CP 102:1973

Incorporating Amendment Nos. 1, 2 and 3

Code of Practice for

Protection of buildings against water from the ground

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Contents

Foreword

As part of BSI's programme of metrication, this Code is expressed in metric terms. The metric values are given in SI units; for further information on SI units, reference should be made to BS 3763, "The International System of units (SI)".

The values in this Code represent the equivalent of the values in imperial units in the 1963 edition rounded to convenient numbers. Although the values are not exact equivalents of the imperial units, this is not a technical revision but it is proposed to withdraw the existing Code when this edition is published.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with it does not confer immunity from relevant statutory and legal requirements.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Section 1. General

1 Scope

This Code deals with the methods of preventing the entry of ground water and surface water into a building from the surrounding areas. It makes recommendations for the drainage of adjoining areas, for special waterproof or water-resisting types of construction below ground level and for the damp-proofing of walls and floors at or near ground level.

It has been assumed that the design of all constructional work within the scope of this Code will be carried out by an architect and/or engineer experienced in the type of construction concerned and referred to throughout this Code as the designer.

Section **2** of this Code describes methods of preventing the entry of ground water into a building at or below ground level where ground or surface water may not be able to escape immediately.

Section **3** of this Code describes methods of providing damp-proofing of walls and floors at or near ground level.

In Section **2** two types of structure are considered:

1) Type A in which protection is provided by a continuous impervious membrane which excludes visible penetration of water and provides a vapour seal.

2) Type B in which visible penetration of water is prevented, but transmission in the form of vapour may not be wholly excluded. For the purposes of this Code, this degree of protection is assumed to be provided by high quality reinforced or prestressed concrete.

No recommendations are included in this Code for the use of embedded heating in basements, floors and wall or for the special requirements in connection with the design and construction of cold-stores.

NOTE The titles of the British Standards referred to in this Code are listed on page 26.

2 Exchange of information and time schedule

The working drawings and specifications should be prepared in sufficient detail to afford proper guidance to all concerned in estimating and in the execution of the work. There should be exchange of information between those responsible for the site preparation, the constructional work, pumping or dewatering, the tanking and waterproofing work and other subsequent work, and these should take place in the early stages to ensure that the various operations can be carried out at the proper time and that all necessary provisions for satisfactory execution have been made in advance.

A time schedule should be prepared before the work is commenced so as to provide for the greatest rate of progress consistent with the most economical use of plant and scaffolding by the various specialists and trades and with a minimum of pumping. In particular, the schedule should provide a sequence agreed by the various specialists and trades which ensures the least interference with the work of others.

Section 2. Waterproofing of structures below ground

3 Materials

3.1 Constructional materials

3.1.1 *Cement.* The cement used should be Portland cement or Portland-blastfurnace cement. Portland cement should comply with the requirements of BS 12-2.

Portland-blastfurnace cement should comply with the requirements of BS 146.

Other cements, such as low heat Portland cement, sulphate resisting Portland cement, high alumina cement and supersulphated cement may be desirable in certain circumstances, but they should only be used with the designer's approval.

High alumina cement should not be mixed with either of the other kinds of cement. It may be unsuitable for use with certain aggregates which may liberate appreciable amounts of soluble alkalies or lime, and the user can only be guided by previous experience in determining whether it is suitable for use with such aggregates. Concretes made with high alumina cement are sometimes unsatisfactory in warm, moist conditions. This cement should be used only in accordance with the manufacturer's recommendations.

Supersulphated cement should be used only in accordance with the manufacturer's recommendations and especially in regard to storage, curing and concreting in cold weather. Supersulphated cement should not be mixed with the other kinds of cement.

3.1.2 *Aggregates for concrete.* Aggregates for concrete should be selected from 1) or 2).

1) Coarse and fine aggregate complying with the requirements of BS 882. The combined aggregates should have an absorption of not greater than 5 %, measured in accordance with BS 812, Section **4**.

2) Other types of aggregates which are suitable, having regard to their strength, durability, absorption and freedom from harmful properties.

Fine aggregates, with gradings complying with Zones 1, 2 and 3 only of BS 882 should be used for nominal mixes but fine aggregates within Zone 4 may be suitable for special mixes.

The combined grading of the aggregates should be such as to produce a concrete of the specified proportions which will work readily into position without segregation and without the use of an excessive water content. The grading should be controlled throughout the work so that it conforms to that used for the preliminary tests.

3.1.3 *Fine aggregate for mortar.* Fine aggregate for mortar should be clean and well graded. It should comply with the requirements for natural sands in BS 1200.

3.1.4 *Water.* Water for concrete should be clean and free from harmful matter. Attention is drawn to the requirements of BS 3148.

3.1.5 *Reinforcement.* In reinforced concrete the reinforcement should be one of the following:

1) Steel bars and hard drawn steel wire complying with the requirements of BS 4449 and BS 4482.

2) Cold twisted steel bars complying with the requirements of BS 4461.

3) Steel fabric complying with the requirements of BS 4483.

4) Such other reinforcement as may be suitable having regard to the yield strength, ductility, tensile strength and other essential properties.

3.1.6 *Prestressing steel.* In prestressed concrete the prestressing steel should be one of the following:

1) Plain hard-drawn steel wire complying with the requirements of BS 2691.

2) Indented or crimped hard-drawn steel wire complying with the requirements of BS 2691 in all respects except that for the bend test.

3) Cold worked high tensile alloy steel bars complying with the requirements of BS 4486.

4) Such other wires, strand or bars having properties not inferior to those laid down in BS 2691 or BS 4486 respectively.

3.2 Waterproofing materials

3.2.1 *Mastic asphalt.* Mastic asphalt for tanking should conform to the requirements of either BS 1097 or BS 1418.

3.2.2 *Bitumen sheeting.* Bitumen sheeting for tanking should conform to the requirements of Class A of BS 743. For three layer work the minimum weight should be 3.8 kg/m^2. For two layer work the minimum weight should be 5.4 kg/m^2.

3.2.3 *Bitumen compound.* Bitumen compound for bonding and sealing bitumen sheeting should be oxidized bitumen of penetration at 25 °C 20/30 softening point (R and B) 80/100 °C.

NOTE The properties of the bitumen materials referred to in **3.2.3** are based on the methods of test given in BS 4692.

4 Preliminary investigations and design criteria for basements

4.1 General. Before commencing work on any structure below ground level a thorough site investigation and exploration of soil and water levels should be made. The testing of soil and ground water samples for sulphate or other aggressive chemicals should also be included. The procedure described in CP 2001 is recommended in all cases, care being taken to ensure that the whole of the area is surveyed by a considered selection of positions for borings or test holes.

Where high concentrations of sulphate are found in the soil or ground water consideration should be given to the provision of an impervious membrane or to the use of special cements to provide a concrete of adequate resistance to sulphate attack.

Almost all basement structures are likely to be subjected to water pressure at some period of their life. Even when the site examination indicates dry conditions, it should be borne in mind that there is a possibility of waterlogged conditions at some time in the future. In a permeable subsoil ground water requires time to drain away and the action of constructing a basement in a hole in the ground may of itself induce a water head. It is, therefore, recommended that all basement structures should be designed on the basis that water pressure will need to be resisted at some stage in their life (see **4.3**).

Basements of reinforced or prestressed concrete, if properly designed and constructed, will resist the penetration of water under a pressure many times in excess of that normally encountered in this type of structure. Water has the capacity, however, of penetrating even minor defects and a high standard of workmanship is required if the structure is to be completely watertight. Minor defects, however, can often be repaired by grouting or rendering and some recommendations are given in this Code (see Clause **9**).

Many basements give the physical impression of dampness unless mechanically ventilated. Additional protection against the ingress of moisture and dampness may be provided by the inclusion of an impervious membrane in the construction, but membranes are only fully effective where the supporting structure is sound and free from cracks.

4.2 Preventative measures. Water or moisture penetration of the basement may be reduced by one or more of the following measures depending on the conditions of the site.

4.2.1 *Reduction of surface water entering into adjacent ground.* Where possible the ground should slope away from the building for a distance of about 3 m to divert the surface run-off and to prevent water from standing near or against the walls. The surface near the walls should preferably be paved. On sloping sites it is usually desirable to construct a cut-off land drain on the high side to lead water around the building to a lower level. Rainwater from the roof of the building and from impervious external wall surfaces, if any, or paved areas, should generally be collected in a separate drain and diverted away from the building. It should not be allowed to enter the ground near the walls nor be connected to the open-jointed sub-surface drain around the foundations. The methods of collection and disposal of surface water and subsoil water described in CP 301 should be followed.

4.2.2 *Provision of sub-surface drainage around basement walls and under floor, and drainage by gravity or by pumping.* If excavation involves cutting through existing land drains they should be carefully diverted into the ground drainage system, or reconstructed so as to be laid in straight lines which are capable of being rodded.

Water may be prevented from remaining in contact with basement walls or floors for long periods by installing a system of drainage round the wall footings or beneath the floor or both together. The provision of drains around the perimeter of the basement is recommended for any site where the ground water table is likely to rise above the top of the footings. These drains should be placed beside the wall footing and should be graded to an open outlet or storm water sewer or to a sump within the building and pumps provided. Drains should be porous or laid with open joints, and should be covered by a graded filter starting with coarse stone around the pipe and changing gradually to material a little coarser than the surrounding soil. Detailed design for a graded filter is discussed in Clause **1.84** of Civil Engineering Code of Practice No. 2.

In porous soils such as sands and gravels, footing drains may have the effect of lowering the ground water table in the vicinity of the basement. In clay soils the movement of water is generally very slow and the drains may not act in this way but will provide a means of removing water which penetrate through fissures in the clay after a period of dry weather.

If adequate surface and footing drains are provided it may not be necessary to provide special drainage under basement floors but a blinding layer of concrete 75 mm thick or a layer of granular material about 125 mm or 150 mm should always be placed as a base for the concrete floor.

4.2.3 *Provision of special waterproof or water-resisting construction in the floors and walls for which this Code gives guidance.* In providing recommendations for the design and construction of buildings below ground level in order to prevent or minimize the entrance of ground water to the inner surface of the building, two types of construction are considered:

1) Type A structures in which protection is provided by a continuous impervious membrane which excludes visible penetration of water and provides a vapour seal.

2) Type B structures in which high quality concrete alone is relied on to provide protection against visible penetration of water, but transmission in the form of vapour may not be wholly excluded.

4.3 Basis of design. The stability of the structure as a whole and the stresses in the materials of construction should be determined in accordance with any relevant byelaws or regulations and the appropriate Code of Practice.

The imposed loadings on the building should be in accordance with CP 3:Chapter V-1 and CP 3:Chapter V-2.

The pressure exerted by the surrounding earth and by subsoil water is generally somewhat indeterminate, but monolithic structures are capable of successfully resisting a variation in service conditions and are generally recommended. It is generally necessary to design for a positive water head and in a normal single storey basement a minimum allowance of not less than one-third of the depth below ground will be necessary.

The maximum head of water cannot in practice exceed the full depth of the structure below ground level, and although it may be difficult to be precise on intermediate conditions, some reduction in the normal load factor used in the design can be accommodated. It is suggested that the design head of water for the purpose of calculating the stresses in the structural walls need not normally exceed three-quarters of the full depth below ground when the design is based on normal stresses.

It is essential that an allowance for the additional pressure of the submerged earth is added to the simple water pressure but it will seldom be necessary to make an additional allowance for superimposed loading on the surface unless heavy loading is likely to occur against the boundary of the building.

Consideration should also be given to ensure that the basement will not float, by checking the overall dead load of the structure against the upward water pressure at various stages of construction, and in these cases the possibility of a full water head may have to be considered. Temporary arrangements to balance the water pressure may need to be provided to cater for intermediate conditions during construction (see also Clause **8**).

5 Type A structures: structures requiring the protection of an impervious membrane

5.1 Structural requirements. Type A structures may be constructed of reinforced concrete or prestressed concrete. In special circumstances plain concrete, brickwork or dense concrete blockwork may be used. Structural steel may also form part of the main structure in conjunction with other materials. The structure should be designed so as to avoid movements which could damage the impervious membrane.

Although mastic asphalt will accept some movement it may be split by differential movement or cracking of the supporting structure. Extra care is therefore necessary when designing in mixed materials, e.g. concrete and brickwork and in any unreinforced structures. Least risk of damage to the membrane is involved in a reinforced or prestressed concrete structure.

5.1.1 *Reinforced concrete.* Structures in reinforced concrete should be designed and constructed in accordance with the recommendations of CP 114-2 or CP 2007-2, except when these are at variance with the specific recommendations of this Code and the special clauses on reinforced concrete in Civil Engineering Code of Practice No. 2. Special attention should be given to the provision of sufficient reinforcement to control cracking.

5.1.2 *Prestressed concrete.* Structures in prestressed concrete should be designed and constructed in accordance with the requirements of CP 115-2, or CP 2007-2 except where these are at variance with the specific recommendations of this Code.

5.1.3 *Plain concrete, brickwork or blockwork.* Plain concrete walls should be designed and constructed in accordance with the recommendations for mass concrete in Civil Engineering Code of Practice No. 2 or CP 123.101. Brickwork or blockwork should comply with the special recommendations of Civil Engineering Code of Practice No. 2 and for brickwork and blockwork below damp-proof course with the recommendations of CP 121.101.

Construction joints should be kept to a minimum. Their probable positions should be foreseen when the design is being prepared and details of the joints shown on the drawings. They should be designed to provide thorough keying of the faces of the concrete and may include the provision of water bars if necessary to prevent the ingress of water. Movement joints in a basement which is to be tanked cannot be tolerated. Special consideration should be given to the resistance to shear at the junction of the wall and the base in order to cater for the pressure due to earth and water at all stages. It is further recommended that any basements with a length exceeding 7.5 m, whether tanked or otherwise, should be constructed in reinforced or prestressed concrete.

5.1.4 *Mastic asphalt.* When the mastic asphalt is fully confined it may be regarded as having the same compressive strength as the containing material. When mastic asphalt is not fully confined to prevent extrusion the maximum design load should not exceed 650 kN/m^2 at normal temperature.

5.1.5 *Bitumen sheeting.* When bitumen sheeting is fully confined it may be regarded as having the same compressive strength as the containing material.

Bitumen sheeting is of a plastic nature and deformation will take place under load if it is not fully confined but this does not impair the waterproofing properties of the sheeting. When unconfined the maximum design load on bitumen sheeting should not exceed 54 kN/m^2.

5.1.6 *Other sheeting material.* Other forms of impervious sheeting are available which can provide a vapour seal, such as polyisobutylene. Before specifying these materials the designer should satisfy himself that advantage is to be gained from their use. No recommendations are given in this Code as to methods of application.

5.2 Requirements for the impervious membrane. The function of an impervious membrane is to provide a continuous waterproof lining to the walls, floors and foundations of structures below ground and to prevent rising moisture through ground floors constructed in direct contact with the ground.

Horizontal membranes may be applied to structurally sound concrete bases. Vertical mastic asphalt membranes may be applied to structurally sound walls of concrete, brickwork or dense concrete blockwork. Vertical membranes of bitumen sheeting may be applied to structurally sound concrete walls of flush faced brickwork or blockwork. Examples of their use are shown in Figure 1 to Figure 11.

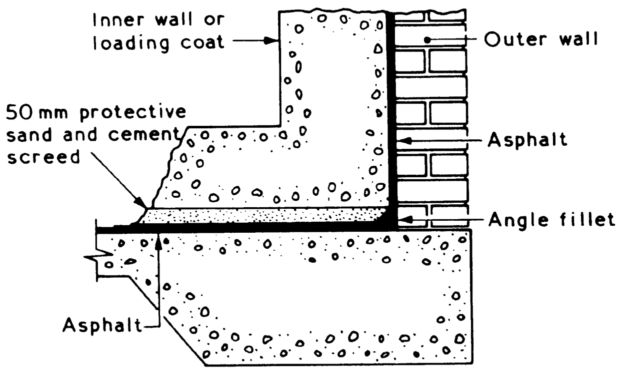


Figure 1 — Internally applied asphalt tanking

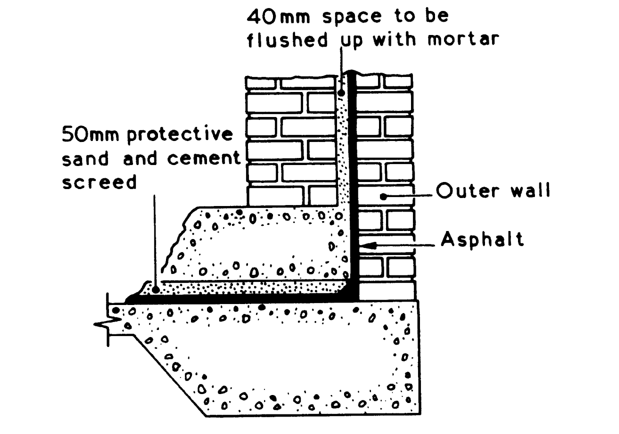


Figure 2 — Internally applied asphalt tanking. Vertical loading with brickwork

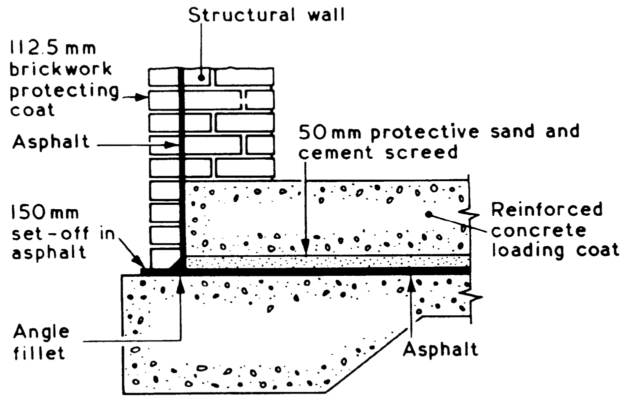


Figure 3 — Externally applied asphalt tanking to brickwork

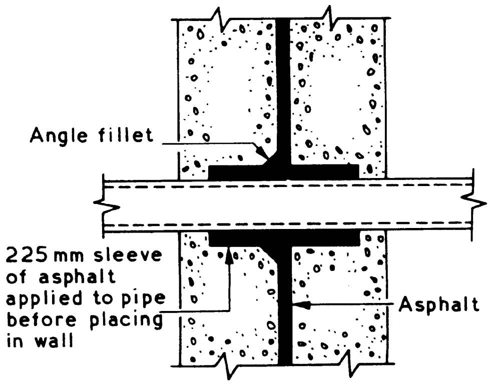


Figure 4 — Asphalt tanking. Treatment of pipes

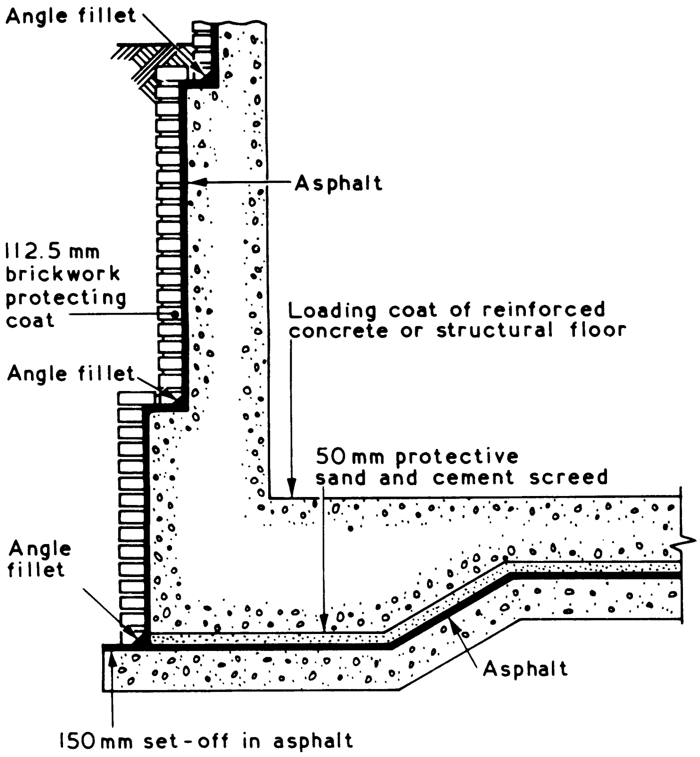


Figure 5 — Externally applied asphalt tanking to concrete

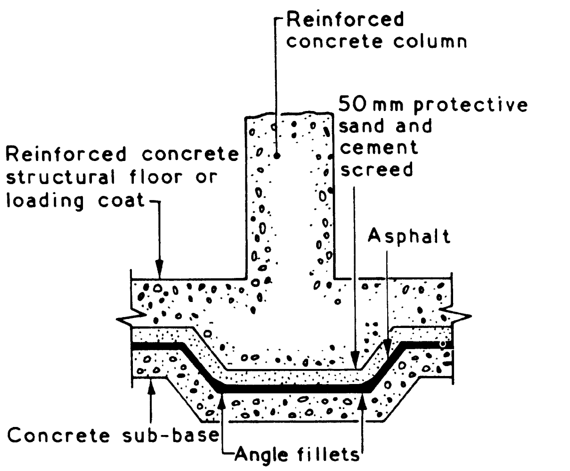


Figure 6 — Asphalt tanking to column bases

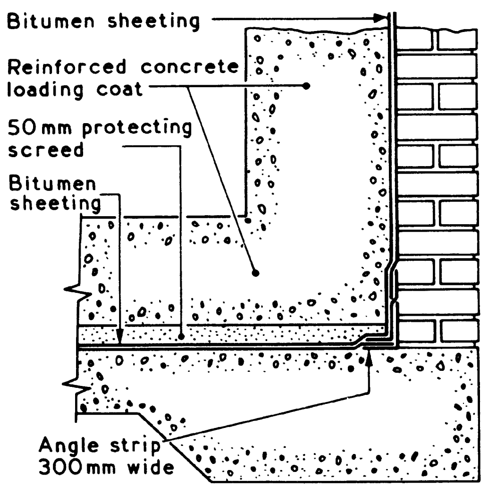


Figure 7 — Internally applied bitumen sheet tanking. Method of forming internal angle

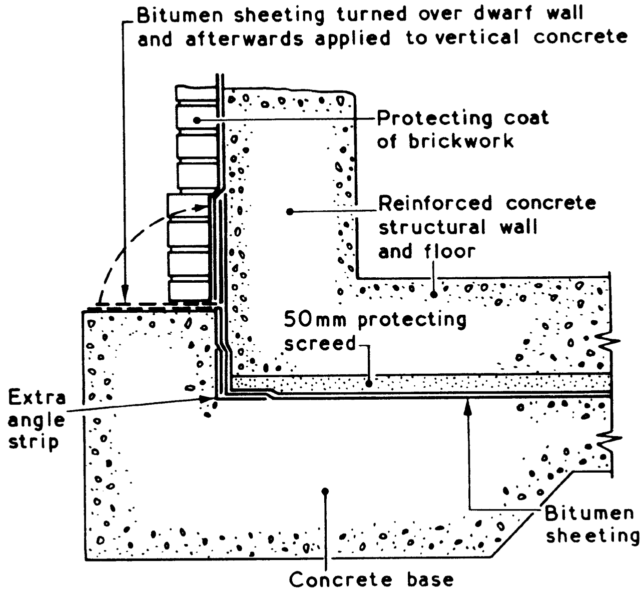


Figure 8 — Externally applied bitumen sheet tanking. Method of forming external angle

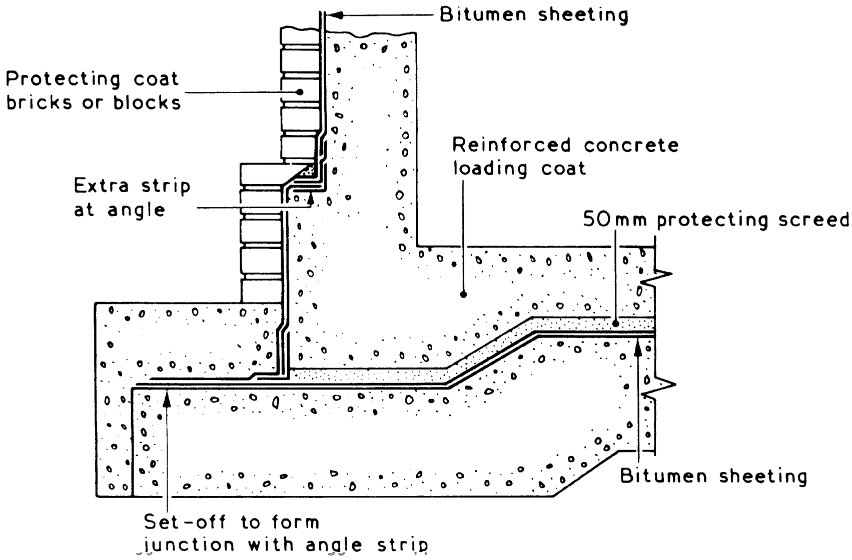


Figure 9 — Externally applied bitumen sheet tanking. Alternative method of forming external angle

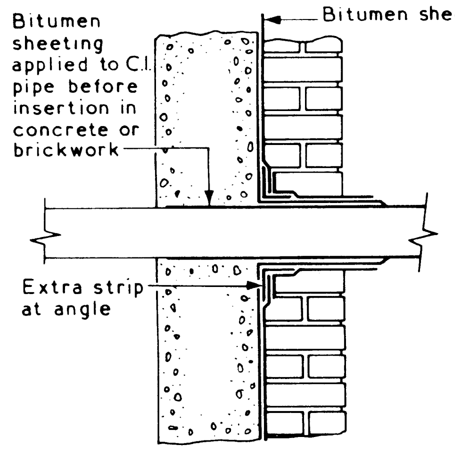


Figure 10 — Bitumen sheet tanking. Treatment of pipes

Two methods of application of the membrane are envisaged which are designated, respectively, externally applied tanking and internally applied tanking. Externally applied tanking is defined as an external application of an impervious membrane to the structural walls. Internally applied tanking is defined as an application of an impervious membrane to the inner surface of walls and the upper surface of floors before the placing of structural walls or floors or protecting or loading coats.

5.2.1 *Externally applied tanking.* When tanking is to be applied externally the concrete base should extend at least 150 mm beyond the outside of the perimeter walls to enable an effective joint to be made between the horizontal and vertical membrane. As soon as the horizontal membrane has been applied a protecting screed of sand and cement 50 mm in thickness should be laid over it and a loading coat sufficient to withstand the maximum likely water pressure applied as soon as possible thereafter. The 150 mm mastic asphalt set-off providing the horizontal base for junction with vertical mastic asphalt, and to which no loading coat is applied, is vulnerable to damage and dirt on many sites. It is recommended, therefore, that it should be protected by application of 50 mm screed of sand and cement, applied over building paper so that the protective screed may be removed at the appropriate time, leaving the mastic asphalt set-off clean and free from defects.

When the vertical structural walls have been built the impervious membrane should be applied to the external faces and a mastic asphalt angle fillet or an angle strip of bitumen sheeting should be formed to join the horizontal and vertical membranes. When this has been completed a protecting wall brickwork or blockwork should be built against the membrane to protect it against puncturing from backfilling or subsequent excavation.

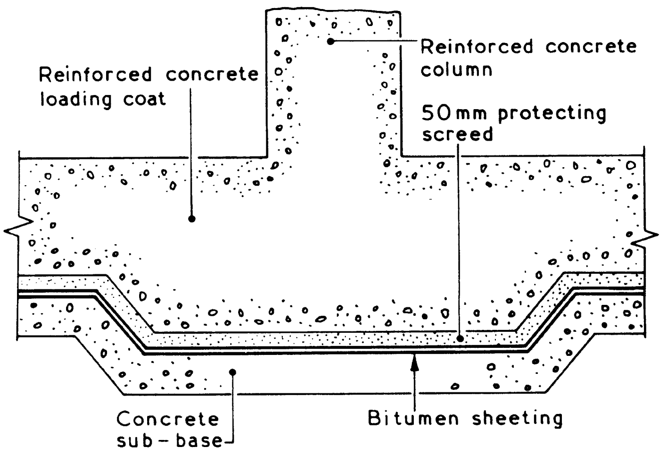


Figure 11 — Bitumen sheet tanking to column bases

5.2.2 *Internally applied tanking.* When tanking is to be applied internally the concrete base should be laid and structurally sound walls of brickwork, blockwork or concrete built up to at least 150 mm above ground level. The membrane should then be applied internally to the base and to the faces of walls. Angle fillets for mastic asphalt tanking or angle strips for bitumen sheet tanking should be applied to the junction of the horizontal and vertical impervious membrane at all internal angles.

Loading coat to a vertical membrane should preferably be of concrete. Where, however, brickwork is used it should be set 40 mm away from the membrane to enable the space so formed to be thoroughly flushed up with sand and cement mortar, course by course, to prevent any voids occurring between the brickwork and the vertical membrane.

5.3 Pumping. It is essential that the site should be kept dry until the basement is completed. For this purpose, dewatering or pumping from carefully arranged sumps with appropriate drainage channels should be continuous whilst the laying of the impervious membrane is in progress and until all loading coats have hardened and the structure has developed sufficient strength to resist the full water pressure. Before discontinuing pumping all necessary steps should be taken to ensure that the structure will not float.

5.4 Basement carried on piles where tanking is used. Where a membrane is required for a basement which is to be supported on piled foundations, it is essential that complete separation is provided between the pile caps and the basement floor. It is essential that the membrane is laid continuously over the whole area of the basement and that loads from the superstructure are transmitted to the pile caps through the basement walls acting as deep beams or to isolated foundations. For column foundations it may be necessary to provide a recess in the base slab as shown in Figure 12.

The pile caps should be interconnected with stabilizing beams and a reinforced concrete slab not less than 100 mm in thickness should be provided over the whole area between the beams and monolithically with them in order to receive the membrane.

6 Mastic asphalt tanking

6.1 General. In order to ensure that the substructure provides a satisfactory base on which to lay mastic asphalt, attention should be given to **6.1.1** and **6.1.2**.

6.1.1 The surface of the structure should permit the laying of mastic asphalt in complete continuity up to damp course level.

6.1.2 In order to ensure continuity of the tanking the provision of openings for service or other pipes, cables etc., through walls or floors which are to be tanked should be avoided whenever possible. Where, however, it is essential to provide such openings, special treatment around the opening will be necessary, such as that shown in Figure 4 and the method to be adopted should be decided in consultation with the mastic asphalt contractor.

6.2 Externally applied tanking. For externally applied tanking special consideration should be given to **6.2.1** to **6.2.4**.

6.2.1 Not less than 600 mm of working space outside the walls should be allowed for in excavation.

6.2.2 A structurally sound base should be provided at least 100 mm in thickness with an even surface to receive mastic asphalt. The base should extend at least 150 mm beyond the outside edge of the wall to permit an angle fillet to be formed between the horizontal and vertical mastic asphalt (see Figure 3 and Figure 5).

6.2.3 As soon as the laying of the horizontal mastic asphalt has been completed, it should be covered to prevent damage by a screed of sand and cement 50 mm in thickness. The horizontal loading coat of concrete or structural slab should be placed as quickly as possible thereafter.

6.2.4 As soon as possible after the vertical mastic asphalt has been applied to the outside of a wall it should be protected against damage by the erection of a wall of brickwork or blockwork. When the wall is of brickwork on edge the frogs should not be in contact with the mastic asphalt.

6.3 Internally applied tanking. For internally applied tanking special consideration should be given to **6.3.1** to **6.3.5**.

6.3.1 The excavation should provide, whenever possible, approximately 300 mm of space outside the wall so as to keep the wall as dry as possible during the application of the mastic asphalt.

6.3.2 The structural slab forming the base should be provided with an even surface to receive the horizontal mastic asphalt. Walls should be built up to the full height of the tanking before the mastic asphalt coat is commenced.

6.3.3 The earth should be kept clear of outside walls and should not be filled in until the three coats of vertical mastic asphalt have been applied and the loading coats have hardened.

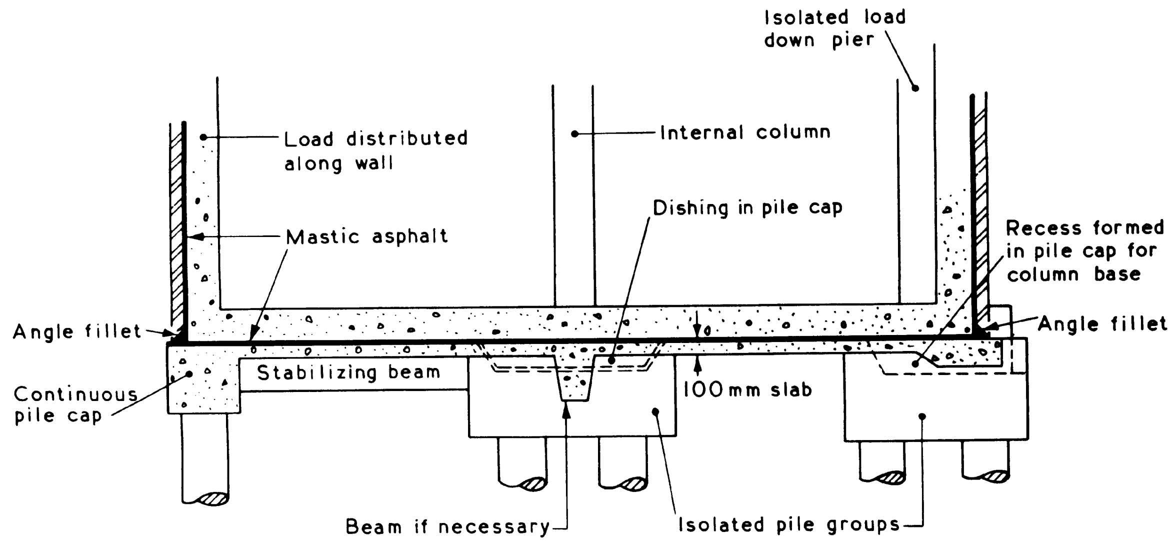


Figure 12 — Tanked concrete basement carried on piles

6.3.4 As soon as the horizontal mastic asphalt has been laid and the angle fillets completed, a protecting screed of sand and cement 50 mm in thickness should be applied to prevent damage to the mastic asphalt.

6.3.5 The protective screed should be followed by the laying of the structural floor and walls, these being designed to withstand the maximum pressure of water which is likely to be encountered when the building is completed.

When brickwork or blockwork is used for the loading coat it should be set 40 mm away from the mastic asphalt and the space so formed should be thoroughly flushed-up course by course with sand and cement mortar in order to ensure that the loading coat and the mastic asphalt are in close contact.

6.4 Pumping. It is essential that the site be kept dry until the basement is completed. For this purpose, dewatering or pumping from carefully arranged sumps with appropriate drainage channels should be continued whilst the laying of the impervious membrane is in progress and until all loading coats have hardened and the structure has developed sufficient strength to resist the full water pressure. Before discontinuing pumping all necessary steps should be taken to ensure that the structure will not float.

6.5 Workmanship

6.5.1 ***Key for tanking of vertical and sloping surfaces***

6.5.1.1 *Brickwork or blockwork.* Brickwork or dense concrete blockwork laid in cement mortar normally provides a satisfactory key, if the joints are set back. Where mastic asphalt is to be applied to existing brickwork or blockwork the joints should be raked out unless the bricks or blocks themselves form an adequate key.

6.5.1.2 *Concrete.* The surface of concrete obtained from timber shuttering is usually sufficiently rough to provide an adequate key for mastic asphalt. Smooth surfaces do not give good adhesion, and if these cannot be avoided, the mastic asphalt contractor should be consulted on the method of treatment. This may, according to circumstances, take the form of applying a cement wash incorporating a bonding agent, or the application of a bitumen compound. In extreme cases, it may be necessary to hack the surface.

6.5.1.3 *Other surfaces.* Glazed brickwork or other similar surfaces should be hacked to form a key. Surface finishes such as lime wash, distemper, paint etc., should be removed and the base so exposed should be hacked and wire brushed. Mastic asphalt should not be applied to soft or friable surfaces.

6.5.2 *External angles.* The external angles of concrete, brickwork or blockwork should be rounded-off to allow the full thickness of mastic asphalt to be applied continuously around the angle.

6.5.3 *Thickness and finish.* On horizontal surfaces and on sloping surfaces not exceeding 30° to the horizontal mastic asphalt should be laid in three coats to a total thickness of 30 mm.

On vertical surfaces and slopes over 30° to the horizontal mastic asphalt should be applied in three coats to a total thickness of not less than 20 mm taken to a height of at least 150 mm above ground level.

An angle fillet not less than 50 mm wide should be applied in two coats at the junction of two planes forming an internal angle.

Joints in successive coats of mastic asphalt should be staggered at least 150 mm for horizontal work and 75 mm for vertical work.

6.5.4 *Chases.* The top of vertical mastic asphalt should be turned into a chase not less than 25 mm × 25 mm unless the mastic asphalt is being continued horizontally.

6.5.5 *Remelting.* Remelting of mastic asphalt should be carried out on the site preferably in a mechanical mixer. For small areas cauldrons may be used. Blocks of mastic asphalt should be broken and stacked in the mixer or cauldron prior to remelting.

The mixer or cauldron containing the mastic asphalt should be heated gradually until the mastic asphalt attains a molten condition, but the temperature of the mastic asphalt should not exceed 215 °C. The mastic asphalt should be stirred continuously to ensure a uniform consistency.

Where asphalt is being transported to the spreading area by means of buckets, the inside of the bucket may be lightly dusted with inert mineral dust to prevent adhesion.

6.6 Laying techniques. The mastic asphalt should be laid in accordance with the following recommendations.

6.6.1 *Spreading mastic asphalt on horizontal surfaces and on slopes of up to 30°.* Mastic asphalt on horizontal surfaces and on slopes of up to 30° to the horizontal should be applied in three coats to the specified thickness. The mastic asphalt for each coat or bay should be spread with a float evenly and uniformly over the previously prepared surface to the recommended thickness. An isolating membrane may sometimes be necessary to prevent "blowing" of the horizontal mastic asphalt.

The second and third coats of mastic asphalt should be applied as soon as possible after the preceding coat so as to prevent the accumulation of dust or dirt between the layers which would impair their adhesion.

Timber gauges of the specified thickness of the mastic asphalt for each coat should be used.

"Blows" in each coat formed by moisture, entrapped air or foreign materials during the laying of the mastic asphalt should be pierced and the affected area carefully made good while the mastic asphalt is still warm or before applying the next coat.

6.6.2 *Spreading mastic asphalt on vertical surfaces and on steep slopes.* Mastic asphalt should be applied in three coats on vertical or on steeply sloping surfaces above 30° to the horizontal. The first coat, which should be applied thinly, acts as a base to ensure complete bonding of the subsequent coats. It is essentially an adhesive layer but will also reduce "blowing". The first coat should be plastered over each bay with a metal trowel as evenly and uniformly as possible using molten mastic asphalt to which bitumen has been added. For easy control of the work timber gauges of the specified thickness should be fixed to the surface to mark out the bays.

The second coat should be applied with a spatula or wooden float to a uniform and even thickness throughout the bays. "Blows" which may occur in each coat should be immediately pierced and made good. The third coat should provide a smooth surface finish, free from "blows" and imperfections.

6.6.3 ***Construction details***

6.6.3.1 *Joints.* Special care should be taken in forming an efficient junction with the edge of a bay already laid. Edges that have been contaminated should be cleaned by warming with hot mastic asphalt and then cut back with a metal trowel to remove any dust or dirt that may have collected. It is essential that mastic asphalt should not be cut with a hammer and chisel as this can cause radial fractures from the point of impact. Hot mastic asphalt should be laid over the edge of the existing bay and allowed to remain until the edge of the mastic asphalt has become warm; it is then removed so that the hot material for the new bay is married to a clean warm surface.

6.6.3.2 *Internal angles.* Solid fillets at internal angles should be formed in two coats, as a separate operation. Dust and sand should be removed from the surfaces of the mastic asphalt in the vicinity of the angle and a temporary coat of hot mastic asphalt applied in order to warm and clean the surfaces. This material should then be removed and the junction scraped and cleaned.

The first fillet coat of hot mastic asphalt should then be applied with a filleter and completely fused to the existing mastic asphalt, followed immediately by the second coat.

6.6.3.3 *Isolating membrane.* Where an isolating membrane is necessary on horizontal concrete due to moisture, or to counteract "blowing", building paper laid with a 75 mm lap or in extreme cases black sheathing felt to BS 747-2 may be used.

7 Bitumen sheet tanking

7.1 General. In order to ensure that the substructure provides a satisfactory base on which to apply bitumen sheeting, attention should be given to **7.1.1** and **7.1.2**.

7.1.1 Concrete should be free from ridges and indentations and be laid to a true and even surface, preferably with a wood float finish. Brickwork or blockwork should have flush joints.

7.1.2 In order to ensure continuity of the tanking the position of openings for service or other pipes, cables etc., through walls or floors which are to be tanked should be avoided wherever possible. Where, however, it is essential to provide such openings special treatment around the opening will be necessary, such as is shown in Figure 10 and the method to be adopted should be decided in consultation with the bitumen sheeting contractor. Salt glazed pipes should be avoided in all cases and pipes passing through the membrane should be sleeved with two layers of bitumen sheeting before being fixed in position.

7.2 Externally applied tanking. For externally applied tanking special consideration should be given to **7.2.1** to **7.2.4**.

7.2.1 For ease of application of the rolls of sheeting adequate working space outside the walls should be allowed for in excavation. This should be at least 600 mm, but increased space may sometimes be necessary.

7.2.2 A structurally sound base should be provided at least 100 mm in thickness with an even surface to receive the bitumen sheeting. The base should extend at least 225 mm beyond the outside edges of the wall to provide the junction to be formed with the vertical work. The method to be adopted in forming the junction should be decided in consultation with the bitumen sheeting contractor. Examples are shown in Figure 8 and Figure 9.

7.2.3 As soon as the laying of the horizontal bitumen sheeting has been completed it should be covered to prevent damage by a screed of sand and cement 50 mm in thickness except over the set-off. The horizontal loading coat of concrete or structural slab should be placed as quickly as possible thereafter. Temporary protection should be provided over the set-off.

7.2.4 As soon as possible after the vertical bitumen sheeting has been applied to the outside of walls it should be protected against damage by the erection of a wall of brickwork or blockwork.

7.3 Internally applied tanking. For internally applied tanking special consideration should be given to **7.3.1** to **7.3.4**.

7.3.1 The excavation should provide, wherever possible, approximately 300 mm of space outside the wall so as to keep the wall as dry as possible during the application of the sheeting.

7.3.2 The structural slab forming the base should be laid with an even surface to receive the horizontal sheeting. Walls should be built up to the full height of the tanking before the bitumen sheeting work is commenced.

7.3.3 As soon as the angle strips, the horizontal bitumen sheeting and the vertical sheeting to the first lift of the structure have been applied, a protecting screed of sand and cement 50 mm in thickness should be applied to the horizontal surface to prevent damage to the sheeting (see Figure 7).

7.3.4 The concrete structural walls and floors, designed to withstand the maximum pressure of water likely to be encountered when the building is completed, should then be constructed and further lifts of bitumen sheeting should then be provided to the full height of the walls.

7.4 Pumping. It is essential that the site be kept dry until the basement has been completed. For this purpose dewatering or pumping from carefully arranged sumps with appropriate drainage channels should be continued whilst the laying of the bitumen sheet tanking is in progress and until all loading coats have hardened, and the structure has developed sufficient strength to resist the full water pressure. Before discontinuing pumping all necessary steps should be taken to ensure that the structure will not float.

7.5 Workmanship

7.5.1 *Number of layers.* Bitumen sheeting should be applied to both horizontal and vertical surfaces by either the application of three layers of 3.8 kg/m^2 or two layers of 4.7 kg/m^2 sheeting, with additional strips at internal angles. The sheeting may be finally dressed with a coating of bitumen compound.

Vertical bitumen sheeting should be taken up at least 150 mm above ground level and be tucked into a chase provided in the concrete or brickwork, or turned over the wall as a damp-proof course.

7.5.2 *Bitumen compound.* In order to ensure an effective bond the bitumen compound should be heated to a temperature within the range of 180 °C to 200 °C.

7.6 Laying techniques. Unless otherwise agreed between the designer and the bitumen sheeting contractor, bitumen sheeting should be laid in accordance with the following recommendations.

7.6.1 *Horizontal and vertical bitumen sheeting.* The surface of the base should be clean and free from dust, sand and foreign material. A priming coat of bitumen solution or bitumen emulsion should be applied uniformly over the surface, where bonding is required.

When the priming coat has dried the first layer of bitumen sheeting should be bonded to the surface with hot bitumen by pouring and rolling, allowing 100 mm laps at the joints.

Subsequent layers should be bonded in a similar manner and should be applied as soon as possible after the previous layer has been laid, as dust or dirt between the layers may impair adhesion. Successive layers of bitumen sheeting should break joint. Laps between sheets should be 100 mm at the side and 150 mm at the end.

7.6.2 *Internal angles.* Internal angles should be covered by layers of sheeting on a strengthening strip 300 mm wide bonded into the angle; see Figure 7.

Before applying the strip, the surface of the base should be thoroughly cleaned of dust, sand and foreign material and then primed with bitumen solution or bitumen emulsion. When the priming coat has dried, the angle strip should be applied and bonded with hot bitumen. The layers of bitumen sheeting should then be applied successively with the edges of the sheeting bent into the angle to give extra thickness and strength. Any surplus bitumen should be removed with a trowel or scraper.

8 Type B structures — structures without membrane

8.1 General. Type B structures may be constructed of reinforced concrete or prestressed concrete. Structural steel may also form part of the main structure in conjunction with these materials. Special consideration should be given to the prevention of differential settlement, to the control of cracking and to the provision of dense impervious concrete. The concrete should have a minimum works cube strength of 27 N/mm^2 at 28 days.

In structures of reinforced or prestressed concrete special consideration should be given to the design of the concrete mix and to the supervision of the placing and compaction in order to provide a dense impermeable concrete. The mix should have a workability which will ensure that it can be satisfactorily placed in the formwork and compacted without risk of segregation, honeycombing or bleeding. Special care should be given to the method and order of placing the concrete and to the construction of joints in order to achieve full continuity and complete watertightness.

The fundamental requirement for a uniform and fully compacted mix of low water/cement ratio is not avoided by the use of additives to the mix or the use of cements in which the manufacturers have incorporated additives. The value of many of the more satisfactory of these materials lies largely in the improvement in the workability and cohesiveness of the mix which is obtainable. Materials of this type may be described as workability aids, plasticizers, water-reducing agents, water-repellent aids, air-entraining agents etc., and if a separate additive is used the amount added to each batch of concrete requires careful control. Before permitting the use of additives the designer should satisfy himself that advantage is to be gained from their use and that no detrimental effect is likely to occur.

Structures in reinforced and prestressed concrete should be designed in accordance with the requirements of CP 2007-2, except where these are at variance with the specific requirements of this Code. Structures in reinforced concrete membranes exceeding 250 mm in thickness, however, may be designed in accordance with the recommendations of CP 114-2. Where the thickness is 250 mm or less the permissible stresses should be in accordance with CP 2007-2.

8.2 Joints in concrete structures. Movement joints will not normally be provided in basements but construction joints may be required, and it is important that these should be so constructed as to achieve full continuity across the division and complete watertightness. A high standard of workmanship is essential. The sequence of casting operation and the size of concrete panels should be determined to avoid excessive shrinkage and undesirable cracking of the concrete.

Their design and preparation requires considerable care if percolation along the plane of the joint is to be avoided.

The surface of the first placed concrete should show a lightly roughened texture over the full section of the joint in which the tips of the aggregate are exposed, but not to be so uneven as to cause porosity at the joint when the next lift is placed. This may be effected by spraying with water, or air and water, assisted by light brushing where necessary. If the concrete has been allowed to harden it will be necessary to achieve the desired surface by hacking the whole of the surface, care being taken to avoid damaging the aggregate.

While the remainder of the concrete should be kept continuously wet, curing of the joint surface may be suspended for a few hours before concreting is to be resumed so as to permit no more than superficial drying of the joint surface. Just before concreting is resumed, the roughened joint surface should be thoroughly cleaned and freed from loose matter, preferably without re-wetting. A thin layer of cement grout or of cement and sand mortar in which the ratios of sand to cement and water to cement do not exceed those in the new concrete, should then be worked well into the surface.

Alternatively, for horizontal joints the layer of grout or mortar may be omitted, provided that the workability of the first batches of concrete placed in contact with the joint is slightly increased. Special care should be taken to avoid segregation of the concrete along the joint plane and to obtain thorough compaction. Tongues in horizontal joints should protrude upwards.

8.3 Junction of floor and wall. Where the wall is designed to be monolithic with the bottom slab, a continuous upstand section of the wall should be cast at the same time as, and integrally with the slab. A suitable arrangement of the reinforcement and formwork should be made to facilitate this. The height of this upstand, which should not be less than 150 mm, should be sufficient to enable the next lift of formwork to fit tightly and avoid leakage of the cement paste from the newly-deposited concrete. Such leakage, where it occurs, is liable to cause porosity in the finished concrete.

8.4 General design recommendations. Basements should generally be designed to act monolithically, with floors and walls continuous. Sharp changes in cross section of floors and walls should be avoided as shown in Figure 13. Reinforcement will normally be provided in two directions in each face.

It is important to avoid differential settlement as far as possible since this may cause cracking of the walls or floors. The arrangement of a uniform level for the underside of the structure is advantageous and simplifies construction. Sinking below the general level to provide column foundations should be avoided as far as possible. Where these are essential, it is an advantage to combine adjacent columns in one direction to form longitudinal strips. When column foundations form part of the basement floor slab, there is usually a high concentration of pressure immediately below the area calculated to spread the column load. The compression of the ground under the column foundation will tend to induce an upward pressure on the thinner section of the basement slab surrounding the column foundation. This redistribution and shade-off of pressure should be allowed for in the design of the basement slab.

In these circumstances the slab should be designed to allow for the assumed water head and should then be checked for the effect of the shade-off of ground pressure as an alternative condition.

A method of design is indicated in Figure 13. The slab between the column bases should be designed to resist the shade-off pressure in bending and shear at section (a) and in bending at section (b), assuming a uniform distribution equivalent in total to that provided by the triangular distribution of pressure. The walls and slab should be designed to resist the actual or nominal water head, whichever is the greater. For the design of slabs the water pressure and shade-off pressure are alternatives and are not added.

In basement walls, column loads may be assumed to spread from the ground floor to induce uniform pressure at the basement slab level and column reinforcement may be curtailed into the walls accordingly.

In general, because of design considerations, basement walls will be 250 mm in thickness, or more. Basements are frequently well buttressed by cross walls and the actual flexural conditions of behaviour are generally indeterminate. The design of the sub-ground structure may be based on a simple statistical analysis of slabs and beams within the depth of the slab.

8.5 Arrangement of reinforcement. Reinforcement in walls and floor slabs should be continuous and be provided on both faces of the concrete section. Laps should be staggered wherever possible and the arrangement and spacing of the bars should be such that the concrete can be satisfactory placed and consolidated by vibration. Hooks which may encourage the formation of voids should generally be omitted and the length of lap and anchorage provided should be in accordance with the requirements of CP 114-2.

Particular attention should be given to the spacing of reinforcement at joints so that access to the concrete surface can be provided to enable it to be prepared to receive the following batch of concrete.

In each of two directions at right angles the percentage of reinforcement based on the gross sectional area should not be less than 0.3 % for plain bars and 0.2 % for deformed bars. Distribution reinforcement provided for the control of cracking that may arise from thermal or other movements should be placed as near the surface of the concrete as possible consistent with the requirements of **7.6**, and the maximum spacing should not exceed 225 mm.

8.6 Cover to reinforcement. The cover to reinforcement, prestressing steel, or sheathing, if present, should be not less than 50 mm adjacent to the water face. The cover to reinforcement or prestressing steel remote from the water face should be in accordance with the recommendations of CP 114-2, or CP 115-2, respectively.

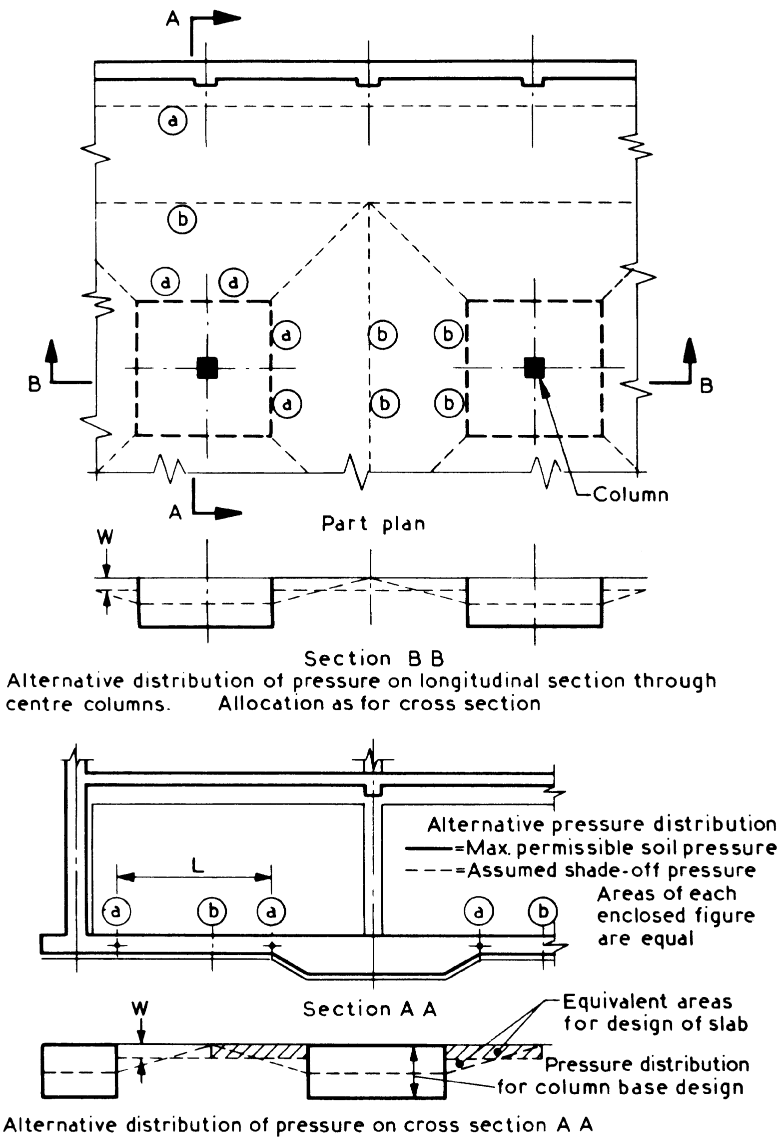


Figure 13 — Pressure distribution diagram

8.7 Pumping. It is essential that the site should be kept free of water during and prior to the concreting of the basement. For this purpose dewatering or pumping from carefully arranged sumps with appropriate drainage channels should be continuous during construction to prevent the level of the water rising. Before discontinuing pumping, all necessary steps should be taken to ensure that the structure will not float.

Tubes with removable caps may be inserted in the basement slab in order to check on the water pressure when necessary and to provide facilities for relief should this be required during the construction of the building.

8.8 Construction. The degree of success in achieving a watertight structure depends on the quality of workmanship in making and placing concrete, on good site organization, clean and dry excavation, careful storage of materials, close fitting formwork, correctly-fixed reinforcement and clean joints.

Reinforced concrete structures designed in accordance with the recommendations of CP 114-2 should be constructed in accordance with the recommendations of Section **5** of that Code.

Prestressed concrete structures designed in accordance with the recommendations of CP 115-2 should be constructed in accordance with the recommendations of Section **4** of that Code.

Reinforced and prestressed concrete structures designed in accordance with the recommendations of CP 2007-2 should be constructed in accordance with the recommendations of Section **4** of that Code.

It is essential that the concrete, when placed, is thoroughly compacted to form a dense uniform mass. The mix should be of adequate workability and compacted by vibration.

Immediately after the removal of formwork the concrete surfaces should be carefully inspected and any defects made good as soon as possible.

9 Inspection and repair of concrete basements

9.1 Inspection of basement. As soon as possible after completion of the basement and before the backfill has been placed the structure should be examined for defects which may lead to water penetration and again when the backfill has been completed and pumping has ceased. All openings exposed to the weather should be covered and all surface water on the floors should be removed and the surfaces allowed to dry before the inspection. If defects are then revealed through which ground water may penetrate, repairs should be carried out to the tanking or to the structural element concerned.

Where internal repairs are to be made the areas of weakness should be isolated by suitable means and any cracks sealed either by a specialist contractor experienced in this type of work, or in accordance with the recommendations of the following subclauses.

9.2 Pressure grouting. The equipment required for pressure grouting of concrete for Type B structures is as follows:

1) Pressure grouting pump (which may be hand operated) fitted with a pressure gauge, hose and quick release connector for attachment to the steel tube stubs.

2) A power drill or compressed air drilling equipment.

19 mm diameter steel tube stubs should first be inserted into holes drilled in the defective areas and caulked with lead wool. The effective radius of grouting is of the order of 300 mm and tube stubs should be inserted on this basis as necessary.

A solution of an approved liquid detergent should then be pumped successively through a group of tubes in order to flush out the channels in the defective zone and to delineate the zone of weeping.

Neat cement grout should then be pumped into the concrete through successive tubes. Pressure should be maintained during the setting of the grout by means of stopcocks and additional intermittent and successive pumping should be continued during this period to ensure ultimate refusal.

9.3 Repair by waterproof renderings. Repairs to a concrete structure may be carried out by the application of a waterproof rendering, which is normally entrusted to specialist contractors. The rendering is a sand cement mortar usually containing one or more admixtures, with the water content kept to the minimum consistent with the ability to place and compact the rendering against the affected areas. The sand should be washed clean, sharp and free from loam and dust and well graded from 3 mm down.

It will generally be advantageous if the site is kept clear of free water by pumping, dewatering or other means. Where, however, infiltration of ground water is occurring under pressure, special admixtures may be used in the mortar to accelerate the rate of hardening.

Before applying the mortar the concrete surface should be roughened over and around the affected area and all loose material around cracks removed. In some cases it may be advantageous to cut back with a concrete saw or by careful chipping to form a suitable joint to which the new rendering can be applied to a surface free from dirt, dust, oil or laitance. The surface should be wire brushed and washed clean before application of the mortar, which should be thoroughly compacted by pressure against the existing concrete. After placing the mortar its surface should be protected and prevented from drying out for about seven days to ensure thorough curing.

Section 3. Methods of providing damp-proofing of walls and floors at or near ground level

10 Damp-proofing of walls

10.1 General. This Clause deals with the damp-proofing of walls rising above ground level but is concerned only with methods of preventing water rising through the capillaries of the material of the walls and not where water can exert a hydrostatic pressure.

10.2 Materials for damp-proof courses. Materials suitable for damp-proof courses in walls are described in BS 743. They include sheet lead, sheet copper and bitumen sheet damp-proof course, mastic asphalt, slates and engineering bricks. These materials can be classified as follows:

1) flexible (metal or bitumen sheet damp-proof course),

2) semi-rigid (mastic asphalt),

3) rigid (slates or engineering bricks bedded in cement mortar). These materials provide a damp-proof course suitable for heavy loads, but are not as resistant to the passage of water as the materials in 1) and 2).

10.3 Durability. Factors which affect the durability of building materials, including those employed as a damp-proof course are discussed in CP 3:Chapter IX. The most important factors for each of the recognized damp-proof course materials are given in **10.3.1** to **10.3.6**.

10.3.1 *Sheet lead.* Lead is liable to corrosion when in contact with mortar or concrete. Protection can be obtained by the application of a bitumen paint of heavy consistency.

10.3.2 *Sheet copper.* Copper is highly resistant to corrosion and is unaffected by most building materials. Where, however, soluble salts are known to be present, protection by bitumen paint of heavy consistency is recommended.

10.3.3 *Bitumen sheet damp-proof course.* Bitumen sheet damp-proof courses will withstand some movement in a wall without fracture and those with an inorganic base have the advantage that the fibres do not rot. Neither partial squeezing of the damp-proof course nor deterioration of the fibres is likely to cause breakdown of the water-resisting properties.

10.3.4 *Mastic asphalt.* Mastic asphalt conforming to BS 1097 or BS 1418, but suitably modified by the addition of 35 % grit, is durable, but it may tend to squeeze out if subjected to local high stresses in excess of 650 kN/m^2 at normal temperatures.

10.3.5 *Slates.* Slates for damp-proof courses should comply with the requirements of **6.3** of BS 680-2. The water absorption should not exceed 0.3 %. Slates of poor quality may be attacked at the exposed edges by sulphur gases in the air. Slates of good quality are unaffected.

10.3.6 *Engineering bricks.* Hard-burnt clay engineering bricks for damp-proof courses should have a water absorption not exceeding 4.5 %.

Mortar for the bedding of slates or engineering bricks should normally be a mix of one part of Portland cement to three parts of sand. Where the mortar is liable to attack by soluble sulphates from either the bricks or the ground water, consideration should be given to the use of sulphate-resisting Portland cement, high alumina cement or supersulphated cement in the mortar.

10.4 Effect of movement. There is sometimes a risk of movement in the wall at damp-proof course level and the type of damp-proof course to be used should be selected with care. The restraint to sliding between sections of a wall below and above damp-proof course level will also be affected by the type of materials used. Rigid units are liable to split and to open up at the joints if movement or settlement of the building occurs.

10.5 Location of damp-proof course. It is essential that the damp-proof course in a wall is placed at least 150 mm above ground level.

10.6 Continuity of moisture barrier. In order to form an effective barrier to the passage of moisture, the damp-proof course should cover the full thickness of the wall or of each of the leaves of a cavity wall and should not be set back from the wall face for pointing nor be bridged by rendering.

The damp-proof course should be continuous with the impervious membrane in the adjacent solid floors and where necessary, a vertical damp-proof course should be provided on the inner face of the wall to form the connection (see Figure 14 and Figure 17).

Damp-proof courses should be provided on sleeper walls which support a floor unless the floor is of impervious material.

Where the site conditions require the provision of a stepped damp-proof course, a continuous flexible material should be used in order to avoid weakness and cracking at the angles between horizontal and vertical surfaces.

10.7 Work on site. In addition to the general recommendations for the laying of damp-proof courses in the following subclauses reference should be made to the recommendations on the laying of damp-proof courses in BS 743, Appendix C. Where flexible damp-proof courses are used, a smooth mortar bed should be provided free from projections which might cause damage to the damp-proofing materials. Contact between dissimilar metals should be avoided in order to prevent electrolytic action and corrosion.

10.7.1 *Sheet lead.* When sheet lead is to be laid on cement and sand mortar or cement and lime and sand mortar, both the surface of the mortar and the underside of the lead should be coated with a heavy bitumen paint. After laying, the top surface of the lead should be coated in a similar way and the paint allowed to dry before continuing the building of the wall. Joints in the sheet lead should be lapped at least 100 mm.

10.7.2 *Sheet copper.* Copper does not normally need a protective coating. Where, however, the metal may be attacked by soluble salts (e.g. sea salt in sand) a protective treatment similar to that recommended for lead is necessary. Joints having a minimum lap of 100 mm are adequate where there is no water pressure. When a copper damp-proof course is used the likelihood of staining appearing on the wall below the damp-proof course level should be considered.

10.7.3 *Bitumen sheet damp-proof course.* Bitumen damp-proof courses are classified in Clause **4** of BS 743. Their application is similar to that given above for lead or copper, but no protective painting is necessary. In cold weather the damp-proof course should be warmed before unrolling. It should be flattened on to the prepared mortar bed and positioned so as to cover the full width of each leaf of the wall. The joints should be lapped at least 100 mm and sealed with bitumen lap cement, or hot bitumen.

10.7.4 *Mastic asphalt.* Mastic asphalt should be laid in one coat 12 mm in thickness throughout the full width of each leaf of the wall.

For all damp-proof courses, the course aggregate content should be increased to not more than 35 % by adding grit on the site. In order to provide a key for the mortar below the next course of brickwork, further grit should be beaten into the mastic asphalt immediately after application and left proud of the surface. Alternatively, the surface of the mastic asphalt may be scored while still warm.

10.7.5 *Slates.* A slate damp-proof course should consist of at least two courses of slates, laid to break joint, each slate being bedded in 1 : 3 cement and sand mortar in accordance with the recommendations of BS 743, Appendix C.

10.7.6 *Engineering bricks.* A damp-proof course of engineering bricks should consist of two courses of bricks laid to break joint, each brick being bedded in 1 : 3 cement and sand mortar in accordance with the recommendations of BS 743, Appendix C.

11 Damp-proofing of floors

11.1 General. This Clause deals with the damp-proofing of floors where there may be capillary rise of moisture but not with those where water can exert a hydrostatic pressure.

11.2 Principles of damp-proofing. Although concrete floors of good quality can be almost impervious to the passage of moisture, over-site concrete and floor screeds as commonly laid should not be expected to keep back all ground moisture whether in liquid or vapour form. Ground moisture can pass through until it either disperses by free evaporation at the surface or reaches a less permeable material under which it tends to accumulate.

Thus, the degree of protection required will depend upon the nature of the floor finish. Some floor finishes can transfer moisture to the air above without deterioration. Others form, in themselves, an effective damp-proof course.

Information on the limitations of damp-proof materials is given in Table 1 and an indication of the order of resistance to ground moisture of common floor finishes is given in Table 2.

Table 1 — Protection against rising damp

A. Waterproof flooring materials	
Material	**Properties and limitations**
Mastic asphalt laid in accordance with the recommendations of CP 204.	Impervious to the transmission of moisture in liquid or vapour form. May be used as a floor finish or as an underlay for other forms of flooring. If the base is in direct contact with the ground or the mastic asphalt flooring is acting as a damp-proof membrane or is liable to be subjected to water or water vapour, a suitable glass fibre tissue isolating membrane should be used.
Pitchmastic laid in accordance with the recommendations of CP 204.	Impervious to the transmission of moisture in liquid or vapour form. May be used as a floor finish or as an underlay for other forms of flooring. May be laid direct to concrete without an isolating membrane.
B. Sandwich membranes (in order of protective value)	
Material	**Properties and limitations**
Mastic asphalt to BS 1097 or BS 1418.	Impervious to moisture in liquid or vapour form.
Bitumen sheet damp-proof course to BS 743.	With joints properly sealed it is impervious to moisture in liquid or vapour form.
Hot applied pitch or bitumen.	When laid on a primed surface to give an average thickness of 3 mm (3 kg/m^2) may be regarded as impervious to moisture in liquid or vapour form. Care should be taken to avoid pin holes.
Cold applied bitumen solution and coal tar pitch/rubber or bitumen/rubber emulsion.	By repeated brush application, can form an impervious membrane. Care in workmanship and supervision is needed, as the success of the membrane depends upon the minimum thickness that is built up.
Polythene film.	Sheets of at least 0.2 mm thickness are of value under floor finishes listed in Group C of Table 2, but may not be satisfactory for Group D.

Table 2 — Properties of flooring materials in relation to resistance to ground moisture penetration

Group	Material	Properties
A Finish and d.p.c. combined	Pitchmastic flooring Mastic asphalt flooring	Capable of resisting rising dampness without dimensional or material failure.
B May be used without extra damp protection	Concrete Terrazzo Concrete or clay tiles	Capable of transmitting rising dampness without dimensional, material or adhesion failure.
	Cement/latex Cement/bitumen	Capable of partially transmitting rising dampness without dimensional or material failure and generally without adhesion failure.
	Wood composition blocks (laid in cement mortar). Wood blocks (dipped and laid in hot pitch or bitumen)	Capable of partially transmitting rising dampness without material failure and generally without dimensional or adhesion failure. *Only in exceptional conditions of site dampness is there risk of dimensional instability.*
C Not necessarily trouble-free without damp protection	Thermoplastic tiles (BS 2592) Vinyl asbestos tiles (BS 3260)	Capable of partially transmitting rising dampness through the joints without dimensional failure and generally without adhesion or material failure. Water penetration at the joints may result in decay at the edges in some conditions when ground water contains dissolved salts or alkalis.
D Reliable damp protection needed	Magnesite	Capable of transmitting rising dampness but adversely affected by water
	Flexible PVC flooring in sheet or tile form (BS 3261)	Impervious, but the flooring adhesive is sensitive to moisture.
	PVA emulsion cement	Impervious, but dimensionally sensitive to moisture (adhesive for tiles also sensitive to moisture).
	Rubber	Impervious, but prone to adhesion failure mainly through sensitivity of its adhesive.
	Linoleum	Sensitive to alkaline moisture attack through breakdown of bond and adhesive film.
	Cork Wood Chipboard	Acutely sensitive to moisture with dimensional or material failure.

11.3 Factors influencing the degree of protection. The degree of protection required must be considered in relation to the floor finish and the site conditions. Certain other factors will have an influence such as the temperature gradient and contamination of the filling.

The effect of a temperature gradient is to increase the moisture content of the cooler part and reduce that of the warmer part. Thus, if the floor surface is colder than the ground below it, moisture will tend to rise and collect near the surface and a higher degree of protection, as recommended in Table 1B will be needed in order to prevent damage to a moisture sensitive floor finish.

Where aggregates, hardcore or filling containing alkali salts such as sea salts are used below the floor a higher degree of protection should be given.

To provide the highest standard of protection for applied finishes, a damp-proof layer should combine impermeability to liquid water and to water vapour with continuity and sufficient toughness to remain undamaged before and during the laying of the finish. Not all "waterproofing" materials combine these properties; information on their limitations is given in Table 1.

11.4 Continuity of membrane. It is essential that the damp-proof membrane in the floor should be continuous with the damp-proof course in the surrounding walls. Where necessary, a vertical damp-proof course should be incorporated to link the two, as shown in Figure 14 and Figure 17.

It is also essential that polythene sheet joints should be lapped at least 150 mm and should be sealed with double-sided pressure sensitive tape; also that punctures in polythene sheet should be patched with polythene of identical thickness lapped at least 150 mm beyond the limits of the punctures, and that the joints between the patches and the sheeting should be similarly sealed with double-sided pressure sensitive tape.

11.5 Preparation of site. Sub-soil drainage should be provided wherever there is a risk of the ground becoming water-logged.

The base should be structurally sound in order to avoid fracture of the membrane and the surface should be sufficiently smooth to avoid puncturing the membrane.

Generally, timber should not be embedded in a floor or fixed below the damp-proof membrane. Any timber grounds required for fixing should be pressure impregnated with a preservative.

11.6 Work on site for waterproof flooring materials

11.6.1 *Mastic asphalt and pitchmastic flooring.* The laying procedure and general information is described in CP 204-2.4 and CP 204-2.5, BS 1076, BS 1410, BS 1451 and BS 3672. Some useful extracts are given in **11.6.1.1** to **11.6.1.7**.

11.6.1.1 *Preparation of the base.* Unless a screed is being applied care should be taken in laying the concrete base so that any undue irregularity is avoided. The surface should be clean to receive asphalt.

11.6.1.2 *Thickness.* The minimum thickness of mastic asphalt, coloured asphalt or coloured pitchmastic should be 16 mm. This thickness may be increased according to traffic conditions.

11.6.1.3 *Isolating membrane.* An isolating membrane of black sheathing felt complying with the requirements of BS 747-2, should be laid over the base to enable the asphalter to provide a polished surface on the mastic asphalt. If the base is in direct contact with the ground or the mastic asphalt flooring is acting as a damp-proof membrane or is liable to be subjected to water or water vapour, a suitable glass fibre tissue isolating membrane should be used. Pitchmastic should be laid at a lower temperature than mastic asphalt and the asphalter is usually able to obtain a polished surface without the use of an underlay. It may be necessary in certain cases, however, to use an underlay, especially where "blowing" occurs from the concrete base.

11.6.1.4 *Remelting.* Remelting of the mastic asphalt or pitchmastic should be carried out in mechanically agitated machines or in cauldrons for small size contracts, the blocks being first broken into pieces of convenient size. Special care should be taken to avoid overheating. The temperature of mastic asphalt should not exceed 215 °C and that of pitchmastic 160 °C.

11.6.1.5 *Laying.* In order to free the molten asphalt or pitchmastic from the buckets which are used to transport the material a small quantity of inert dust may be sprinkled into the buckets. The mastic asphalt or pitchmastic should be applied uniformly in one coat on the prepared foundation to the specified thickness by means of a wooden float. Timber gauges should be used to regulate the thickness.

11.6.1.6 *Surface finish.* The mastic asphalt or pitchmastic should be floated to a uniformly level surface and should be free from roughness or imperfections. When a polished finish is required, it should be produced by using a hard wood float while the mastic is still hot.

Where mastic asphalt is used as a waterproof base coat to receive other floor coverings such as sheet, block or tile finishes, the mastic asphalt should be not less than 13 mm in thickness and of similar composition to that of 16 mm thickness flooring, described in CP 203.

11.6.1.7 *Putting into service.* Mastic flooring should not be subjected to traffic until it has cooled sufficiently.

11.7 Work on site for sandwich membranes

11.7.1 *Mastic asphalt.* Mastic asphalt for sandwich membranes between two layers of concrete should comply with the requirements of BS 1097 or BS 1418.

11.7.1.1 *Preparation of base.* The concrete surface should be true and even without ridges or indentations. It should be finished by a screed board or wooden float.

11.7.1.2 *Remelting.* Remelting of the mastic asphalt blocks should be carried out in a mechanically agitated mixer or cauldron, the blocks being first broken into pieces. Special care should be taken to avoid overheating. The temperature should not exceed 215 °C.

11.7.1.3 *Laying.* When the material is sufficiently heated to be workable, it should be transported in buckets. To prevent the heated mastic asphalt sticking to the buckets they should first be sprinkled inside with a small quantity of inert dust. The mastic asphalt should be spread by means of a wooden hand float to the specified thickness, usually 12 mm for one coat work or 10 mm where two coat work is required, timber gauges being used to give the required thickness. With two coat work 150 mm break joints should be provided to ensure that the joints in successive layers do not coincide. If "blows" occur, they should be stabbed and the affected area floated to a uniformly level surface free from roughness and imperfections. Application of the top layer of concrete can commence immediately the asphalt has cooled to the temperature of the surrounding atmosphere.

11.7.2 *Bitumen damp-proof courses.* The bitumen damp-proof sheeting for sandwich membranes between two layers of concrete should comply with the requirements of BS 743.

11.7.2.1 *Preparation of base.* The concrete base should be true and free from ridges and indentations and projections that might penetrate the membrane.

11.7.2.2 *Laying.* The rolls of damp-proof sheeting should be laid out flat and cut to length to minimize subsequent stretching and curling. The bitumen sheet damp-proof course can be laid loose or wholly bonded to the base concrete but in both cases laps, at least 100 mm wide, should be sealed.

In cold weather the rolls should be kept in a warm place or warmed before laying to prevent cracking of the bitumen sheeting. When the damp-proof course is to be wholly bonded the base concrete should first be treated with a bitumen primer or bitumen emulsion which should be allowed to dry before the sheeting is applied. The operation of wholly bonding the sheeting to the concrete base is one of rolling and pouring and consists of laying out the sheet for its full length, rolling back half way in a tight roll and then rolling it out and pressing into position over hot bitumen which is poured from a can immediately in front of the roll.

A junction can be made between a bitumen damp-proof course protruding from the wall and sheeting laid on the concrete base by means of strips of sheeting cut into convenient lengths, and bonded to both as a separate operation.

Where the damp-proof course is laid loosely, the procedure for cutting and laying out the sheeting to minimize subsequent stretching and curling is as given above; the laps between adjacent strips of sheeting are then sealed with bitumen lap cement as the sheets are applied. When the laps are sealed with hot bitumen, the "roll and pour" method can be applied in preference to mopping the edges with bitumen. As soon as the bitumen damp-proof course has been applied, it should be covered with concrete or screed to prevent damage by other trades.

11.7.3 ***Hot laid pitch or hot bitumen***

11.7.3.1 *Preparation of base.* The surface of the concrete should be even and true, and smoothed off with a screed board or wood float in order to avoid all ridges and indentations and to ensure uniformity in the membrane. The surface of the concrete should be dry and swept clean of dirt and dust.

11.7.3.2 *Laying.* The surface of the concrete base should be treated with a primer of bitumen solution, bitumen emulsion or coal tar pitch solution (whichever is appropriate) by brushing the primer into the surface of the concrete, the primer being allowed to dry before the application of the hot pitch or bitumen. The bitumen should be hard enough to avoid tackiness in warm weather and soft enough to avoid brittleness in cold weather. A softening point of 50 °C to 55 °C would be appropriate. This corresponds to a penetration of 40–50 at 25 °C. The hot bitumen for the coating should not be heated to a temperature in excess of that necessary for it to be poured easily and should not exceed 215 °C.

The hot coal tar pitch should not be heated to a temperature in excess of that necessary for it to be poured easily and should not exceed 160 °C. Pitch having a softening point of 35 °C to 45 °C is appropriate. The hot pitch or bitumen should be poured evenly across the concrete base and spread with the aid of a squeeze or strip of hardboard until the whole of the concrete is obscured, to give an average thickness of 3 mm (3 kg/m^2). As soon as the membrane has cooled to the temperature of the surrounding atmosphere, the concrete or screed should be applied to prevent damage by other trades.

Care should be taken to see that frothing of the hot bitumen or pitch does not occur due to dampness in the concrete as this may impair the damp-proofing qualities of the membrane by leaving pin-holes in the material.

11.7.4 *Cold bitumen solution.* The surface of the concrete base should be clean and dry before the application of the solution. The solution should be applied by brushing on to the surface of the concrete. The first coat should be allowed to dry out thoroughly before the next is applied. At least three coats are recommended, but two coats may be accepted provided they give a dried membrane thickness of 0.6 mm. The top layer of concrete or screed should not be applied until the whole of the membrane has dried out and care must be taken to see that the membrane is not damaged by other trades during the drying out period. Care should be taken also to prevent damage to the membrane when the concrete is being placed.

11.7.5 *Cold coal tar pitch/rubber emulsion or bitumen/rubber emulsion.* The concrete base should be prepared similarly to that described for the application of cold bitumen except that the concrete does not in this case need to be completely dry as emulsions are not so sensitive to dampness.

The application of emulsions is similar to that for cold bitumen solutions. At least three coats are recommended, but two coats may be accepted provided they give a dried membrane thickness of 0.6 mm.

11.8 Damp-proofing for suspended timber floors

11.8.1 *General.* The main requirement in a suspended timber floor is to keep the moisture content of the timber below 20 % by weight. Timber with this or a slightly higher moisture content is vulnerable to attack by the dry rot fungus, *Merulius lacrymans.* At still higher moisture contents, wet rot fungi, such as *Coniophora cerebella,* can attack timber.

Precautions are taken in three ways:

1) By preventing direct contact between timber and porous materials below damp-proof course level.

2) By providing under-floor ventilation.

3) By covering the ground below the floor so as to prevent or minimize evaporation of water into the air space below the floor.

11.8.2 *Covering site.* The whole of the area under the suspended floor should be covered with either 100 mm of dense concrete or a damp-resisting covering.

11.8.3 *Supports for joists.* Floor joists should be carried on wall plates supported by sleeper walls. The wall plates should be separated from the sleeper walls by a damp-proof course. The ends of the joists should not be built into solid walls, but may be built into the inner leaf of cavity walls above damp-proof course level provided that the ends of the joists are treated with preservative.

11.8.4 *Sub-floor ventilation.* Ventilation of the under-floor space should be provided by means of vents in the external walls. The minimum area of vents should be 3 200 mm^2 per metre run of wall. Vents should be provided on opposite sides of the building to encourage a through draught. Dead pockets, near an area of solid flooring, should be ventilated by ducts, see Figure 17.

11.8.5 *Sleeper walls.* All sleeper walls should be in honeycomb bond so as not to obstruct ventilation.

11.8.6 *Depth of sub-floor space.* The distance between the underside of the floor joists and the site covering should be not less than 150 mm. Typical construction details are shown in Figure 15 to Figure 17.

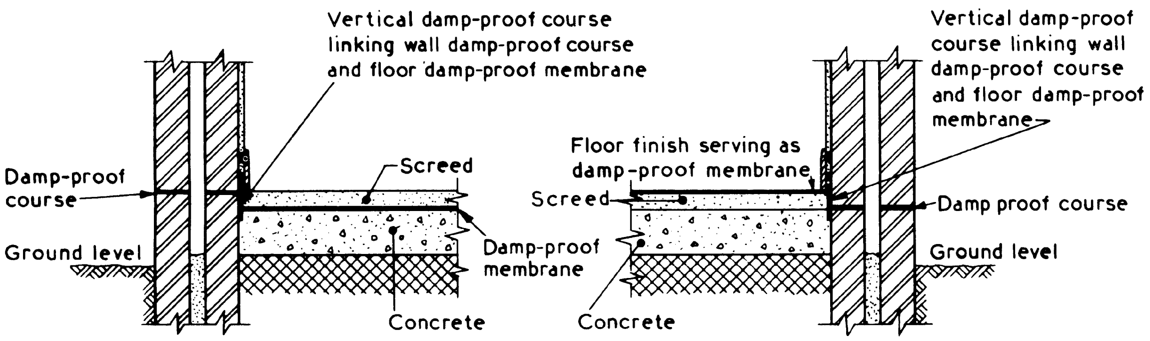


Figure 14 — Continuity of wall and floor damp-proof membrane

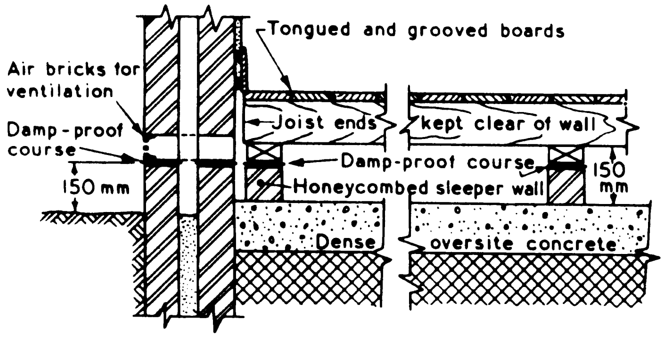


Figure 15 — External wall (suspended floor)

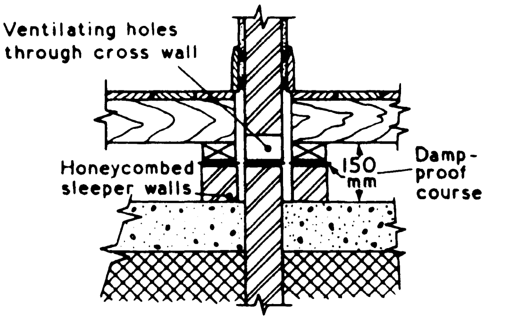
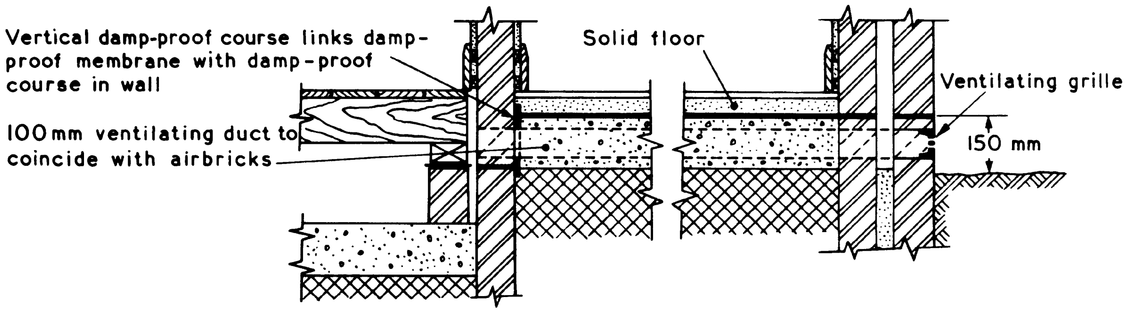


Figure 16 — Internal load-bearing wall



a. Division wall between suspended and solid ground floors

b. External wall (solid floor)

Figure 17 — Treatment of combined solid and suspended floors

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Publications referred to

This Code of Practice makes reference to the following British Standards, British Standard Codes of Practice and special publications:

BS 12, *Portland cement (ordinary and rapid-hardening).*
BS 12-2, *Metric units.*
BS 146, *Portland-blast furnace cement.*
BS 680, *Roofing slates.*
BS 680-2, *Metric units.*
BS 743, *Materials for damp proof courses.*
BS 747, *Roofing felts.*
BS 747-2, *Metric units.*
BS 812, *Methods for sampling and testing of mineral aggregates, sands and fillers.*
BS 882, BS 1201, *Aggregates from natural sources for concrete (including granolithic).*
BS 1076, *Mastic asphalt for flooring (limestone aggregate).*
BS 1097, *Mastic asphalt for tanking and damp-proof courses (limestone aggregate).*
BS 1200, *Sands for mortar for plain and reinforced brickwork; blockwalling and masonry.*
BS 1410, *Mastic asphalt for flooring (natural rock asphalt aggregate).*
BS 1418, *Mastic asphalt for tanking and damp proof courses (natural rock asphalt aggregate).*
BS 1451, *Coloured mastic asphalt flooring (limestone aggregate).*
BS 2592, *Thermoplastic flooring tiles, sometimes known as "asphalt" tiles.*
BS 2691, *Steel for prestressed concrete.*
BS 3148, *Tests for water for making concrete.*
BS 3260, *PVC (vinyl) asbestos floor tiles.*
BS 3261, *Flexible PVC flooring.*
BS 3672, *Coloured pitch mastic flooring.*
BS 4449, *Hot rolled steel bars for the reinforcement of concrete.*
BS 4461, *Cold worked steel bars for the reinforcement of concrete.*
BS 4482, *Hard drawn mild steel wire for the reinforcement of concrete.*
BS 4483, *Steel fabric for the reinforcement of concrete.*
BS 4486, *Cold worked high tensile alloy steel bars for prestressed concrete.*
BS 4692, *Method for determination of softening point of bitumen (ring and ball).*
CP 3, *Code of basic data for the design of buildings.*
CP 3:Chapter V, *Loading.*
CP 3-1, *Dead and imposed loads.*
CP 3-2, *Wind loads.*
CP 3:Chapter IX, *Durability.*
CP 114, *Structural use of reinforced concrete in buildings.*
CP 114-2, *Metric units.*
CP 115, *The structural use of prestressed concrete in buildings.*
CP 115-2, *Metric units.*
CP 121.101, *Brickwork.*
CP 123.101, *Dense concrete walls.*
CP 203, *Sheet and tile flooring (cork, linoleum, plastics, rubber).*
CP 204, *In-situ floor finishes.*
CP 204-2, *Metric units.*
CP 301, *Building drainage.*

CP 2001, *Site investigations*.
CP 2007, *Design and construction of reinforced and prestressed concrete structures for the storage of water and other aqueous liquids*.
CP 2007-2, *Metric units*.
Civil Engineering Code of Practice No. 2. Earth retaining structures.

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