Code of practice for

Protection of structures against water from the ground
Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Civil Engineering and Building Structures Standards Policy Committee (CSB/-) to Technical Committee CSB/55, upon which the following bodies were represented:

Association of British Roofing Felt Manufacturers
British Board of Agrément
Cement and Concrete Association
Concrete Society
Contract Flooring Association
Department of the Environment (Building Research Establishment)
Department of the Environment (Construction Industries Directorate)
Flat Roofing Contractors Advisory Board
Incorporated Association of Architects and Surveyors
Institution of Civil Engineers
Institution of Structural Engineers
Mastic Asphalt Council and Employers’ Federation
National House-Building Council
Royal Institute of British Architects
Royal Institution of Chartered Surveyors

Amendments issued since publication

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The following BSI references relate to the work on this standard:
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Publications referred to Inside back cover
Foreword

This British Standard code of practice has been prepared under the authority of the Civil Engineering and Building Structures Standards Policy Committee CSB/-

This code of practice is an extensive revision of section 1 and section 2 of CP 102:1973. Structures are now divided into three types and a new table giving guidance in the selection of performance requirements and construction of basements is included. The code also includes new materials and a section on the inspection and waterproofing of existing basements. All references to workmanship are excluded, these are now to be found in the code of practice on workmanship on building sites (BS 8000-4).

On the publication of this code of practice, section 1 and section 2 of CP 102:1973 are superseded.

Section 3 of CP 102:1973 which deals with methods of providing damp-proofing of walls and floors at or near ground level is undergoing revision separately and will be published as a new British Standard code of practice for design and installation damp proof courses in masonry construction.

It has been assumed in the drafting of this code of practice that the execution of its provisions is entrusted to suitably qualified and experienced people, for whose guidance it has been prepared.

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 a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 32, 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.
Section 1. General

1 Scope
This code of practice provides guidance on methods of dealing with and preventing the entry of water from surrounding ground into a building below ground level. The main methods described are the use of applied waterproofing finishes, watertight construction and drained cavity construction.

The code does not make any recommendations concerning the use of embedded heating in basements, floors and walls or for the special requirements in connection with the design and construction of cold stores.

NOTE The titles of the publications referred to in this code are listed on the inside back cover.

2 Definitions
For the purposes of this code of practice, the definitions in BS 6100-2 apply.
Section 2. Design and structure

3 Design requirements and design criteria

3.1 General

3.1.1 Pre-design considerations

Before any design is carried out for building works below ground level a thorough site investigation in accordance with BS 5930 should be made including the exploration of water levels. The testing of soil and groundwater samples for sulphate or other aggressive conditions should also be included. Where high concentrations of sulphate or other aggressive conditions are found, consideration should be given to the provision of an external impervious membrane or to the use of special cements, both in the structure and in any internal waterproofing, so as to provide adequate resistance to attack. Otherwise normal concrete or sound brickwork are as adequate for below ground use in saturated conditions as they are in standard foundations. Reference should be made to Building Research Digest No. 250, 1981.

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, the risk of waterlogging at some future time should be considered. In a permeable subsoil groundwater requires time to drain away and if there is a pump failure, working space around basements under construction can soon become inundated with surface water. It is, therefore, recommended that basements should include provision for resisting a pressure equivalent to 1 m head of water at least (see 3.4).

The use of prestressed concrete in basements is rare and generally only employed when shapes are simple.

3.1.2 New construction

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. 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. Some recommendations for the repair of minor defects are given in clause 8.

In certain circumstances, as for example in large deep town centre basements, access to the external face of the perimeter wall is not possible and site restrictions make high standards of workmanship difficult to achieve. Also, the chosen method of construction may be such that watertightness cannot be assumed, e.g. diaphragm or contiguous piled walls – particularly at the junction of the base slab and the wall. In these cases complete watertightness may be neither economically nor practically possible and the designer, after establishing the intended use or possible future use of the basement areas, should make reference to Table 1 for the alternative forms of construction and waterproofing which may be used to meet the performance requirements.

Many basements give the impression of dampness due either to the penetration of moisture or to condensation. Providing the supporting structure is sound, the inclusion of an impervious membrane will resist the former while the provision of adequate ventilation, assisted by heating, coupled with the suitable treatment of floor and wall surfaces will combat the latter.

At the earliest stages, there should be exchanges of information between those responsible for the site preparation, the construction work, the pumping and dewatering, the tanking and waterproofing work and other subsequent work to ensure that the various operations can be carried out in the due sequence and with all necessary prerequisite provision.

House construction on sloping sites introduces a requirement for waterproofing the below ground portion of the structure. Further complications arise where houses are stepped in section and/or staggered in plan. Here the solid separating wall between houses changes to cavity construction when it becomes an outside wall. Different masonry materials are specified to meet thermal and acoustic requirements. The ensuing junction needs to be most carefully detailed if problems of damp penetration are also to be avoided. Typical design solutions are given in Figure 1, Figure 2 and Figure 3.
3.1.3 Existing buildings

When consideration is being given to waterproofing an existing building, most of the foregoing applies to some degree. Additionally however, the condition of the structural elements and their ability to withstand the possible increase in head of water resulting from the waterproofing together with the ability of any surface to accept the waterproofing treatment has to be investigated. A structure of suitable strength and stiffness and built of concrete, brick or masonry lends itself to treatment by means of an internal waterproof render. An alternative is to provide a drained floor and to build an inner leaf with a drained cavity behind (see Figure 4 and Figure 5). Where cost consideration is of prime importance or reduction in room size is unacceptable any residual dampness of the wall face can be masked by dry lining.

Consideration should be given to any change in use or changes in loading as these could result in ground movements that could crack the structure and thus aggravate water penetrations.

3.2 Preventative measures

3.2.1 General

Water or moisture penetration of the basement may be reduced by one or more of the methods described in 3.2.2 to 3.2.4 depending on the conditions of the site.

Figure 1 — Example of stepped construction for sloping ground
Figure 2 — Example of cavity masonry wall construction

All dimensions are in millimeters.
Figure 3 — Example of solid masonry wall construction

All dimensions are in millimetres.
3.2.2 Exclusion of surface water

Wherever possible, rainwater should be prevented from soaking into the ground adjoining any basement. This may be achieved by one of the following methods.

a) Arrange for the adjoining ground surface to slope away from the structure for about 3 m and provide sufficient transverse gradient to avoid ponding.

b) On sloping sites or where the gradient of the ground surface adjoining the 3 m strip is adverse, construct a cut-off land drain to intercept approaching surface water to conduct it to a lower level.

c) Where possible, pave the 3 m strip and take its surface water run-off, together with any other run-off from adjoining paving, wall surfaces or roofs to a separate drain, (which should not be an open jointed or other pervious sub-surface drain) for disposal well clear of the structure.

BS 8301 gives recommendations on collecting and disposing of surface and subsoil water.

Figure 4 — Drained cavity construction

All dimensions are in millimetres.
3.2.3 Sub-surface drainage

Any existing system of land drains should be most carefully preserved. Where any construction demands it, local diversions should retain the existing geometry so far as practicable with new pipework laid in easily roddable straight lines. Water may be kept from prolonged contact with basement walls or floors by porous or open jointed land drains, protected by graded filter laid to proper falls around the perimeter of the structure, adjacent to the wall footing and where appropriate, beneath the floor itself. This sub-surface system should be graded to an open outlet, or stormwater drain or to a pumped sump and can also provide a suitable outfall for any vertical drainage medium or system which may be applied to the outside faces of the walls of the sub-structure or for any granular blanket blinding layer beneath the floor. Perimeter drainage at basement floor level is likely to lower the ground water table to a degree which will vary with the permeability of the subsoil.

Figure 5 — Deep basement construction suitable for utility uses, car parking etc
Temporary pumping during construction is likely to create a similar effect. Great care should be exercised in either case to ensure that no damage will result in nearby structures. Where deep basements are contemplated in built-up areas, groundwater lowering is not recommended. Perimeter diaphragm walls providing a cut-off into an impervious layer or stabilization of granular subsoils by grout injection or similar alternative treatments should be considered instead.

3.2.4 Water-resisting forms of construction
This code contains recommendations for either minimizing or preventing the entry of water to the inner surfaces of basements and identifies three different types of construction. These are set out below and illustrated in Figure 6. Table 1 relates form of construction to performance level requirements for different uses.

a) Type A (Tanked protection). Constructed from concrete or masonry and offering no protection against the ingress of water and water vapour by the nature of its design. Protection is therefore totally dependent on a continuous barrier system applied to the structure.

b) Type B (Structurally integral protection). Designed and constructed in reinforced or prestressed concrete either to BS 8110 (to minimize water penetration) or to BS 8007 (to prevent water penetration) dependent on the chosen grade of basement use. Transmission of water vapour may not be wholly prevented.

c) Type C (Drained protection). Constructed from structural concrete (including diaphragm walls) or masonry to minimize the ingress of water. Any moisture which does find its way into the basement is channelled, collected and discharged within the cavity created through the addition of an inner skin to both walls and floor. Vapour transmission may be prevented by ventilation of the cavity and by providing an effective damp proof membrane over the under drained floor. For those seeking maximum assurance this combination of construction and waterproofing is considered the most effective and trouble free.

3.3 Degree of watertightness
Table 1 should be consulted in conjunction with the following recommendations.
Table 1 — Guide to level of protection to suit basement use

<table>
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<tr>
<th>Grade</th>
<th>Basement usage</th>
<th>Performance level</th>
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<td>1</td>
<td>Car parking; plant rooms (excluding electrical equipment); workshops</td>
<td>Some seepage and damp patches tolerable</td>
<td>Type B. Reinforced concrete design in accordance with BS 8110</td>
<td>Groundwater should be checked for chemicals which may have a deleterious effect on the structure or internal finishes</td>
</tr>
<tr>
<td>2</td>
<td>Workshops and plant rooms requiring drier environment; retail storage areas</td>
<td>No water penetration but moisture vapour tolerable</td>
<td>Type A. Type B. Reinforced concrete design in accordance with BS 8007</td>
<td>Careful supervision of all stages of construction is necessary. Membranes can be applied in multi-layers with well lapped joints</td>
</tr>
<tr>
<td>3</td>
<td>Ventilated residential and working areas including offices, restaurants etc., leisure centres</td>
<td>Dry environment</td>
<td>Type A. Type B. With reinforced concrete design to BS 8007. Type C. With wall and floor cavity and DPM</td>
<td>As grade 2</td>
</tr>
<tr>
<td>4</td>
<td>Archives and stores requiring controlled environment</td>
<td>Totally dry environment</td>
<td>Type A. Type B. With reinforced concrete design to BS 8007 plus a vapour proof membrane. Type C. With ventilated wall cavity with vapour barrier to inner skin and floor cavity with DPM</td>
<td>As grade 2 As grade 1</td>
</tr>
</tbody>
</table>
It is fundamental to the success of any below-ground structure that the designer and the client have a clear understanding of each others’ requirements and limitations. The designer should explain to the client the options of grades 1, 2, 3 and 4 in Table 1 and the cost implications of increasing performance level requirements. The client, on the other hand, must share with the designer his expectations on the use to which the building will be put, whether there are any acceptable limitations on this use and the extent to which the financial emphasis will fall upon either first cost or future maintenance. The following checklist may provide a useful framework for designer/user discussion.

a) The consequences of any leakage or condensation or dampness.
b) The feasibility and form of remedial works.
c) The scope for testing during construction (e.g. the controlled application of a head of water).
d) The risk of aggressive groundwater penetrating inadequately water-tight construction and causing it damage.
e) The risk of changes to the surrounding groundwater regime.
f) The need and/or ability to incorporate movement joints within the structure.
g) The need or ability to provide heating and/or ventilation and the consequences arising in terms of humidity.
h) The need or ability to provide particular floor or wall surface treatments in response either to the users wishes or to meet some risk perceived by the designer (e.g. a) or g) above).
i) The impact of the chosen method of construction and the consequential risk attendant upon less than adequate workmanship.
j) The balancing of cost against risk in choosing whether further construction cost or future maintenance cost will assume priority or in choosing whether the building contract will place greater or less emphasis on a performance requirement.

Subsequent sections of this code give recommendations on the following tanking systems.

1) Asphalt (clause 9) W V L
2) Bitumen sheet tanking (clause 10) W V S B
3) Cement/sand mixtures (clause 11) W L B
4) Polyurethane based mixtures (clause 12) W V L B
5) Self-adhesive rubber bitumen membranes (clause 13) W V S B

where:

W = Waterproof
V = Water and vapour proof
S = Sheet or board system
L = Liquid or cementitious system
B = Fully bonded.

In general terms systems 1), 2), 4) and 5) are suitable for external tanking or for internal tanking where support to the membrane is provided. System 3) is suitable for internal tanking where no support is provided. All these systems can be applied to both new and old structures although care may be necessary in the case of certain masonry structures (see clause 8).

The limited and limiting ability of waterproofing membranes to accommodate movement and bridge over cracks should be taken into account when choosing a structure or system.

3.4 Structural considerations

The imposed loading on the buildings, the stability of the structure as a whole and the stresses in the materials of construction should be determined in accordance with any relevant British Standards and Building Regulations (BS 6399, BS 8110, BS 8007 and CP 3:Chapter V-2 for example). Methods for designing below-ground structures are adequately covered in text books but the following matters should be considered.

a) Monolithic structures are to be preferred in that they are better able to resist the varying conditions imposed by the relatively indeterminate nature of subsoil earth and water pressures.
b) For basements not exceeding 4 m deep a design head of ground water, three-quarters the full depth below ground (subject to a minimum of 1 m), is usually adequate.
c) For deeper basements the water table should be taken as being 1 m below ground level.
d) In addition to simple water pressure, allowance should be made for the additional pressure of the submerged earth, the loading effects of adjoining buildings or any heavy ground surface loading against the boundary of the building.
e) The structure should be checked for flotation at various stages of construction and temporary arrangements to balance water pressures may have to be considered.
f) Any improvements to the waterproofing of an existing structure may increase the water pressure upon it and this should be checked.
4 Materials

4.1 Waterproofing materials

4.1.1 General

Waterproofing materials are intended to provide a barrier against water. They may also provide resistance to the diffusion of water vapour.

4.1.2 Mastic asphalt

Mastic asphalt for tanking should comply with BS 6925 or BS 6577.

4.1.3 Preformed bitumen sheetings

Bitumen sheeting for tanking should comply with either:

a) 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\(^2\)); or

b) BS 747: Type 5B polyester reinforced bitumen felt roofing.

4.1.4 Other sheeting materials

Other forms of proprietary impervious sheetings are available which can provide a barrier to water but for which there are no British Standards. The specifier should be satisfied that such sheetings have been adequately tested and certified for use for the tanking application and service conditions in question.

Such proprietary materials should be used strictly in accordance with the conditions and requirements set out in the relevant certificates and in accordance with the manufacturer’s recommendations.

4.1.5 Bitumen compound

Bitumen compound for bonding and sealing bitumen sheeting should be oxidized bitumen with the following characteristics when tested in accordance with BS 2000-49 and BS 2000-58.

<table>
<thead>
<tr>
<th>Grade</th>
<th>85/25</th>
<th>95/25</th>
<th>105/35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration at 25 °C</td>
<td>25 ± 5</td>
<td>25 ± 5</td>
<td>35 ± 5</td>
</tr>
<tr>
<td>Softening Point °C</td>
<td>80 to 90</td>
<td>90 to 100</td>
<td>100 to 110</td>
</tr>
</tbody>
</table>

4.1.6 Bitumen primer

Bitumen primer should be a bitumen cut back with volatile solvent. It should have the following characteristics when tested in accordance with BS 2000-72:

Min. volatile solvent content : 40 % by mass

Max. viscosity (using 4 mm orifice Standard Tar Viscometer) at 25 °C : 10 s

Emulsion based primers should not be used.

4.1.7 Cement based waterproof renders

Cement based waterproof renders consist of fresh cement, well graded sharp sand, water and a waterproofing admixture.

Generally these renders are applied in multi-coats and are proof against liquid water but allow some vapour penetration.

4.1.8 Polymer/cement based waterproof coating

Polymer/cement based waterproof coatings consist of wet or dry polymer resins and prepacked, blended Portland cement, fillers and admixtures.

The coatings are mixed on site and applied in two or more coats with a brush or trowel. They are waterproof and may also be proof against vapour penetration.

4.1.9 Resins of polyurethane etc.

Resins of polyurethane, polyurethane resin tanking membranes, polyurethane/coal tar or similar high performance bonded elastomeric tanking membranes are liquid materials applied by airless spray, trowel or roller to thicknesses specified by the manufacturer. After a period of between 24 and 48 hours the liquid membrane cures to a moisture proof and vapour proof jointless, flexible, rubber-like sheet which is well bonded to the substrate.

4.1.10 Waterstops

Proprietary waterstops of various materials are available. The specifier should be satisfied that such waterstops have been adequately tested and certified for the application and service conditions required (See also section 4).

4.2 New materials

This code is written to reflect the use of the most widely established methods and materials.

There are other materials and systems of waterproofing below-ground structures, which are not included in this code.

NOTE Where the use of methods or materials that are not covered by this code is contemplated it is recommended that enquiries be made regarding the following:

a) certification by the British Board of Agrément (BBA);
b) performance characteristics compared with established BBA criteria;
c) certification from overseas national bodies;
d) results from independent test houses;
e) established performance in the UK and overseas.
5 Structures requiring protection against water and water vapour penetration (type A structures: tanking protection)

5.1 Structural aspects

5.1.1 General

Type A structures should be constructed of reinforced or prestressed concrete or masonry. Structural steel may also form part of the main structure in conjunction with other materials. The structure should withstand the imposed loads, including the maximum external water head without undue movement or cracking other than at defined movement joints and the applied membrane should provide the appropriate protection against water and water vapour without disruption or decay. The structure should be adequately stiff at all stages of construction to minimize the occurrence of differential movements. This is particularly important where isolated pads or groups of piles or single piles are used as foundations.

Although some membranes will accept minimal movement most are damaged by differential movement or cracking of the supporting structure. Extra care should be taken when designing in mixed materials, e.g. concrete and masonry and in any unreinforced structures. Least risk of damage to the membrane is involved in a reinforced or prestressed concrete structure.

Type A structures should be designed to avoid movement or cracks which could damage or overstress the impervious membrane and should provide a firm, smooth and continuous support so that water pressure is transferred directly through the membrane to the load bearing structure without distortion of the membrane.

Cracks, other than hair line cracks, which occur before the application of the membrane, should be made good. A flexible membrane system should be capable of accommodating, without loss of waterproofing, unanticipated cracks of up to 0.6 mm wide and the structure should be designed accordingly.

NOTE 1 While some membranes may accommodate a greater crack opening in the supporting structure, the effect of sustained water pressure is to force the membrane into any opening in the load bearing structure with a consequent risk of membrane failure.

NOTE 2 Recommendations for the installation of impervious membranes are given in section 3.

5.1.2 Reinforced concrete

Structures in reinforced concrete should be designed and constructed in accordance with the recommendations of BS 8110 except when these are less stringent than 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 in accordance with the recommendations of BS 8110-1.

![Figure 7 — Tanked concrete basement carried on piles](image-url)
5.1.3 Prestressed concrete
Structures in prestressed concrete should be designed and constructed in accordance with the requirements of BS 8110 except where these are at variance with the specific recommendations of this code.

5.1.4 Plain concrete and masonry
Plain concrete walls should be designed and constructed to comply with the recommendations for mass concrete in Civil Engineering Code of Practice No. 2. Masonry should comply with the special recommendations of Civil Engineering Code of Practice No. 2. Additionally, masonry below damp-proof course should comply with the recommendations of BS 5628.

The position of construction joints in plain concrete should be specified and shown on the drawings. Joint details should provide thorough keying of the faces of the concrete. If movement joints are incorporated in a basement which is to be tanked, the tanking design details should incorporate waterproof movement joints at the same positions. Special consideration should be given to the resistance to shear at the junction of a wall and a base in order to cater for the pressure due to earth and water at all stages.

5.1.5 Pumping
It is essential that the site should be kept dry until the basement structure is completed. For this purpose, on open sites where any existing structures are sufficiently remote to be unaffected by groundwater lowering, 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. However where an internal render waterproofing system is to be used it is permissible for pumping to be discontinued as soon as the basement structure is complete. The render should be applied when the structure has been completed in order to minimize the risk of further settlement and cracking.

5.1.6 Basement carried on piles where tanking is used
Where a membrane is required for a basement which is supported on piled foundations it is essential that complete separation is provided between the pile caps and the basement and that the tanking forms a continuous membrane over the whole area of the basement.

The pile caps should be interconnected with stabilizing beams and a reinforced concrete slab not less than 150 mm thick should be provided over the whole area between the beams and monolithically with them to receive the membrane (see Figure 7).

5.2 Barrier materials
5.2.1 Mastic asphalt
Fully confined tanking products should be regarded as having the same compressive strength as the containing materials. When mastic asphalt is not fully confined to prevent extrusion the maximum design load should not exceed 650 kN/m$^2$ at ambient temperature.

5.2.2 Preformed waterproofing sheet membrane
The waterproofing membrane should be firmly supported by the load bearing structure so that external ground and water pressures are transmitted direct through the membrane to the supporting structure.

In the case of externally applied membranes, a protecting wall of masonry or appropriate rot-proof board should be built against the exposed membrane in accordance with the provisions of this code.

The allowable pressure on a bituminous membrane should be taken to be the same as the compressive strength of the containing load bearing material, provided that the membrane is fully confined between the smooth and voidless surfaces of the protection and the load bearing structures.

In the case where the dimension of confinement is 1 m or less from free edges the design pressure allowable on Class A bitumen sheetings should not exceed 50 kN/m$^2$ averaged over the zone of confinement.

For materials referred to in 4.1.4 the designer should obtain information on allowable stresses from the material manufacturer.

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1) Published by the Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1X 8BH
5.2.3 **Waterproof render**

Dense cementitious render modified with appropriate admixtures can provide a waterproof render. It can be applied internally or externally to all commonly used substructure materials and will resist considerable water pressure. Waterproof flexible details should be incorporated into the system to allow for movement joints or cracks in the structure (see Figure 8). Some types of stonework and lightweight building blocks are difficult or unsuitable for applications of this type. The product specification and/or manufacturer’s guidance should be checked before specifying. Prepacked polymer modified coatings consisting of an appropriate polymer, cement filler and admixtures which are applied by brush or trowel, can give a water and vapour proof coating.

5.2.4 **Polyurethane resin tanking**

Polyurethane resin tanking, when fully confined, should be regarded as having the same compressive strength as the containing materials. In unconfined situations the inclusion of glass fibre scrim in the membrane thickness will improve compressive strength and the manufacturer’s recommendations should be sought.

6 **Structures in watertight construction (type B structures: integral protection)**

6.1 **General**

It is permissible for reinforced concrete structures to be built, as already described, to solely structural standards and made waterproof by the application of an appropriate membrane. Alternatively, they should be designed to specifically prevent the ingress of liquid water. The design should ensure the prevention of differential settlement, the control of cracking and the provision of a dense impervious concrete structure. It should be recognized that such structures are susceptible to the percolation of water vapour and should incorporate a vapour proof membrane or barrier where the proposed use of the building dictates (see Table 1).

6.2 **Design considerations**

Basements should be designed to act monolithically with floors and walls continuously. Sharp changes in cross section of floors and walls should be avoided. Wall and floor thicknesses should not be less than 250 mm with reinforcement percentages assessed on a serviceability crack width limit state. Special consideration should be given to the provision of reinforcement at the junction of walls and slabs due to the bending flexure which can occur at such positions.

Cover to reinforcement on the external face should be determined in accordance with severe conditions of exposure as defined in Table 3.4 of BS 8110-1:1985. Where aggressive soils are present the specification of concrete quality should comply with Table 6.1 of BS 8110-1:1985. Service entries are particularly vulnerable to water penetration and their design and installation should be given careful consideration.

Where circumstances dictate section thicknesses less than 250 mm, and in consequence the recommended cover cannot be achieved, consideration should be given to the use of galvanized, epoxy coated, or stainless steel reinforcement.

Structures should be designed and constructed in accordance with BS 8110 or BS 8007, as appropriate to the required category of performance (see Table 1), except where there is variance with the specific recommendations of this code.

For grade 1 basements, design should be to BS 8110-2 with calculated crack widths not exceeding 0.3 mm. Waterstops should be used in all construction joints and the sequence of construction should be such as to avoid trapped panels, a closing panel being limited in length and the reinforcement lapped. Wall panels should be cast as soon as possible after casting floor bays with kickers to minimize differential movement.

The lowest level of basement floor slabs should be cast either in bays or as a series of continuous strips with transverse induced contraction joints provided to ensure that cracking occurs in predetermined and protected positions. Closing pours should be of limited size with reinforcement lapped and coincide with similar closing pours in walls wherever possible. Longitudinal joints between the strips should form complete contraction joints.

For the lowest level of basement floor slabs which contain internal column foundations, full account should be taken of the upward pressure exerted on the floor slab surrounding the column base induced by the compression caused by the local highly concentrated column load.

For grade 2, 3 and 4 basements, where reliance is placed upon the structure to prevent the ingress of water, reinforced concrete design and construction should comply with BS 8007 and elements should be so proportioned that concrete strengths and maximum cement contents referred to therein can be adhered to.
(a) Movement joint: major movement

(b) Movement joint: minor movement

Toughened shoulders may need to be provided where the joints are in floors subject to heavy traffic loading.

NOTE 1. Joints (a) and (b) are suitable for wall or floor use, and should be continuous through the structure.

NOTE 2. Where large movements of the service pipe are expected the pipe should be led through a sleeve sealed as shown and a mechanical seal provided between the sleeve and pipe.

Figure 8 — Movement joints and service pipe penetration in internal waterproof cementitious render
6.3 Site conditions

It is essential that the site should be kept free of water during and prior to the concreting of the basement. For this purpose on open sites where any existing structures are sufficiently remote to be unaffected by groundwater lowering, dewatering or pumping from carefully arranged pumps 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 (see 3.4).

It is permissible for tubes with removable caps to 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.

NOTE 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, clean and properly prepared joints and adequate curing.

7 Structures with internal drainage (type C structures: drained protection)

7.1 General

Where an internal wall and floor cavity is to be provided in grades 3 and 4 basements (see Table 1), the reinforced concrete structure should be designed in accordance with BS 8110 and comply with the recommendations given in clauses 5 and 6 of this code.

Other materials should be designed and constructed as recommended in 5.1.4.

7.2 Floor cavities

The drainage tiles used to cover the floor of a basement should be of clay or concrete and be of sufficient strength to withstand loadings from walls, plant, equipment, vehicles, etc., appropriate to its intended use.
The tiles should be of a close fitting non rocking type to avoid breaking up of finishes due to movement in service. Special consideration should be given where the tiles cross a movement joint in the main structure.

The surface on which the tiles are laid should be firm and smooth to allow free flow of any water penetrations and should be level or laid to a slight fall depending on the spacing of the water collecting points, either channels or gullies, provided within the structure. It is permissible for channels or gullies to discharge either into a sump or to a cavity wall drainage channel, the collected water then being pumped or connected to a drainage system. Where no-fines concrete is used as a drainage layer, it should have an adequate thickness to withstand loading (min. 300 mm) and avoid blockages.

7.3 Wall cavities
The inner skin of the cavity wall construction should be of masonry. Care should be taken during its construction to keep the cavity clear and free from debris and mortar droppings. Any ties used to stabilize the inner skin should be non ferrous and dimpled or twisted to shed any water which may collect on them.

NOTE The inner skin is normally non load-bearing.

7.4 Cavity ventilation
Wall cavities should preferably be ventilated to allow a through draught of air and prevent the build up of a saturated atmosphere in the cavity. Any excess moisture should be free to drain to the wall and floor drainage system (see Figure 4 and Figure 5).

NOTE Openings at intervals at the top and bottom of the inner skin may be sufficient but it is preferable if the air can be exhausted direct to the outside of the building. Mechanical ventilation may be necessary where air movement is limited.

8 Inspection and waterproofing of existing basements

8.1 General
In existing buildings, when refurbishment work is being considered, the space available in basements or semi basements is often converted into habitable rooms. Their previous use may have been for other purposes where dampness was of less concern than for the proposed use.

8.2 Inspection and survey
Initially a comprehensive survey should be undertaken of the existing water proofing arrangements. There may have been none or there may have been previous attempts to mask dampness by dry lining or a cementitious render. It should be established which walls are earth retaining and which free standing. Where an external cavity is found checks should be made that the cavity is not bridged by debris, that the drainage is still functioning and not silted up and that air bricks are not obstructed by soil or vegetation.

NOTE 1 The external cavity form of construction is sometimes encountered but is not immediately obvious. In this a retaining wall has been built with a cavity between it and the load-bearing wall. This cavity is normally closed/capped with a plinth, drained at the base and ventilated by air bricks.

The basement floor should be thoroughly surveyed for signs of moisture penetration. Correction of any problems should be considered for integrated treatment with the walls.

The survey should include any constructions such as garden walls and arches under steps which abut the main structure as these are a potential source of moisture transfer.

NOTE 2 Moisture from the ground can move across abutting constructions at any level and in extreme conditions running water may be encountered.

8.3 Tanking systems and methods
The design and construction of tanking systems for waterproofing existing structures should comply with clause 5 and appropriate clauses in section 3.

Methods available for waterproofing existing structures are similar to those for new buildings although the problem will need to be tackled from inside the building. It should be remembered that some internal membranes require a loading skin of masonry and this arrangement will reduce the internal dimensions. Similarly a drained cavity construction will take up space. Cementitious renders intrude by the thickness of the applied coats.

Where there is only limited moisture penetration, costs can be kept to a minimum by the use of proprietary lathings which are dry lined or plastered over. Ordinary gypsum based materials should not be used as these can act as a poultice and draw hygroscopic salts from the structure if defects occur in the lathing.
Internal partition walls built without a damp proof course should be treated. A membrane damp proof course can be cut in or, alternatively, a chemical injection system should be used in accordance with BS 6576. The use of a chemical injection system is not recommended for vertical line application at the junction of a partition wall and an earth retaining wall. In such cases, where physical separation is not practicable, a cementitious render should be considered on party and internal walls.

Arches under steps and barrel vaults under pavements, etc. should be given special consideration. Where they are to be retained they should be waterproofed to the appropriate standard for the intended use of the area. They should be thoroughly dried and waterproofed by the use of a superimposed membrane or an internal cementitious render or by the installation of an inner skin of sheeting material provided with drainage from the formed cavity to a drainage system or pump. Where different methods are used in a single basement area care should be taken to ensure continuity of integrity.

8.4 Control of condensation
Whichever method of waterproofing is selected, arrangements should be made to minimize subsequent dampness from controlling condensation (see BS 5250). When natural ventilation cannot be provided in condensation prone areas, e.g. bathrooms and kitchens, mechanical ventilation should be specified.

8.5 Decorative finishes
Recently waterproofed walls should not be papered or painted for at least 6 months after treatment other than with water based emulsion paint which will allow walls to dry through the paint film and can be applied as soon as the internal surface is dry. In all cases the paint manufacturer should be consulted regarding suitability of product.

8.6 Provision for fixings
It is essential that any tanking membrane should not subsequently be pierced by drilling, nailing or fixings. The siting of fixings should be determined before the walls are waterproofed so that special provisions can be made to ensure continuity of the membrane.

8.7 Land drainage
In order to reduce the water pressure on a wall to acceptable levels adequate land drainage should be provided as deep as possible and at a distance of approximately 1 m from the wall. The drains should be surrounded in filter material to prevent silting or provided with inspection chambers and/or rodding points to allow for cleaning.

8.8 Pressure grouting
Where pressure grouting is used to repair defective concrete basements the work should be entrusted to a specialist grouting contractor.

8.9 Repair by waterproof renderings
Where repairs to the waterproofing of a concrete structure are carried out by the application of a waterproof rendering, the work should be entrusted to a specialist contractor.

It should not be necessary to keep the site clear of free water by pumping, dewatering or other means. Where infiltration of ground water is occurring under pressure, special waterproofing admixtures should be used in the mortar to accelerate the rate of hardening and provide a water stopping capability.

The application of render to repair a leak is similar in method to that described for waterproof rendering (see 5.2.3). It is essential to cut out defective areas and prepare the surface.
Section 3. Tanking systems

9 Mastic asphalt tanking

9.1 General

In order to ensure that the substructure provides a suitable base on which to lay mastic asphalt, attention should be given to the following factors.

a) Horizontal surfaces to which mastic asphalt tanking is to be applied should be level and free from irregularities such as ridges, dips, fins or concrete or mortar droppings. The surface of the concrete should, therefore, be given a wood-floated finish and be laid plane and true to allow the specified thickness of mastic asphalt to be applied uniformly.

b) The concrete slab on which mastic asphalt tanking is applied should be designed and laid in a manner to ensure that any superimposed loads, such as protective screeds, concrete loading slabs and any plant, equipment or machinery subsequently used or installed, can be supported without deflection or other movement which could induce cracking in the mastic asphalt tanking.

c) It is essential that the vertical asphalt is applied to structural walls capable of resisting any anticipated internal or external loads or pressures.

d) In order to ensure continuity of the tanking, the provision of openings for services, pipes, cables, etc. through walls or floors which are to be tanked should be avoided. However, where such openings are essential, special treatment should be provided around the opening (see Figure 9).

e) To ensure continuity of the mastic asphalt tanking in a basement supported on piled foundations it is essential that there should be complete separation between the floor of the basement and pile caps. The mastic asphalt tanking should be laid as a continuous membrane over the entire area of the basement floor.

Methods of achieving such continuity are shown in Figure 7 and Figure 10.

9.2 Externally applied tanking

9.2.1 Excavation should allow not less than 600 mm of working space outside the walls to be treated.

9.2.2 A structurally sound base should be provided, with an even surface to receive mastic asphalt, and 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 11).

9.2.3 As soon as the laying of the horizontal mastic asphalt has been completed, it should be covered by an isolating layer and a screed of sand and cement 50 mm in thickness to prevent damage. Temporary protection should be provided to the projecting length of base. The horizontal loading coat of concrete or structural slab should be placed as quickly as possible thereafter.

9.2.4 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 masonry wall or protective board. When the protective wall is of brickwork on edge the frogs should not be in contact with the asphalt. Dry-jointed blockwork or any form of masonry should not abut directly against the asphalt but should be built in accordance with 9.3.4.

Figure 9 — Asphalt tanking: treatment of pipes
9.3 Internally applied tanking

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

9.3.2 The structural slab forming the base should be provided with an even surface to receive the horizontal mastic asphalt and walls should be built up to the full height of the tanking before the mastic asphalt coat is commenced.
9.3.3 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.

9.3.4 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 and laid on an isolating layer should be applied to prevent damage to the mastic asphalt. The protective screed should be followed by the laying of the structural floor and walls. When masonry 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 (see Figure 12).

9.4 Pumping

It is essential that the site be kept dry until the basement is completed. For this purpose, dewatering or pumping from suitably positioned sumps with appropriate drainage channels should be continued whilst the laying of the impervious membrane is in progress and until all loading coats have been 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.

9.5 Site preparation

9.5.1 Key for tanking vertical and sloping surfaces

9.5.1.1 Concrete surfaces. Where vertical or sloping concrete is very smooth, e.g. where steel shuttering has been used, some form of surface treatment is necessary to provide a satisfactory key for the mastic asphalt. One of the following treatments may be adopted and may also be necessary if excessive blowing is experienced:
   a) removal of surface laitence by wire brushing;
   b) application of a proprietary sand and cement slurry incorporating a plasticizing agent in accordance with the manufacturer's recommendations;
   c) a light application of a proprietary high bond primer.

Damage to the mastic asphalt and loss of key will be caused by excessive use of mould oil.

9.5.1.2 Lightweight concrete. Mastic asphalt should not be applied directly to lightweight concrete, which should be rendered with a suitable sand and cement facing, or treated with a proprietary sand and cement slurry incorporating a plasticizing agent in accordance with the manufacturer's recommendations.

9.5.1.3 Brickwork. The horizontal joints in brickwork should be lightly raked and well brushed out or bagged. Where mastic asphalt is to be applied to old brickwork, the surface should be cleaned and a proprietary high bond primer applied. Blistering or loss of bond may be experienced if mastic asphalt is applied direct to calcium silicate (sandlime) bricks or brickwork bedded in unduly hygroscopic mortars.

9.5.1.4 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.

9.5.2 External angles

The external angles of concrete and masonry should be rounded-off to allow the full thickness of mastic asphalt to be applied continuously around the angle.

9.6 Thickness and finish

On horizontal surfaces and on slopes 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.

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.

9.7 Applications: special conditions

9.7.1 Boiler houses, sumps and fuel oil storage areas

Mastic asphalt tanking will be seriously damaged by contact with oils. In tanked basements where fuel oil is stored or spillage of oils may occur provision should be made for an oil resisting lining which will resist saturation of the concrete loadings by oil leaks and consequent damage to the tanking.
9.7.2 Ventilated boiler bases
Failure of concrete slabs (with consequent failure of the mastic asphalt tanking), due to differential settlement caused by drying out of the sub-soil by heat from industrial boilers, can occur unless the floor is adequately ventilated by air spaces immediately below the boiler or by other effective means. The construction should be such that at no time is the mastic asphalt subjected to temperatures in excess of 30 °C.

9.7.3 Hot water pipes
Where service pipes carrying hot liquid pass through the mastic asphalt tanking special detailing and treatment may be required to provide both insulation and continuity of the tanking.

9.7.4 Manholes
If manholes are located in the basement area the designer should ensure that the manhole structure is fully contained in a mastic asphalt membrane. The requirement for drains discharging into and draining the manhole are identical to those for other service pipes penetrating the tanking. Provision should be made for protection of the tanking from the discharge of aggressive liquids into the manhole.

9.7.5 Discharge of hot liquids
When a sump or manhole is not in a tanked area and is lined with mastic asphalt the frequent discharge of hot liquids combined with appreciable fluctuations in the level of the liquid in the tank may cause slumping of the lining. Provision should be made to provide permanent structural support for the mastic asphalt in the form of an inner brickwork lining.

10 Bitumen sheet tanking
10.1 General
In order to ensure that the substructure provides a satisfactory base on which to apply bitumen sheeting, attention should be given to the following factors.

a) Concrete should be free from ridges and indentations and should be laid to a true and even surface, preferably with a wood float finish.

b) Brickwork and blockwork should have flush joints.

c) In order to ensure continuity of the tanking, the provision of openings for services, 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 13.

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

10.2.2 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. An example is shown in Figure 14.
Figure 13 — Bitumen sheet tanking: treatment of pipes

Figure 14 — Externally applied bitumen sheet tanking: junction of vertical and horizontal sheeting
10.2.3 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, laid on an isolating layer. Temporary protection should be provided to the projecting length of the base. The horizontal loading coat of concrete or structural slab should be placed as quickly as possible thereafter.

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

10.3 Internally applied tanking

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

10.3.2 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.

10.3.3 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 and laid on an isolating layer should be applied to the horizontal surface to prevent damage to the sheeting (see Figure 15).

10.3.4 The concrete structural walls and floors should then be constructed and further lifts of bitumen sheeting should then be provided to the full height of the walls.

10.4 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.

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**Figure 15 — Internally applied bitumen sheet tanking: method of forming internal angle**
10.5 Number of layers

It is recommended that the waterproof tanking membrane consists of not less than two fully bonded layers of bitumen sheeting on both horizontal and vertical surfaces in Type A construction. The membrane should be reinforced by extra strips of material at angles, steps and corners.

The provision of a vapour control membrane in Type B and Type C construction is optional and may be limited to a single layer.

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.

11 Internally applied cementitious waterproof render

11.1 General

11.1.1 In order to ensure that the sub-structure provides a satisfactory base upon which to apply cementitious waterproof render, attention should be given to the following.

a) The structure whether it be concrete or masonry should have sufficient structural strength to withstand the applied loads without undue deflection or movement at positions other than designated movement joints.

b) The surface of the structure should allow adequate adhesion of the applied render (lightweight blocks and some types of igneous and sedimentary rocks are unsatisfactory).

c) The provision of openings for services, pipes, cables etc. through walls or floors which are to be tanked should be avoided in order to ensure continuity of tanking. Where, however, it is essential to provide such openings, special treatment around the openings will be necessary, such as is shown in Figure 8.

d) Special provisions are required for internal fixings.

e) Designated movement joints should be waterproofed by incorporating flexible details. (see Figure 8).

f) Unless there is clear evidence that all movement has ceased, any cracks in the structure should be treated as if they were movement joints.

g) Due to the susceptibility of this type of waterproofing to disruption by building movements, in new construction the waterproofing should be left until most or all the structural weight has been added. This allows for settlement of the building and also tends to avoid interference between the waterproofers and other trades.

h) Because the material is applied from the inside there is no need to provide any working space outside the wall.

11.1.2 Because this type of waterproofing is applied to the inside of a new structure, which is in itself likely to diminish effectively the ingress of water, there is no need to avoid back-filling the excavation or removing de-watering pumps at the earliest possible moment. Such flooding as may occur of the basement space can be readily removed by internal pumps and infiltration of water even under considerable pressure can be stopped through the use of rapid setting waterproofing admixtures.

11.2 Site preparation

11.2.1 Brickwork or blockwork

Brickwork or dense concrete blockwork laid in cement mortar normally provides a satisfactory substrate. Rough textured blockwork and riven, grooved or serrated bricks should need no more preparation than thorough cleaning and wetting down. Normal and glazed bricks and fair-faced blockwork should be defaced by bush hammering or by similar means to provide a clean, sound, rough surface which will also need washing and wetting down to prevent excess suction.

11.2.2 Concrete

Concrete will need preparation by bush hammering or new concrete may be given a rough surface by the application of retarders to the shutters and vigorous brushing of the concrete surface after stripping to remove all retarded cement paste and to expose the aggregate. Of these two methods, bush hammering is preferred because of the angular roughness of the finished surface.

11.2.3 Natural stone

Fair-faced limestone construction is a satisfactory substrate, subject to mechanical preparation as recommended for concrete (see 11.2.2). Other rocks can also provide sufficient adhesion but the very hard and very soft types (e.g. granite and sandstone) provide little adhesion and require special techniques to ensure success.
Floors of brick or stonework are unlikely to be able to resist the uplift forces which may develop after waterproofing. They therefore require to be replaced or supplemented by a reinforced concrete floor which can be waterproofed on the inside or, if of waterproof construction itself, linked into a waterproof render applied to the insides of the walls.

Multi-coat waterproof renders should be applied to walls to a total nominal thickness of up to 20 mm whilst on floors a finished screed of 40 mm nominal thickness gives the strength necessary for normal trafficking. Walls and floors should be finished with a wood float, the render generally following the existing line of the walls and floor, with the screeds being laid flat or to falls with normal tolerances. Walls may be finished to a plumb and dot finish if required. The first two coats on the wall should be continued through the corner onto the floor surfaces, to achieve a staggered overlap with the floor coats (see Figure 16).

**Figure 16 — Formation of lap and corner joints in cementitious waterproof renders**
11.4 Curing
Curing of the cement rich mixes used is often unnecessary due to the still, humid conditions which are to be found in a previously wet basement and although some surface crazing may occur the main waterproofing layers of render are protected and cured by the weaker top coats. However, in drier conditions, normal curing by covering or water spraying for a period up to 7 days should be carried out.

12 Polyurethane resin tanking

12.1 Site preparation
12.1.1 Horizontal concrete of appropriate design strength should be well compacted and finished by trowelling without excess laitence to provide a dense, smooth finish free from defects.
12.1.2 Vertical concrete should be smooth fair-faced with blow holes and other surface defects made good or ground down. Brickwork, dense concrete blocks, etc. should be flush pointed and any defects made good.
12.1.3 Liquid resin tanking may be applied to damp or dry surfaces in temperatures ranging from 0 °C to 60 °C. Surfaces should be ice-free and dry weather should be expected for at least 4 h.
12.1.4 Because these products have a pot life of not more than 45 min it is essential that all surfaces, trowels, spray equipment etc. are ready before mixing starts.

12.2 Externally applied tanking
12.2.1 Not less than 600 mm of working space outside the walls should be allowed for excavation.
12.2.2 A suitably finished structurally sound base should be provided. To ensure adequate joining of horizontal and vertical tanking the base should extend a minimum 150 mm beyond the outside edge of the wall.
12.2.3 On completion of application the resin tanking should be covered to prevent damage with a minimum 50 mm thick cement mortar screed. Prior to screeding over the 150 mm wide extension, the cured tanking should be dusted with cement and covered by building paper or glass fibre tissue. The horizontal loading structural concrete should be laid as quickly as possible thereafter.

12.3 Internally applied tanking
When applied as an internal tanking system, the tanking should be loaded against back pressure. If a brick or concrete block inner skin is used, a minimum gap of 20 mm should be allowed between the membrane and skin. This gap should be completely filled with cement mortar as the wall is built, thus ensuring a firm loading against the resin tanking.

12.4 Protection
12.4.1 24 h after laying, the resin tanking will normally be cured sufficiently to accept rubber-soled foot traffic. Any tackiness of the surface should be neutralized by dusting with dry cement before operatives are allowed on the area. A cementitous slurry will give some protection but on barrow-runs or where men will be working on the membrane, hardboard or fibreboard should be used to protect against damage.
12.4.2 Steel reinforcement should not be prefabricated on nor laid directly against any membrane. A minimum 50 mm thick cement-mortar screed may be laid over the membrane to provide a protective wearing and working surface.
12.4.3 Below ground, resin tanking applied to exterior wall surfaces should be protected against back filling. This protection should be by masonry skin, bonded rendering, or protective board.

13 Self-adhesive rubber bitumen membrane tanking system

13.1 General
13.1.1 Materials
Clause 13 deals with the use of preformed self-adhesive rubber bitumen materials consisting of a surface layer of polythene or cross-orientated polythene film and a backing layer of elastomer modified bitumen adhesive.
These materials may be used either on their own or in conjunction with waterstops to prevent the ingress of water and water vapour. They may be applied by both internal and external tanking techniques.

13.1.2 Surface preparation
The surface onto which the membrane is to be adhered should be smooth and free from ridges and indentations.
Concrete surfaces, unless cast against shuttering, should be worked to a true and even surface preferably using a wooden float.
Masonry surfaces should be flush jointed. If the masonry is uneven or has an open texture surface or the joints are not flush, it should be rendered and allowed to dry before the membrane is applied.

13.1.3 Corners

Sharp internal or external corners should be avoided wherever possible. External corners in concrete structures should be cast with a minimum 25 mm × 25 mm splay. Angle fillets should be provided at internal corners.

13.1.4 Openings

In order to ensure continuity of the tanking, the provision of openings for pipes, cables, etc. through walls or floors which are to be tanked should be avoided. Where, however, it is essential to provide such openings, special treatment will be necessary.

13.2 Externally applied tanking

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

13.2.2 A concrete blinding should be provided at least 75 mm in thickness, with an even surface to receive the self-adhesive membrane. The base should extend at least 200 mm beyond the outside edges of the wall to provide the junction to be formed with the vertical work.

13.2.3 As soon as the laying of the horizontal membrane 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.
13.2.4 Alternatively, the membrane may be protected with a rot-proof protection board. The advantage of this method is that the protection is immediate and does not damage the membrane when placing “protection” screeds. These boards may be used to provide temporary protection to the set-off.

13.2.5 As soon as possible after the vertical membrane has been applied to the outside of walls, it should be protected against damage by the erection of a masonry wall (see Figure 17) or by rot-proof board which should be bonded to the membrane.

13.3 Internally applied tanking

13.3.1 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 membrane.

13.3.2 The structural slab forming the base should be laid with an even surface to receive the horizontal membrane. Walls should be built up to the full height of the tanking before the membrane is applied.

13.3.3 As soon as the reinforcing strips, horizontal membrane and the vertical membrane to the first lift of the structure have been applied, the horizontal membrane should be protected by the placing of a cement and sand screed (minimum thickness 50 mm) or by a rot-proof protection board.

13.3.4 The concrete structural walls and floors should then be constructed and further lifts of the membrane should be provided to the full height of the walls. (See Figure 18).

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Figure 18 — Example of self-adhesive damp proof membrane applied internally

All dimensions are in millimetres.
13.4 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 tanking is in progress, until all loading coats have hardened and the structure has developed sufficient strength to resist the full water pressure.

13.5 Finish

At the top of retaining walls the vertical membrane should be taken up at least 150 mm above the ground level, to be terminated into a 20 mm × 20 mm chase and sealed with a bitumen mastic, or linked to an approved damp-proof course. Where the provision of openings for services through the tanking system is unavoidable the pipes should be treated with reinforcing strips and collars (see Figure 19).

Figure 19 — Typical details of service penetrations through self-adhesive membranes
Section 4. Waterstops

14 General
In some circumstances the use of waterstops is considered desirable. Waterstops are preformed strips of durable impermeable material that are wholly or partially embedded in the concrete during construction. They are located across joints in the structure to provide a permanent liquid-tight seal during the whole range of joint movements. Waterstops are usually proprietary materials made from flexible PVC, rubber or metal and should be used as recommended by the manufacturer. It is essential that the concrete placed around the waterstop is well compacted and that the waterstop be fixed and maintained firmly in position until the concrete placing is completed.

Typical applications of waterstops are shown in Figure 20.

The design of the structure should generally provide for the continuity of the waterstop system, particularly between floor and wall systems. The waterstop manufacturer should, when possible, be consulted at the design stage to avoid complicated or unnecessary junctions.

Prefabricated junction pieces are available from the waterstop manufacturers to reduce the number of joints to be made during installation. Site jointing should be restricted to butt joints between the same sections. External and internal waterstop types are provided which may also be used in combination by utilizing factory prefabricated transition pieces.

15 External waterstops
These are applied to the external face of the concrete structure and provide a system which prevents entry of groundwater at source. All joints between adjacent pours should be sealed by using a waterstop. Such waterstops offer the following advantages over the use of internal types.

a) Both layers of steel are protected.

b) The waterstop is supported by either the blinding layer or wall shutter and cannot be displaced.

c) The waterstop is placed and jointed before steel is fixed.

d) Concreting is not interrupted by waterstops in the centre of the shuttering.

Waterstops of the external type are not restricted in their maximum dimension, but should not generally be less than 240 mm for a watertight construction. External waterstops must never be cast inverted as this causes compaction difficulties for the concrete.

16 Internal waterstops
These are placed centrally in the concrete and may be used in basement walls in either the horizontal or vertical plane. Internal waterstops are not recommended for use in floor or roof installations due to compaction difficulties for the concrete. Internal waterstops should always be specified in place of external waterstops when the wall is to be tanked with mastic asphalt or other materials likely to have an adverse reaction with the waterstop material.

The size and profile of the waterstop should be selected by the designer. A large range of waterstops of varying profiles is available.

Internal waterstops are limited in their optimum size, as the overall width of a centrally placed waterstop should not exceed the thickness of the wall into which it is cast. Internal waterstops should be carefully supported by wires or other means in accordance with the manufacturer’s instructions to prevent displacement when the concrete is placed and compacted.

17 Limitations
PVC and rubber waterstops can withstand high pressures with fairly small extension or, alternatively, can accommodate relatively large extension at more modest pressures. Seepage problems are normally more related to pressure than extension. Further protection can be provided by using other materials in conjunction with waterstops. Joint sealers and filler boards can provide for additional movement and self-adhesive rubber bitumen sheetings can prevent the penetration of water vapour.

Further guidance is given in BS 8007 and BS 6213. Manufacturer’s recommendations should be followed for proprietary systems.
Figure 20 — Typical applications of waterstops
Publications referred to

BS 743, Specification for materials for damp-proof courses.
BS 747, Specification for roofing felts.
BS 2000, Methods of test for petroleum and its products.
BS 2000-49, Penetration of bituminous materials.
BS 2000-58, Softening point of bitumen (ring and ball).
BS 2000-72, Viscosity of cut-back bitumen.
BS 5250, Code of practice for control of condensation in buildings.
BS 5628, Code of practice for use of masonry.
BS 5930, Code of practice for site investigations.
BS 6100, Glossary of building and civil engineering terms.
BS 6100-2, Civil engineering.
BS 6213, Guide to selection of constructional sealants.
BS 6399, Loading for buildings.
BS 6576, Code of practice for installation of chemical damp-proof courses.
BS 6577, Specification for mastic asphalt for building (natural rock asphalt aggregate).
BS 6925, Specification for mastic asphalt for building and civil engineering (limestone aggregate).
BS 8000, Workmanship on building sites²).
BS 8000-4, Waterproofing.
BS 8007, Code of practice for design of concrete structures for retaining aqueous liquids.
BS 8110, Structural use of concrete.
BS 8110-1, Code of practice for design and construction.
BS 8301, Code of practice for building drainage.
CP 3, Basic data for the design of buildings.
CP 3:Chapter V-2, Wind loads.
CP 102, Code of practice for protection of buildings against water from the ground³).
Civil Engineering Code of Practice No. 2:1951³).
Building Research Digest No. 250 1981⁴).

²) Referred to in the foreword only.
³) Available from the Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1X 8BH.
⁴) Available from BRE, Garston, Watford, Herts, WD2 7JR.
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