CHAPTER 6: Substructure

CONTENTS

FUNCTIONAL REQUIREMENTS

6.1 SUBSTRUCTURE - 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 defined tolerances as defined in Chapter 1 of this Manual.
ii. All work 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 which 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 on-site.
v. Basements must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.
vi. All baserments 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 (ie Certified Surveyor in structural Waterproofing (CSSW) or similar)

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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 which 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 in 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, and hence correct design is the first step in achieving the desired outcome.

To this end, BS 8102 includes a section regarding '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 Specialist role.

Designers must carry professional indemnity insurance cover appropriate to the project.

It must be noted that where relying on the use of waterproofing product manufacturer 'standard details', they typically disclaim design responsibility, so it is incumbent on the Waterproofing Design Specialist 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 waterproofing is compromised by working within the constraints of an ill-considered structure relative to achieving the required standard of environment.

Designers must have on-going 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 risk of waterlogging,or encouraging 'perched water table', where water stands temporarily or permanently within the ground against a structure, and arguably this affects more properties with basements versus 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 Site Audit 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 which 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 in itself is relatively impermeable, the degree to which water is excluded will greatly be influenced by crack sizes and 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 which remove standing water away from the vulnerable areas also 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 sufficiently remove 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 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 rainwater 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 within the defects and remedial measures 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 at 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 on the structure.

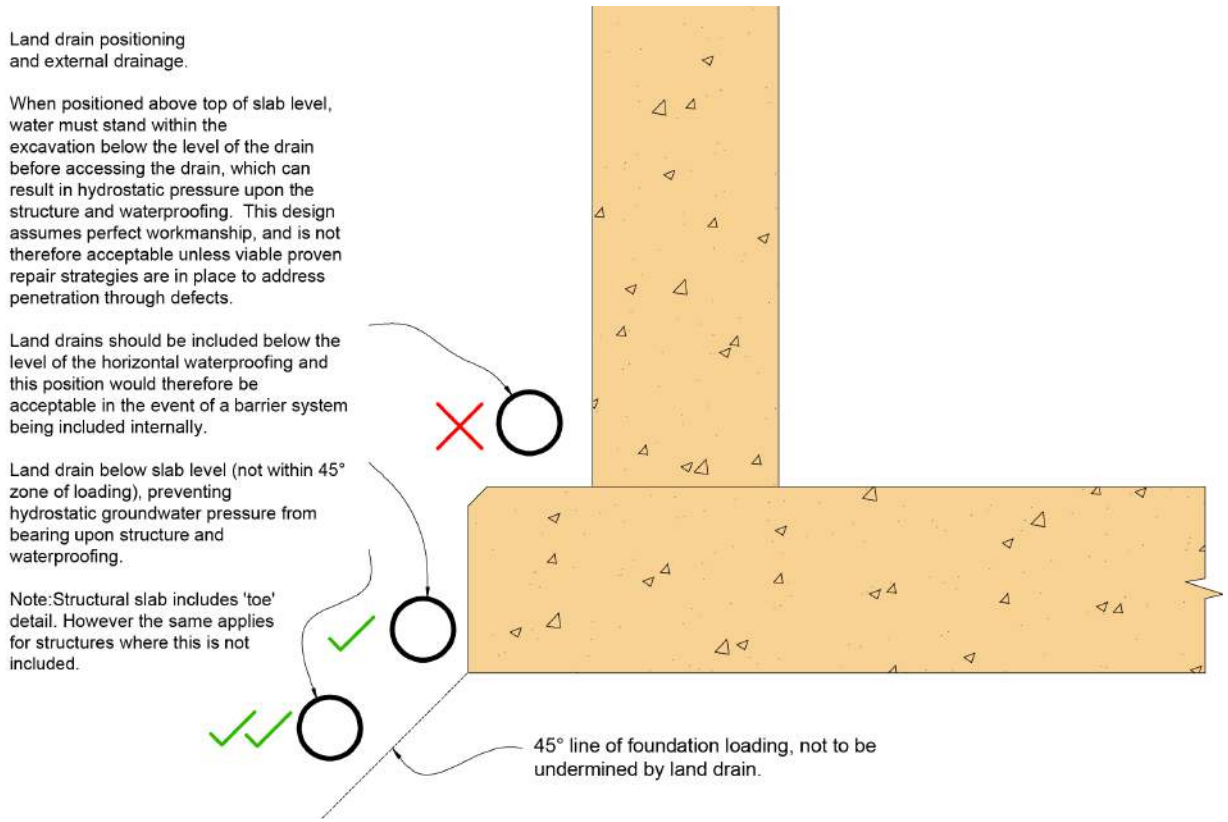

Figure 1: Suitable position of land drains

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 upon 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.

The Site Audit 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 ventilations 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. Examples of Grade 1 include basic car parking.

Most basements should be constructed to allow a minimum of Grade 2, with 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 Site Audit 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', in that 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.

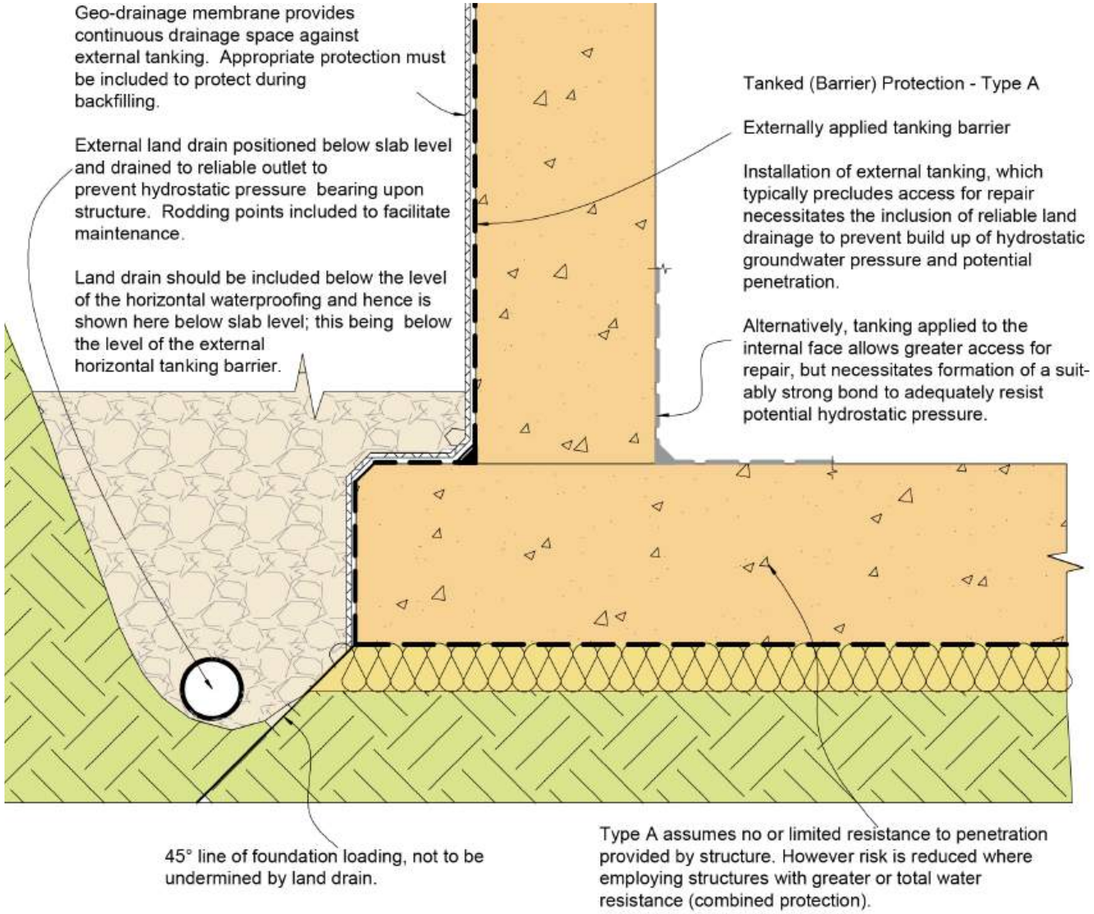

Figure 2: Type A barrier protection

With regard to repair strategies, internal systems have the benefit of greater accessibility, meaning that repair is more feasible. However, being applied to the internal face of the structure, the implications of preparation, strength of substrate and bond becomes 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, make it difficult to confidently determine 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 defect externally.

On the basis that BS 8102 advises that 'repairability' must be considered, the use of external adhesive membrane tanking systems on permeable constructions is precluded, unless employed in 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 Type B is formed using reinforced concrete; however this may take several forms.

Where the objective is for 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 which would normally be required as part of the structural design.

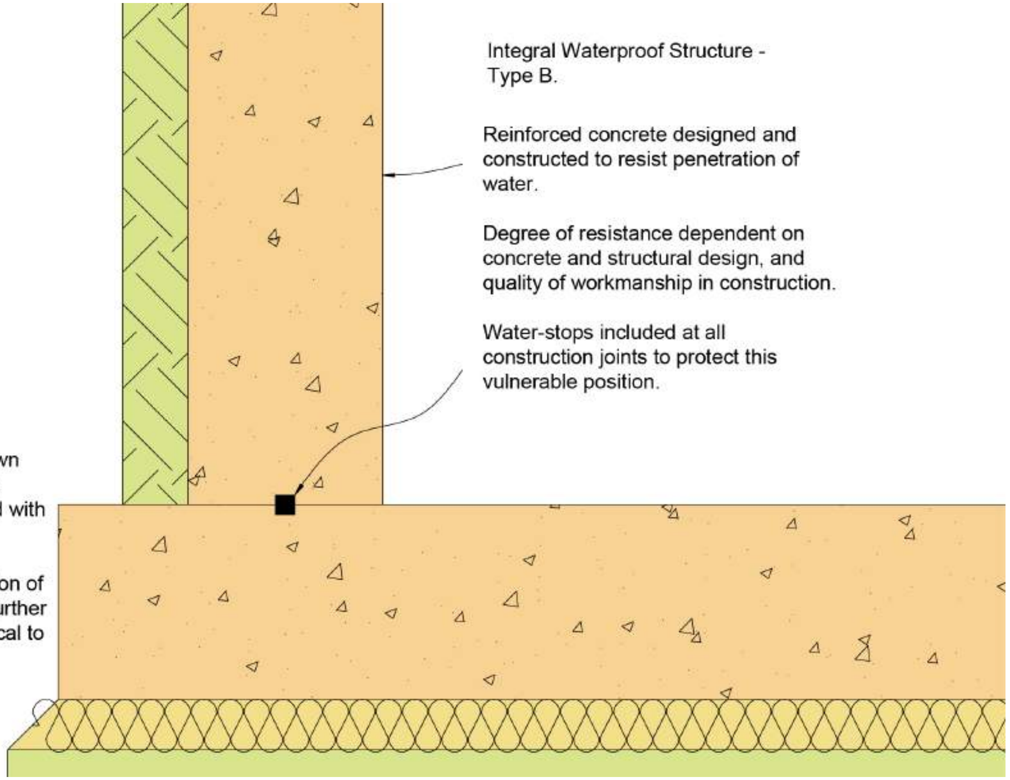

Figure 3: Type B structurally integral protection

Concrete without additives and including more typical levels of steel reinforcement (with cracking <0.3mm), while providing a 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 which aims to entirely block out water, this must be free of defects which 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 which 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 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 of 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 also drain out via gravity, the risks associated with surcharge of external drains are high, so that practice is excluded from warranty cover.

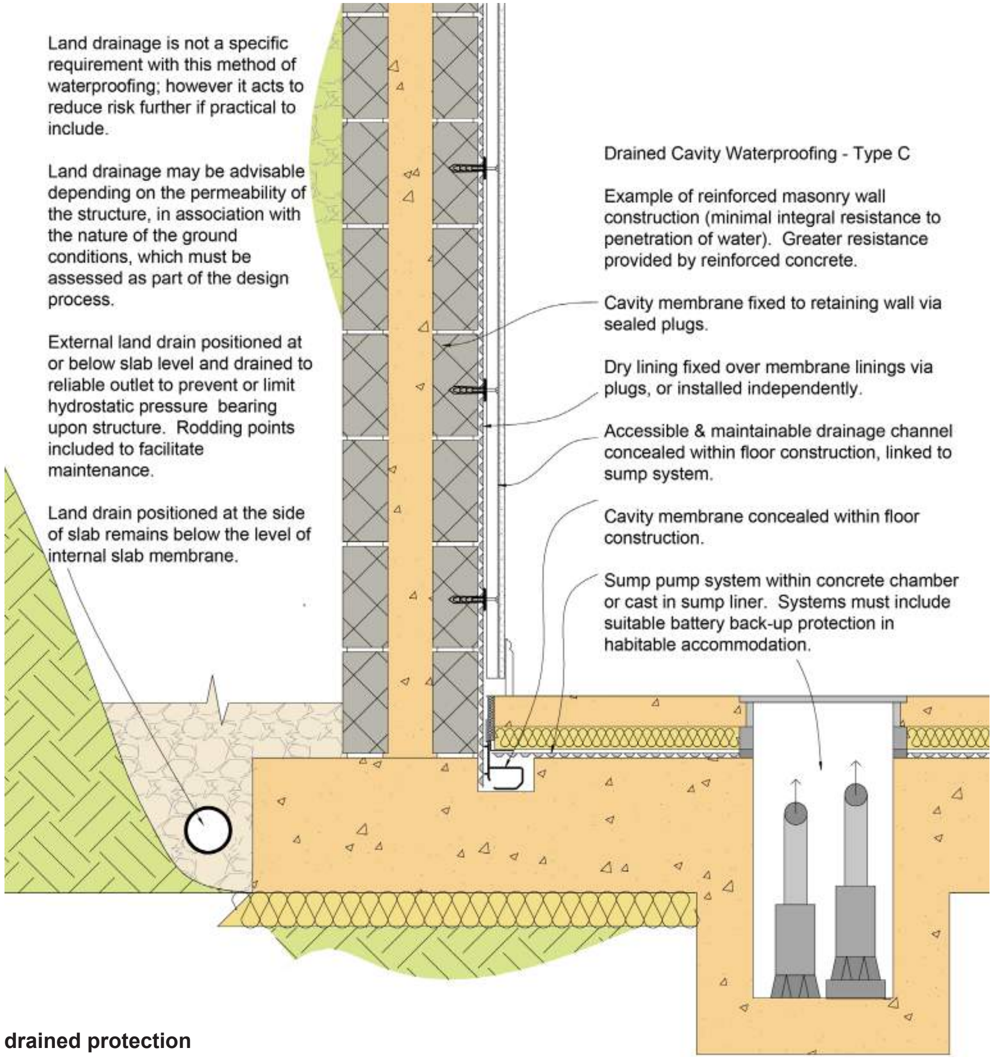

Figure 4: Type C, drained protection

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 groundwater 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 also 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 over-flow detail must be formed at the point of discharge, to allow water to spill out externally in the event of drains blocking or surcharging.

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 over-flow detail must be employed to allow water to spill externally in the event of 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 with 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 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 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 is viable once 240v supplies are installed.

Systems must not link directly by gravity to soakaways, where any of the reasons previously stated 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 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 removes 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 unacceptably high risk when employing a single system.

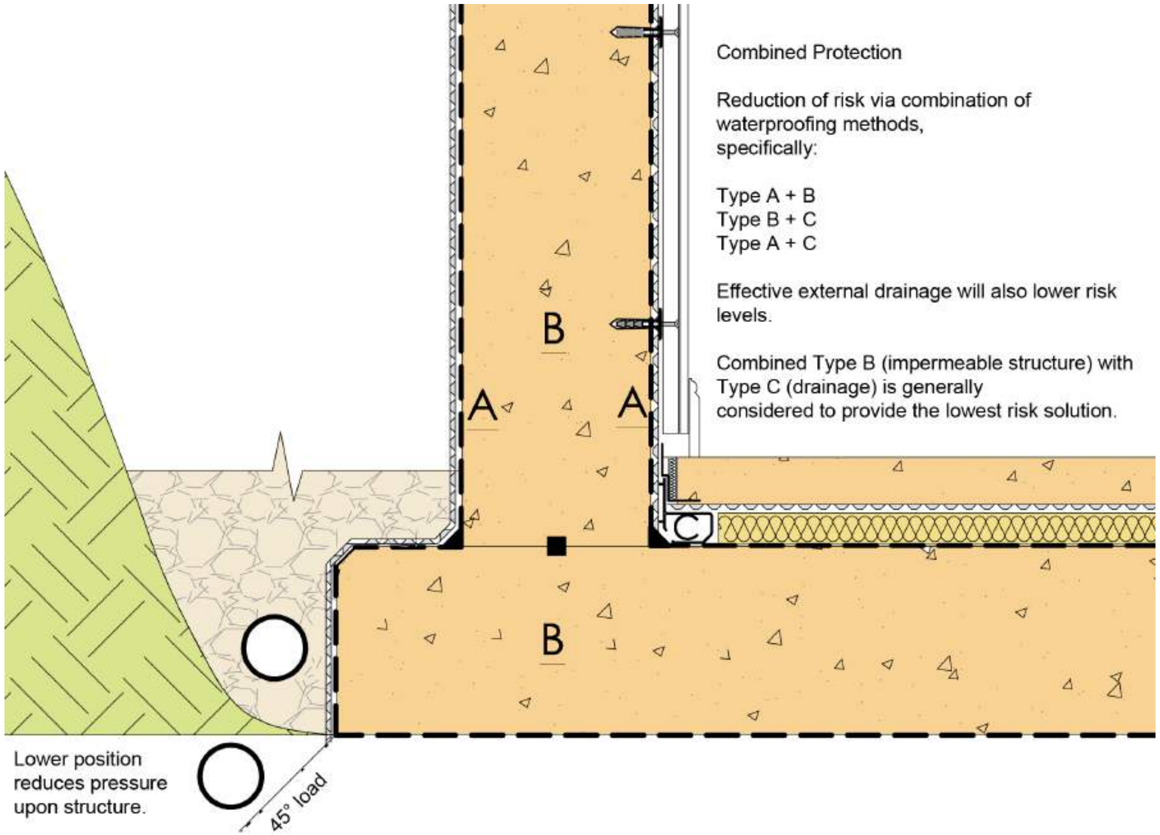

Figure 5: Combined protection

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.

FUNCTIONAL REQUIREMENTS

6.2 SUBSTRUCTURE-WALLS BELOW GROUND

Workmanship

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

Materials

i. All materials should be stored correctly in a manner which 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. 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 and other statutory requirements, British Standards and Euro-Codes.

6.2.1 Bricks and blocks below ground

Bricks should be selected that are appropriately durable against saturation in accordance with BS 3921; brick and block classifications that are suitable for walls up to damp proof course (DPC) can be found 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.

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/mm^2	Min strength 20N/mm^2 [(c)]
Block work	Min strength 7N/mm^2 and density greater than 1500kg/m^3 [(d)]	Min strength 7N/mm^2 and density greater than 1500kg/m^3 [(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

6.2.2 Mortar mixes

Mortars below damp proof course are exposed to higher saturation and therefore require a higher durability as indicated in Table 2.

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

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 Figures 6 and 7 between the DPC and the top of the concrete. The concrete should be of a GEN1 grade and a consistence class of S3.

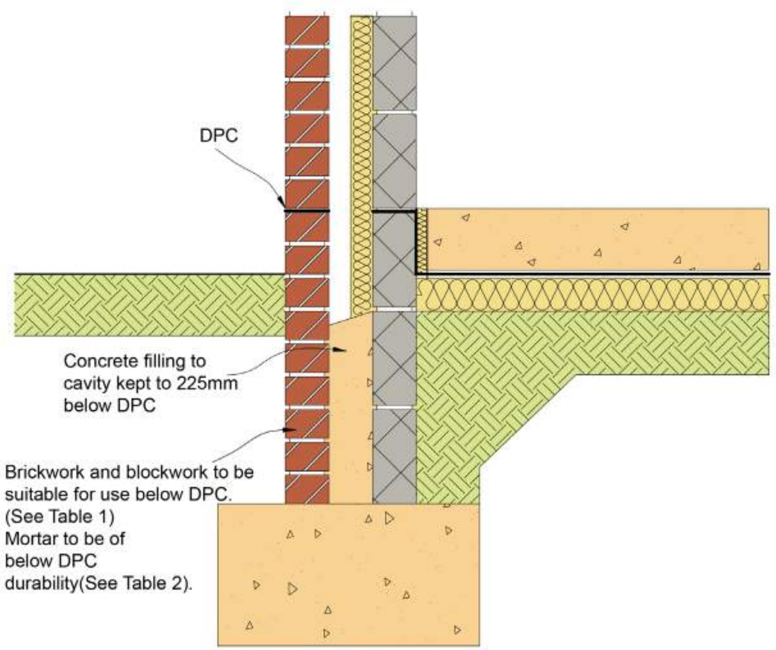

Figure 6: Concrete cavity fill - traditional ground bearing slab

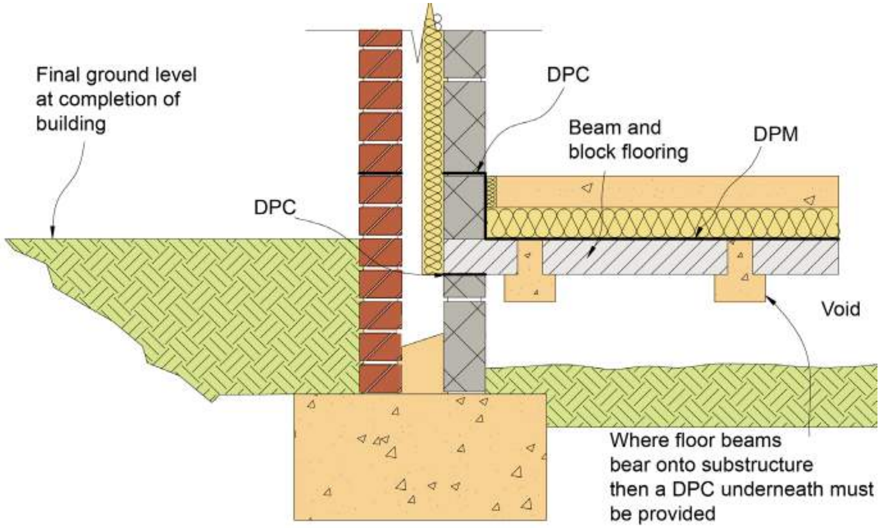

Figure 7: Concrete cavity fill - beam and block floor

FUNCTIONAL REQUIREMENTS

6.3 SUBSTRUCTURE - DAMP PROOFING

Workmanship

- **i.** All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
- **ii.** All work 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 which 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.** 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 and other statutory requirements, British Standards and Euro-Codes.

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6.3.1 Damp proof courses (DPC)

Damp proof courses should be of a flexible material which is suitable for its intended use. The damp proof course should have appropriate third party certification. Generally, blue brick or slates will not be accepted as a damp proof course.

Damp proof courses 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.

Damp proof courses should not bridge any cavities unless it is acting as a cavity tray.

6.3.2 Damp proof membranes (DPM)

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

Other damp proof membranes may be considered if they have appropriate third party certification and are installed in accordance with manufacturer's instructions.

6.3.3 Stepped membranes

Damp proof membranes should be continuous where floors are stepped as illustrated in Figure 8.

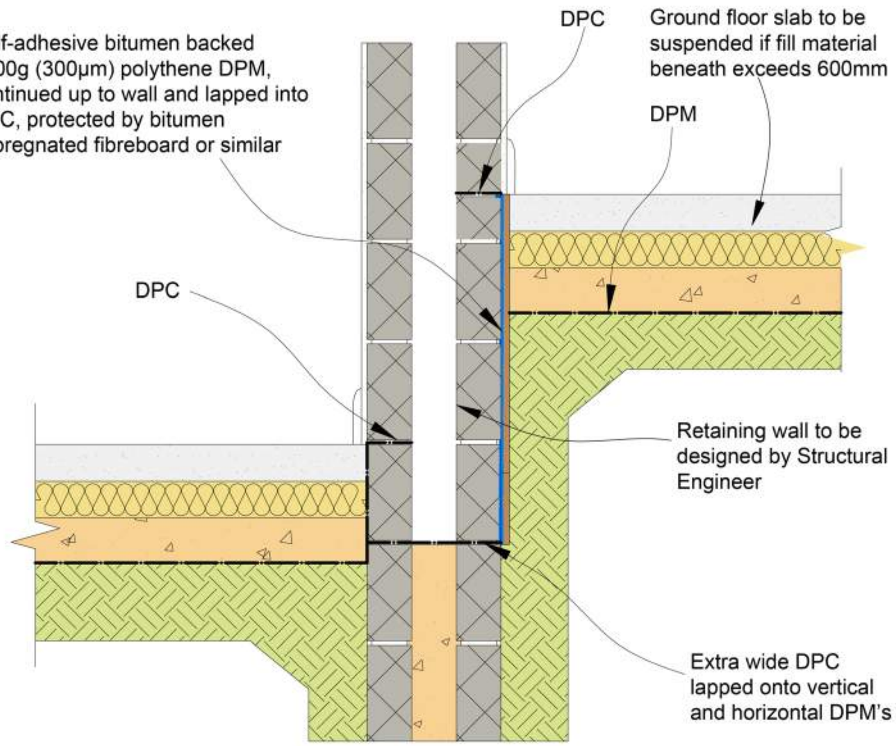

Figure 8: Stepped damp proof membrane

FUNCTIONAL REQUIREMENTS

6.4 SUBSTRUCTURE - GROUND FLOORS

Workmanship

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

Materials

i. All materials should be stored correctly in a manner which 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. 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 and other statutory requirements, British Standards and Euro-Codes
iv. Pre-cast structural elements must have structural calculations which prove their adequacy that have been 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 which are available as a result of any site demolition should not be used as hard core beneath floor slabs unless specifically agreed by the Site Audit 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)

Damp proof membranes 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.

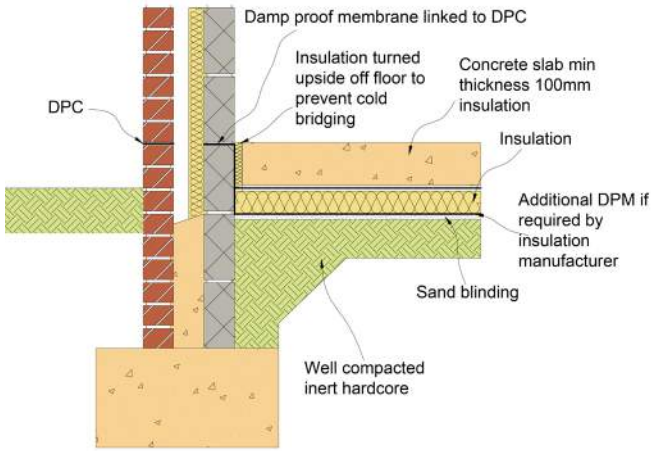

Figure 9: Typical ground bearing floor slab

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 manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional damp proof membrane 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 which 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 which 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 pouring and curing stages. Any backfill material should not contain any organic matter, contain contaminants which could react with the concrete or be susceptible to swelling such as colliery waste.

6.4.2.3 Damp proof membranes (DPM)

Damp proof membranes 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 be lapped into the DPC by at least 100mm as shown in Figure 9.

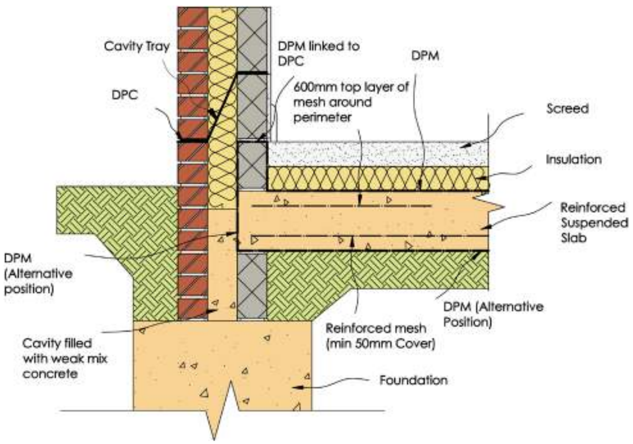

Figure 10: Typical cast in-situ concrete suspended floor

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 manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional damp proof membrane 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 the external wall and floor slab. 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.

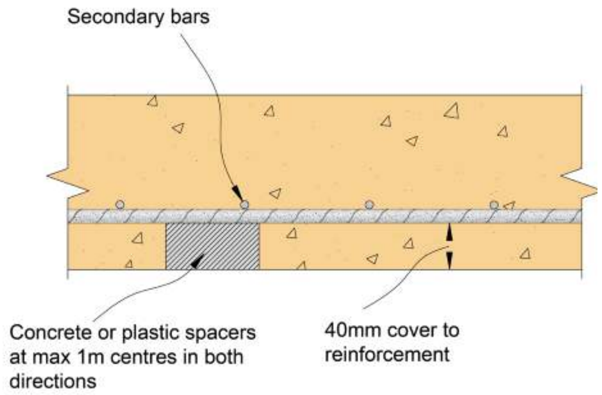

Figure 11: Cast in-situ suspended concrete floor - reinforcing cover and support

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 which 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.

Lapping of reinforcing

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

BS Reference	Primary bar			Secondary bar		
	Size (mm)	Spacing of bars (mm)	Area mm^2/m	Size (mm)	Spacing of bars (mm)	Area mm^2/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

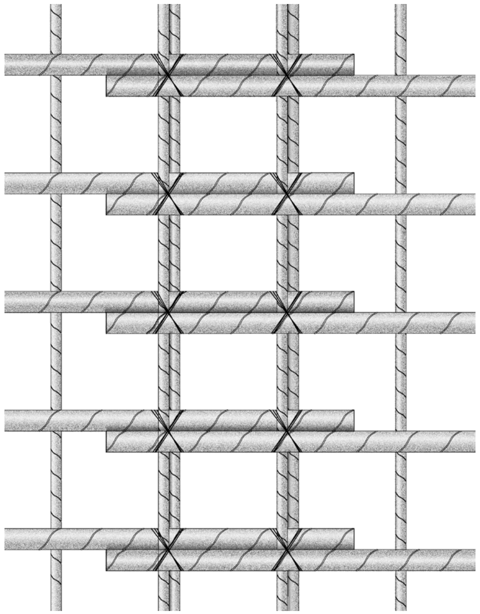

Figure 12: Typical reinforcing lap

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

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 damp proof course level;
- A minimum void of 150mm is provided between the joists and over-site;
- Air bricks are provided to give adequate cross ventilation to the floor void;
- Joists have adequate bearings and do not protrude into the cavity.

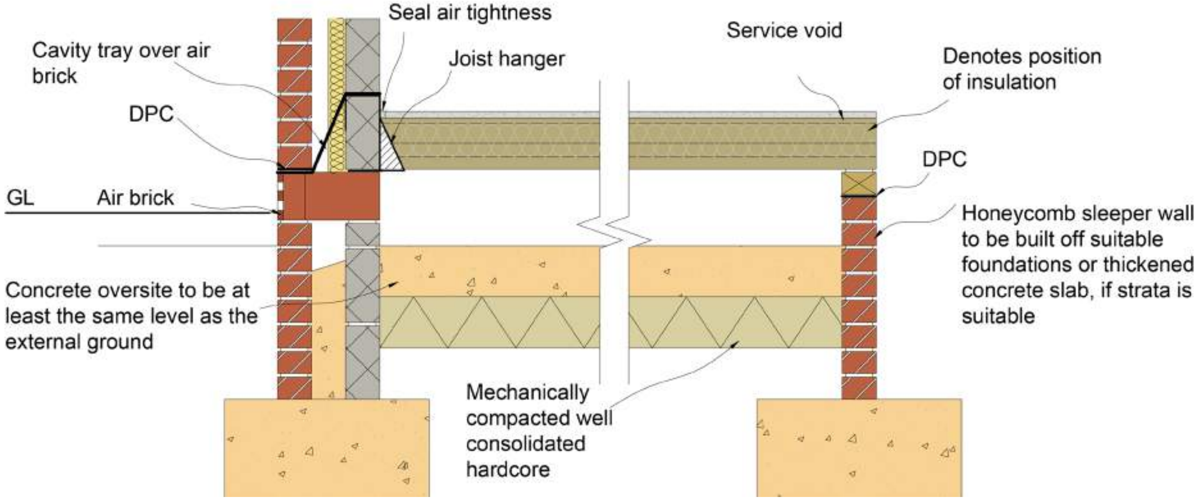

Figure 13: Typical suspended timber floor

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, stress grade, and 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 or if the ground is of suitable bearing strata, or can be built off a reinforced thickened slab where designed by a Chartered Structural Engineer.

6.4.3.3 Concrete over-site

A suitable over-site should be provided at least 150mm below the timber suspended floor.

The over-site should be either:

- 100mm thick concrete over-site (GEN3) on well compacted hard core or;
- 50mm thick concrete over-site on a 1200g damp proof membrane laid on 25mm sand blinding and well compacted hard core.

For sites that are susceptible to gas migrations, the over-site should incorporate gas protection measures that have been 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 which meet the following provision as 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 WxH (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 to be 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 3 times the depth of the board. Boards to have a minimum thickness, as indicated in Table 7.

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 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. OSB boards should be type 3 or 4 to BS EN 300. OSB boards should be laid with its 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 3 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 that suspended timber ground floors will be more difficult to demonstrate satisfactory levels of air tightness and sound insulation. 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, which meet the Functional Requirement 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 will be required to the screed to distribute loads effectively. This reinforcing should be of at least an 'A' mesh quality and the screed should have enough thickness to give an appropriate depth of cover.

6.4.4.3 Resistance to ground moisture

The pre-cast beam and block substructure floor shall be designed to prevent water ingress. There are commonly two 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 and 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.

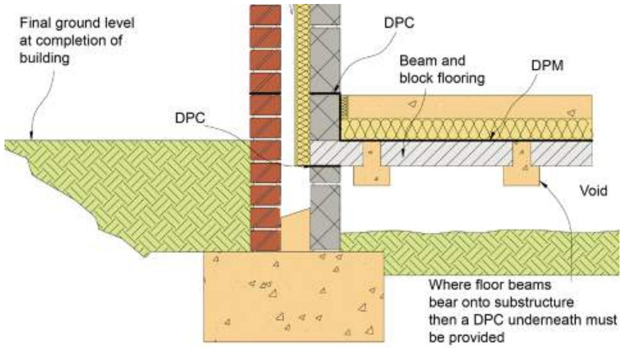

Figure 14: Typical pre-cast beam and block floor with DPM

Method 2 - No Damp Proof Membrane (DPM)

Where no DPM is incorporated into the pre-cast beam and block floor, the following provisions will apply:

The beam and block floor must be laid above the damp proof course. 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.

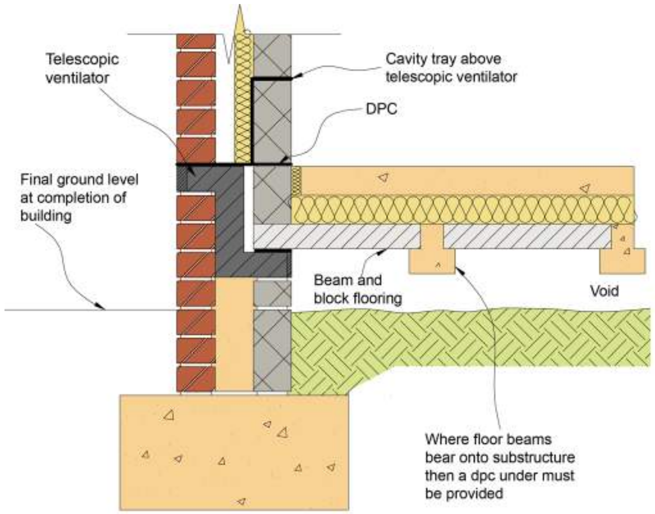

Figure 15: Typical pre-cast beam and block floor without DPM

6.4.4.4 Insulation

Insulation that is to be provided to ground floor should be placed above the beam and block. Insulation should be installed in accordance with 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.