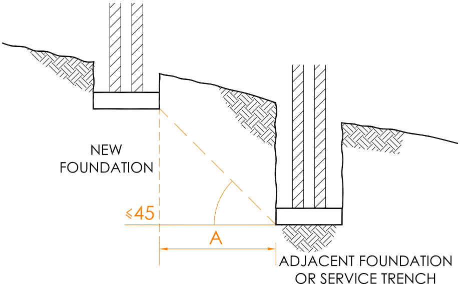
- If the trench bottom has been left for some time and has dried out and / or cracking appearing in the clay, the trench should also be 'bottomed up' by excavating the trench width by a further 50 – 100mm depending on the conditions.

- Where a trench has been left open for a considerable length of time an engineer's advice should be sought before continuing with the construction works.

SURGE FROM ADJACENT FOUNDATIONS, STRUCTURES AND DRAINS

Where a foundation adjoins an adjacent foundation or service trench, the layout shown in the detail below should be followed (unless specialist engineering advice is taken).

Foundation adjoining a trench



- The zone of loading below the new foundations should not fall within the excavation area of the lower trench.

- Where 'A' is less than 1m, the lower trench must be back filled with concrete up to the lowest level of the adjacent 'higher' trench.

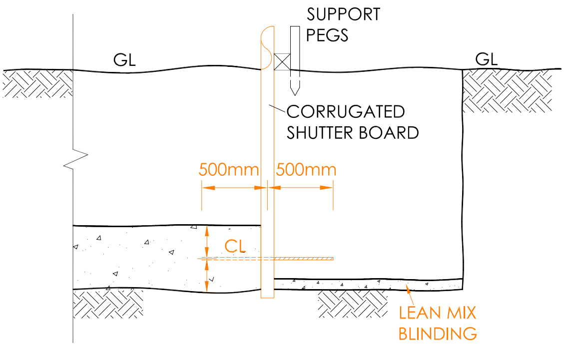
Case Study:

Particular care must be taken with new works on a sloping site where excavations for adjacent plots could be undermined or at risk – particularly if strip foundations rather than trench fill methods are being adopted. Precautions must also be taken when constructing new works adjacent to existing buildings where for example a cellar may exist.

CONSTRUCTION JOINTS

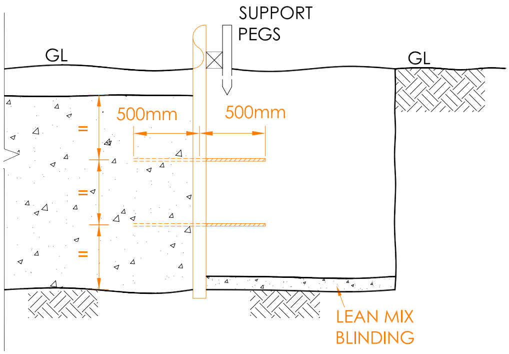
The following methods may be considered for strip and trench fill foundations only. Any other arrangement should be engineer designed.

Strip Foundation



- The reinforcing bars should be at least 1 metre long projecting 500mm either side of the shutter. Typically 2 no, T16 or T20 bars used.

Trench Foundation



- The reinforcing bars should be at least 1 metre long projecting 500mm either side of the shutter. Typically; 2 no; T16 or T20 bars used for every 150mm depth of concrete.

Notes:

- The concrete pour should ensure a consistent depth of concrete (150mm minimum).

- Construction or day joints should always be avoided where possible. If however a construction joint is to be formed, it should be positioned and constructed along the line of excavation, not near a return.
- Ideally, corrugated shutter boarding should be used.
- Any remaining lengths of foundation should not be excavated, or the formation should be blinded with concrete to prevent it from softening.

PLASTIC SHUTTERING

When using plastic shuttering for ground beams, care must be taken to ensure the shuttering is properly supported by the backfill material prior to the pour of concrete. The shuttering must be kept straight to ensure the correct 'depth' of cover to the reinforcement will be achieved.

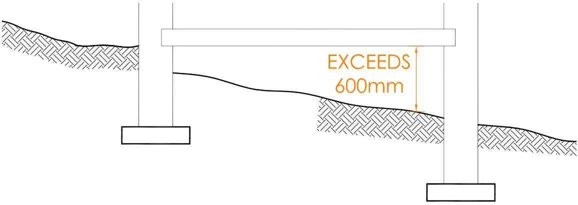
SUBSTRUCTURE

SETTING OUT OF WALLS

- The Foundations must be the correct width to accommodate the walls centrally.
- The concrete foundation must be level.
- The diagonals must be checked before constructing the substructure walls.
- Masonry should be set out to achieve correct cavity widths.
- Initial cavity widths may require increasing to allow for timber frame sheathing panel projections (Timber framed superstructures).
- Brickwork set to the edge of the foundation trench or corbelled in order to rectify cavity widths must be avoided.

Depth of infill on sloping sites

A sloping site may require steps in the floor levels of the housing unit and terracing of the external ground levels. As a consequence, the depth of fill material below the floor could exceed 600mm and require a suspended floor to be constructed.

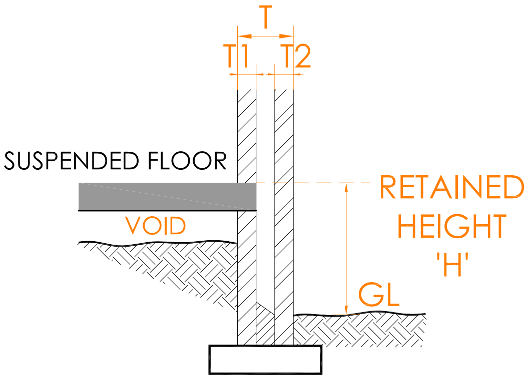


Thickness of walls below DPC level on sloping sites

As a result of the slope of the ground, the substructure walls may also act as retaining walls. A structural design must be provided:

a) to assess the compressive strength of the masonry below DPC level, and

b) if the retained height of the wall 'H' exceeds the following;



Clear cavity: 'H' should be less than or equal to 1m and less than 4 x (T1 + T2) and wall ties must be provided

Note: If the cavity wall is filled with lean mix up to the retained height level 'H'. 'H' should be less than or equal to 1m and less than or equal to 4 x total thickness of the wall (T).

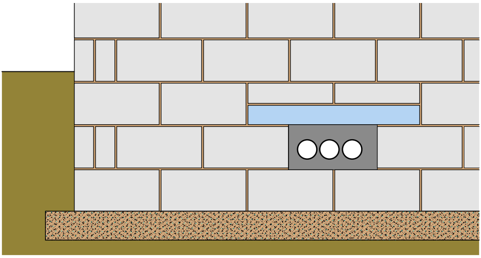
DRAINAGE AND SERVICE ENTRIES

Drains and services passing through the external (and internal walls) must be protected from damage by the use of lintels or `rocker pipes'.

Case Study:

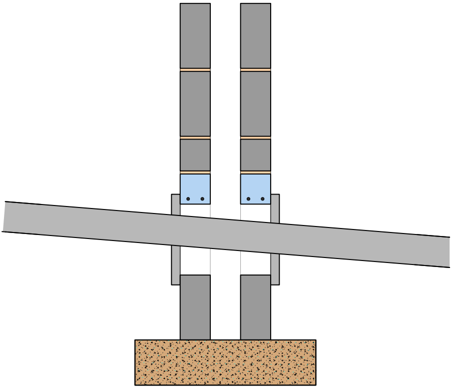
Excessive lengths of openings formed must be avoided.

Reinforced Concrete Lintels should be used over the opening on each structural leaf with a minimum 150mm end bearing. Do not use metal lintels below the ground level.



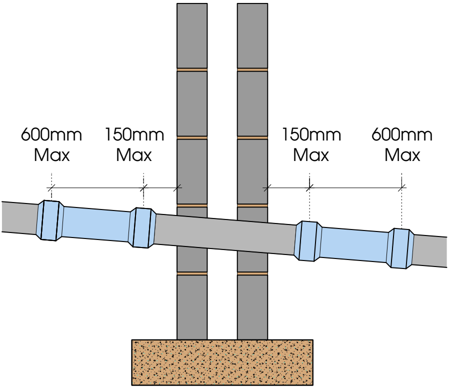
A minimum 50mm space around pipes should be provided.

Lintel Opening



Openings should be sealed with a suitable board (for underground use) both sides to prevent vermin access.

Rocker Pipe Construction



Where drains are built into the wall construction, flexible joints (rocker pipes) must be provided as shown.

Case Study:

Plastic drains must have equal provision for movement and must not be built in 'solid'.

Case Study:

Inspection chambers should not be sited so close to substructure walls that lintels and large voids are created in order to bridge the chamber construction.

Note: the horizontal DPC was also found to bridge the cavity without a suitable cavity tray installed

OVERSITE FILL BELOW GROUND BEARING FLOOR CONSTRUCTIONS

- Topsoil and organic matter (including roots) must be removed and the resulting underlying layer must be level and provide a consistent bearing surface.

- The ground floor slab must be constructed on a minimum 150mm of inert well graded fill material, such as crushed stone or other suitable fill, blinded with fine material. The fill material should be compacted in layers not greater than 225mm thick and should not contain any pieces that will not pass through a 75mm diameter ring.

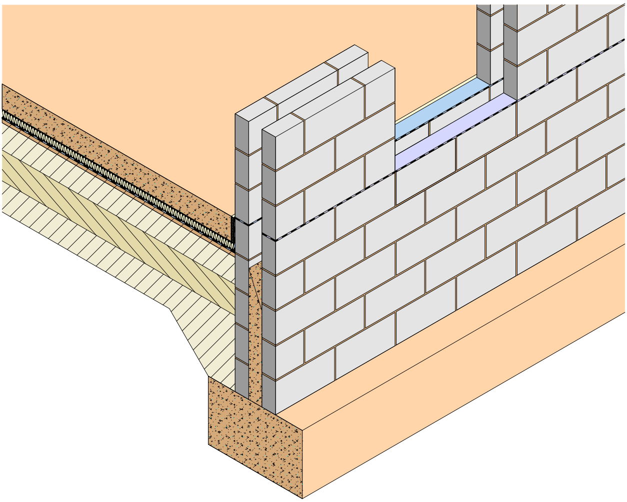
- Where the total depth of any infill under the slab (including the foundation trench area) exceeds 600mm, a suspended floor construction must be provided.

- Fill material should be free from harmful toxic substances and be of a type of material that will not result in expansion of the hardcore that would cause distress to walls and or the floor structure. Fill material should be certified by a competent laboratory as to their fitness for purpose. They should be chemically analysed to check if they contain any contaminants (e.g. pyrite).

- Where sulphates are present in the ground, the concrete mix must be able to resist sulphate attack and a suitable protecting layer of 1200gauge polythene provided.

Case Study:

Topsoil and vegetation must be removed from the area forming the floor footprint.



- The maximum individual layer thickness of filled material should not exceed 225mm and be properly compacted.
- Maximum total depth of the filled material layers, should not exceed 600mm under the slab and the foundation trench areas.
- Concealed chambers, manholes or soft localised pockets of fill under slab areas should be removed. A suspended floor may be required.

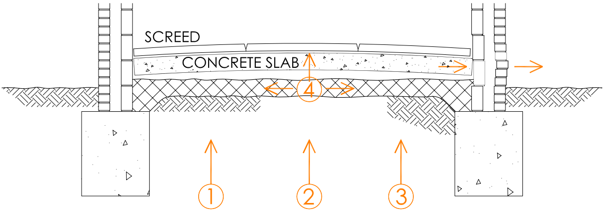
Case Study:

Uncontrolled and excessive areas of fill. A suspended floor construction is the only solution in this situation.

PREVENTION OF HEAVE UNDER GROUND BEARING FLOOR SLABS

There are four potential areas of concern;

1) Where ground recovers due to removal of load e.g. substantial excavations of soil to create basements (commonly called removal of overburden).
2) Swelling of Clays (including movement caused by trees).
3) Frost heave.
4) Chemical reaction e.g. Sulphates or pyrites in infill material.



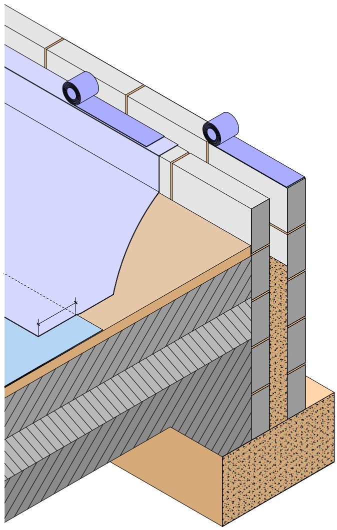
1) **Overburden:** occurs in both granular and cohesive soils. A structurally designed foundation is recommended e.g. piles, to allow the soil to swell without effecting support to the building and provide a suspended floor construction with a void under.

2) **Swelling of Clays:** where preventative measures are deemed necessary for the foundation design, a Suspended floor construction is recommended with a void formed under.

3) **Frost Heave:** mainly occurs on very exposed sites. Ensure foundations are dug to at least the minimum depths described in the Foundation Depths section of this book and avoid leaving the reduced levels exposed for long periods during freezing weather prior to construction of floor areas.

4) **Chemical reaction:** avoid Sulphate attack on concrete from potential contaminants in the soil or back fill material. Appropriate testing must be carried out on suspected soils and imported fills. Shale, brick rubble with attached plaster must not be used. Fill material must also be checked for containing pyrites. The concrete used in the foundations and floor should be an appropriate mix to resist sulphate attack.

DAMP PROOF MEMBRANES



- Ensure the hardcore infill is well compacted and is covered with sand blinding to provide even support for the insulation / DPM.

- Membranes to be not less than 1200 gauge. The thickness may have to be increased if a Radon or other gas barrier is required. Additional provisions for laps / service pipe penetrations also apply.

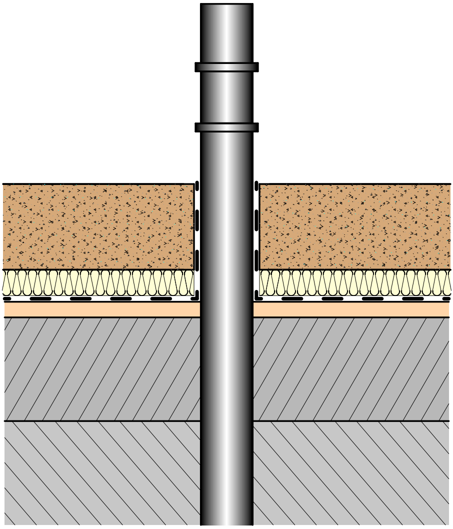
- DPM sheets must be overlapped by min 150mm. It is recommended, that all laps in DPM are taped or sealed.

- Where the DPM is sited below the concrete slab it should also be below any insulation level if that insulation material is not resistant to ground contaminants.

- The DPM must be turned up at slab edge and be lapped under the DPC for the full thickness of the inner leaf to form a continuous barrier.

Where ground floors and walls fall below the external ground level (e.g. stepped layouts on sloping site, semi or full basements), normal DPM's will not be adequate. A third party approved 'tanking system' should be used and the design should follow recommendations in BS 8102.

Service Pipe entries through ground floor constructions



Ensure the DPM is properly installed around pipe area and all joints sealed. Cut the main membrane tightly around the service pipe. Form additional seals with off cut squares of membrane in the form of a 'collar' or 'top hat'. This should be lapped and sealed to the main membrane with adhesive jointing tape (Proprietary 'top hat sleeves' are available for this purpose).

Note: Where Radon Barriers are required, additional measures will be necessary.

Case Study:

The edges of the DPM, insulation and DPC must be protected with a temporary timber board (or other durable material) during construction to prevent damage when tamping or power floating the floor slab or from general construction traffic (especially at door openings).

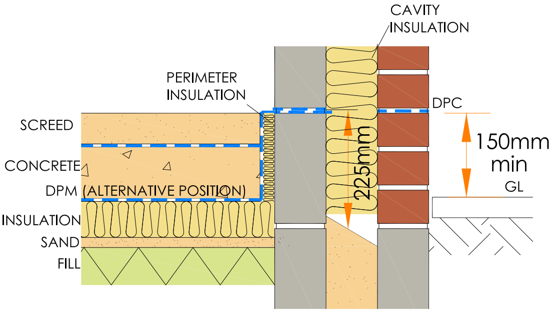
Ensure that the correct perimeter insulation is in place and that sufficient overlap of DPM is provided to lap under the DPC for the full thickness of the inner leaf to form a continuous barrier.

GROUND BEARING CONCRETE FLOOR SLABS

- The appropriate mix for concrete slabs should meet BS EN 206 -1 / BS 8500 standards.
- Ensure a DPM is provided and lapped to the DPC.

Note: where insulation slabs are sited below the concrete slab:

- They are supported off a compacted sand blinded base.
- Insulation slabs must be butted together to avoid sections of concrete 'cold bridging' against the ground - and avoid potential cracking occurring in the floor above.
- Ensure the perimeter insulation is in place and taken up to screed level (if provided).



Unreinforced concrete ground bearing slabs must not be less than 100mm thickness. Unbonded screeds; minimum thickness 65mm – see BS 8204-1:2003.

Case Study:

Inadequate thickness of concrete will lead to cracking.

SUSPENDED FLOOR CONSTRUCTIONS

Where designed and third party approved precast concrete beam and concrete block construction is proposed:

- It is preferable (to prevent water ponding) to raise the ground level below the floor ('Solum') to match that of the external ground levels (assume level site) and position the beams and blocks above DPC level.

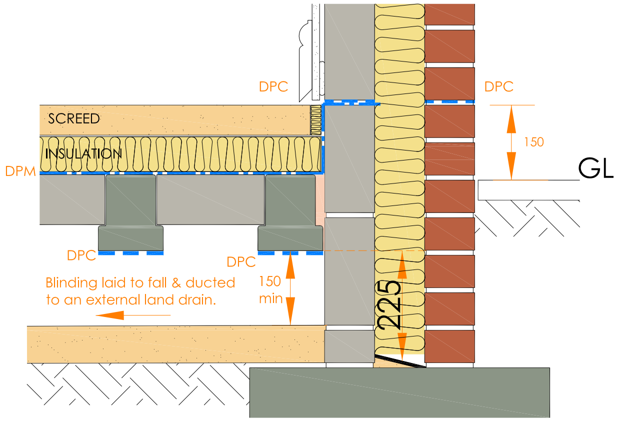
- There must be at least 50mm space between the underside of the floor beams and the ground level below. The beams must be placed onto a DPC at the bearings. Ensure 90mm minimum bearings of the beams and blocks onto supporting walls.

- Ensure the cavity fill material is 225mm below the lowest DPC level.

- The upper surface of the beam and blocks are grouted with a 1:6 cement sand mix.

- Ventilation at two opposite walls must be provided to the floor void with a recommended provision of 1500mm2/m run.

Beam and Block Construction below DPC level



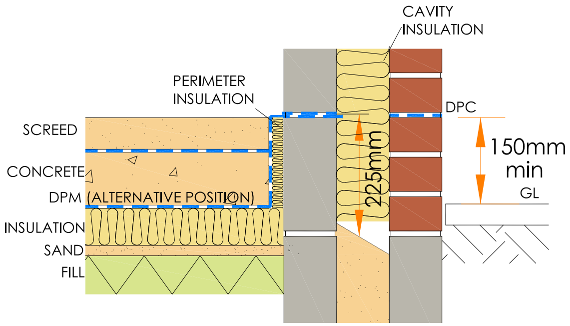
Where the ground level below the floor is below external ground level and not effectively drained;

- A DPM must be provided above the beam and block and linked to the wall DPC.
- Provide a blinded 'Solum' laid to a fall to an external elevation wall with appropriate vermin proof piping through the wall to a land drainage system externally.

Beams ready to be set out to correct spacing's on top of DPC.

Telescopic Ventilators in position ready for outer leaf to be built.

HORIZONTAL DAMP PROOF COURSES



- The DPC must be positioned not less than 150mm above the finished ground level (including paviours). The top of the lean mix cavity fill material must be at least 225mm below the lowest DPC level.

- The DPC must be laid on a mortar bed in a continuous length for the full width of the leaf (including an external render finish unless a bell mouth stop provided).

- The DPC must not bridge the cavity (unless forming part of a cavity tray).

- The DPM must lap under the DPC for the full thickness of the leaf.

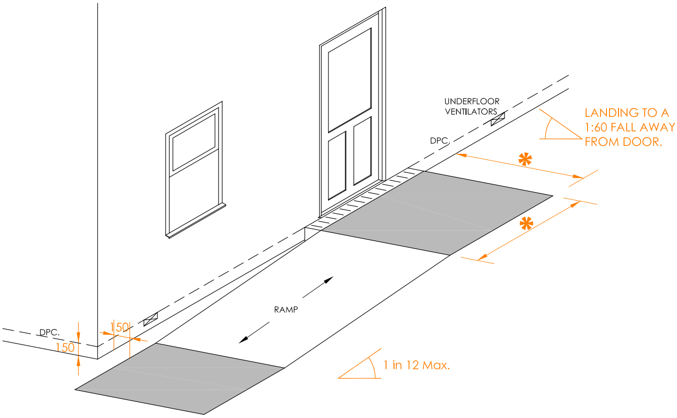
Case Study:

Where a damp proof membrane (and / or gas barrier) is to be sited above the floor construction, but not laid until the superstructure is completed or the floor screed installed, it is appropriate to install a 450mm wide DPC lapped onto the inner leaf prior to the walls being constructed. This allows a lapped and taped installation with the DPM at a later date.

In the photo, the inner leaf DPC is not the full width of the block.

Ramp and Landing area

The construction of the access landings and ramps must not compromise the DPC in the walls



- See Building Regulations for disabled ramp design and landing dimensions. Ramps should not exceed 1:12 gradient. Where the outside ground levels slope towards the property, an effective gulley system should be provided to prevent flooding, e.g. in front of garage doors.

Case Study:

Measures to drain surface water from access door landings are required: The landing should be laid to a 1 in 60 fall away from the door. The drainage channel should discharge to an outfall, e.g. storm water drain system or a suitable soak away.

Level Threshold Construction

Case Study:

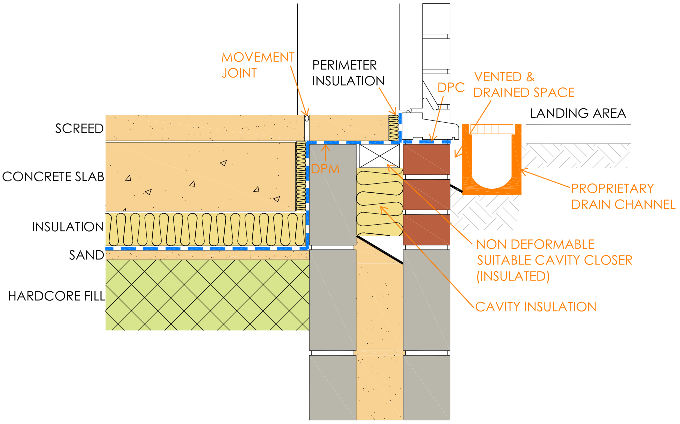
Poor detailing of the floor slab construction at the door threshold position has resulted in a potential cold bridging issue (Note, there is also a lack of a correct horizontal DPC – blue bricks should not be used as the sole means of preventing damp).

Case Study:

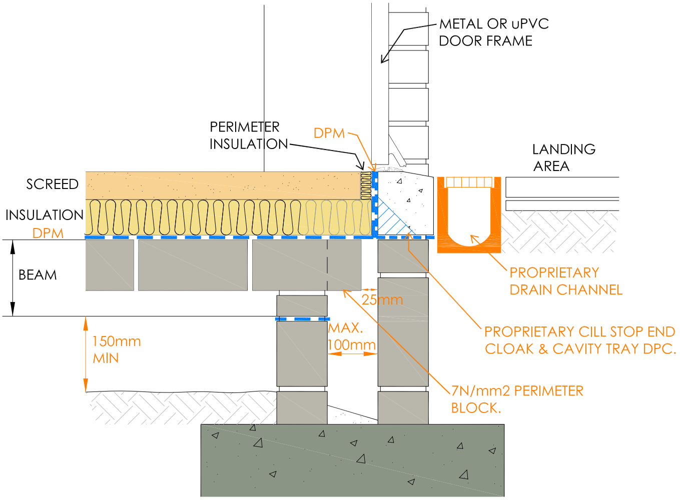
Threshold constructions must have adequate DPC's and thermal breaks to avoid cold bridging.

External Wall Level Threshold Solutions

Ground bearing concrete floor construction, timber door sill.



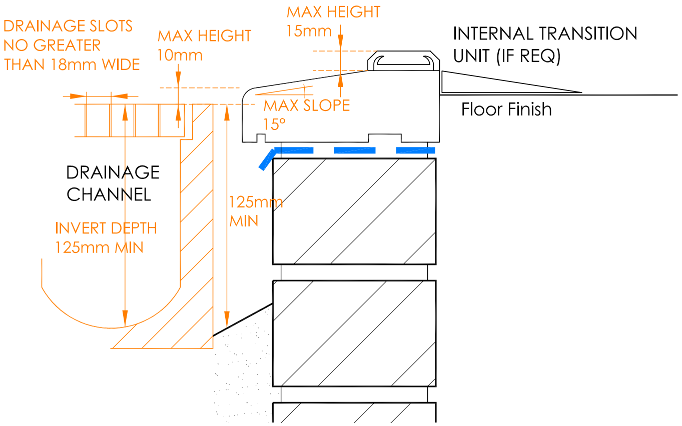
Suspended ground floor – beam and block, pre cast concrete sill.



Sill and Lower Threshold Requirements

Note: where timber sills are installed, to prevent deterioration of the timber due to the risk of moisture ingress, a drained and vented void must be provided immediately in front of the sill (at least 125mm invert).

The following dimensions should be observed to ensure an almost level threshold but provide reduced risk of moisture ingress.

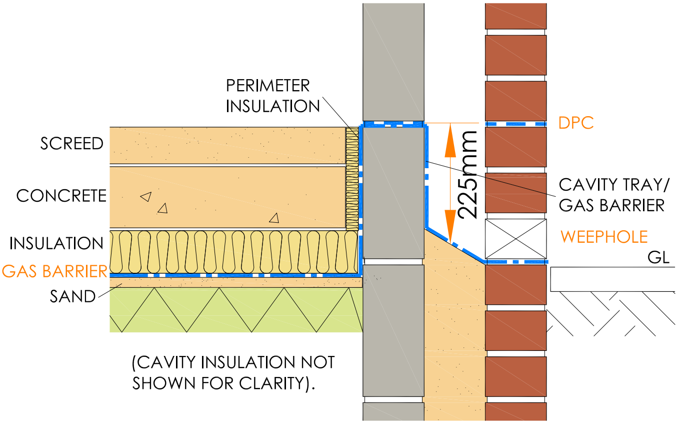


- Proprietary drainage channels must be connected to a suitable outfall (storm drainage system or soak away – if ground conditions permit).

- Please refer to current Building Regulations for guidance in respect of; damp proofing, thermal bridging, sub floor ventilation and further disabled access requirements. (reference to `Accessible thresholds in new housing ` is made in Approved Document M).

RADON AND GAS BARRIERS

- Only third party accredited materials must be used.
- Additional measures to extract the gases from the substructure such as sumps and associated pipework should be provided.
- All joints must be correctly lapped, following the manufacturers instructions (gaffer tape is not acceptable).
- Service entries require special attention.
- Detailing at cavity wall bridges must ensure membranes are carefully supported.



Case Study:

Gas barrier where exposed must be protected from damage.

NOTES:

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NOTES:

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