

BASEMENTS

INTRODUCTION

A basement can be considered the lowest floor of a building, generally, but not always, fully below ground. They may be required to provide whole or partial support to the remainder of the structure.

Some of the earliest surviving basements are medieval dungeons built into the lower storeys of the keeps that were often cut into the solid bedrock of the site. In later centuries, crypts were frequently built under churches and cathedrals.

Many existing Georgian terraces in London and other cities appear to have basements; they were often used as accommodation for domestic staff. Basements fell out of favour after the First World War with fewer people entering domestic service, therefore reducing the need for accommodation 'below stairs'. In addition, the demand for cheap volume housing soared and large areas of land were released for development in the suburbs.

With a shortage of land and planning regulations requiring efficient land usage and greater housing density, basements are back in vogue. The provision of basements to new housing improve land utilisation by increasing the useable living space per plot, thereby optimising land usage whilst helping to reduce the environmental impact of new housing. Basements can provide up to 50% more living space for a two-storey house and up to 100% for a bungalow.

Basements offer high standards of thermal performance; heat losses through basement floors and walls are less than those at ground and upper floor levels. Living space below ground also offers excellent acoustic insulation.

Basements can assist in overcoming poor ground conditions on brownfield sites or sloping land. Poor ground conditions often requires deep excavations and foundations which favour the provision of basements in the excavated space. Considering the average foundation depth in Britain is now 1.4m, the additional cost of constructing a full or semi-basements is becoming a more cost effective option in comparison to the high costs of conventional substructures on these problem sites.

Many commercial properties and industrial buildings include the provision of basements not only to maximise the use of valuable land space below ground, but in some cases to support the site boundary, avoiding settlement or damage to adjacent buildings or roads.

FUNCTIONAL REQUIREMENTS

Walls that exist below ground level such as those associated with the construction of basements perform rather differently from traditional low rise construction forms, however, they do share common functional requirements in that they must maintain structural stability, durability, exclude moisture etc, the means by which this is achieved may differ considerably.

The structural walls of a basement below ground are retaining walls that must offer resistance to the soil and ground water pressures in addition to assisting with the transmission of loads from the superstructure to the foundations. The walls are subjected

to axial pressures from the building above ground and lateral pressures exerted by the mass of earth, which surrounds the walls. These lateral loads must be adequately resisted if the stability of the wall is to be maintained. This can be achieved by bracing the walls below ground level with temporary supports or to utilise the floors as permanent bracing. Alternatively, these loads can be resisted by constructing walls that are sufficiently robust to cope with the stresses involved.

The ground environment in which some elements of the structure are sited can be hostile to construction materials frequently used. The presence of aggressive salts, methane and other gases, groundwater, particularly in high water table levels can impede the construction process and can affect the durability of the building elements. The use of materials with low porosity is recommended for use below ground as they are less likely to suffer deterioration. Porous materials tend to absorb ground moisture, which expands on freezing, causing spalling and friability of the material. Non porous materials tend to perform better in terms of moisture exclusion as they do not promote moisture migration through capillarity.

BASEMENT USAGE

There are many uses for basements including domestic accommodation, car parking, storage facilities etc. Table 1 of BS8102 relates acceptable performance levels to basement usage, and defines them in Grades 1 to 4.

Grade	Basement usage	Performance level	Form of construction (see Figure 6)
1	Car parking; plant rooms (excluding electrical equipment); workshops	Some seepage and damp patches tolerable	Type B. Reinforced concrete design in accordance with BS 8110
2	Workshops and plant rooms requiring drier environment; retail storage areas	No water penetration but moisture vapour tolerable	Type A. Type B. Reinforced concrete design in accordance with BS 8007
3	Ventilated residential and working areas including offices, restaurants etc., leisure centres	Dry environment	Type A. Type B. With reinforced concrete design to BS 8007. Type C. With wall and floor cavity and DPM
4	Archives and stores requiring controlled environment	Totally dry environment	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

Figure 1 – Table 1 BS8102:1990 Code of Practice for Protection of Structures against Water from the Ground

The design of basement walls and method of water protection employed is related to the standard required of the internal environment. BS 8102 describes three types of basement wall structure classified as types A, B and C.

TYPE A STRUCTURES

Type A structures have no integral protection against water penetration and therefore rely on an impervious material applied to the structure, internally or externally to exclude

moisture. This process is often referred to as 'tanking'. It must be able to withstand hydrostatic pressures from groundwater together with any additional loadings.

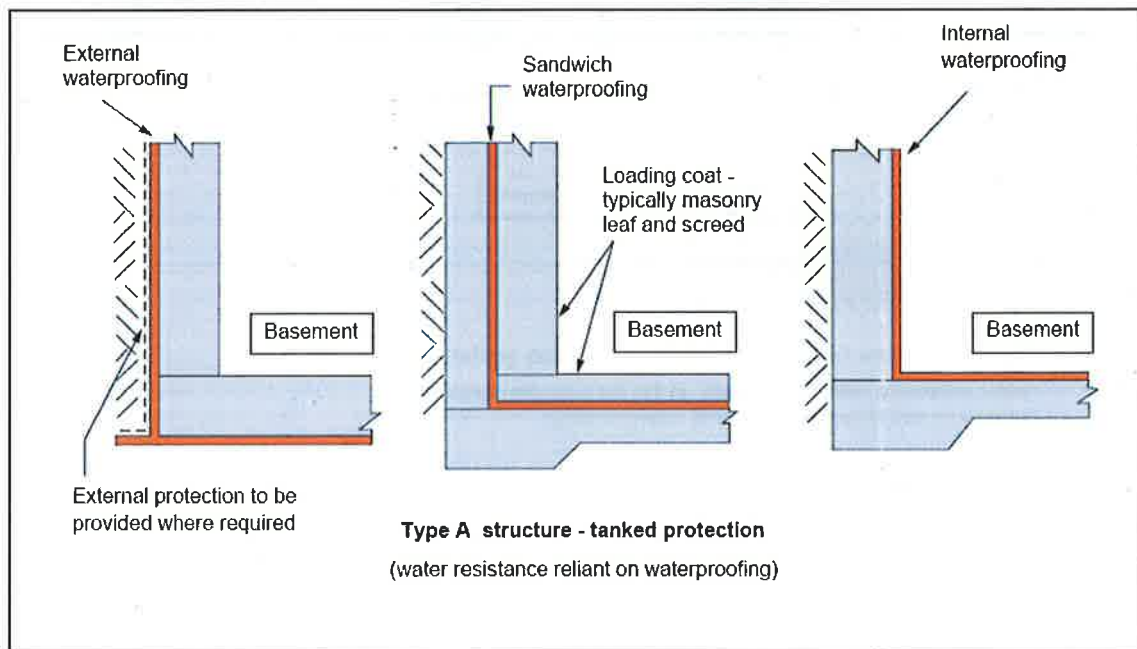


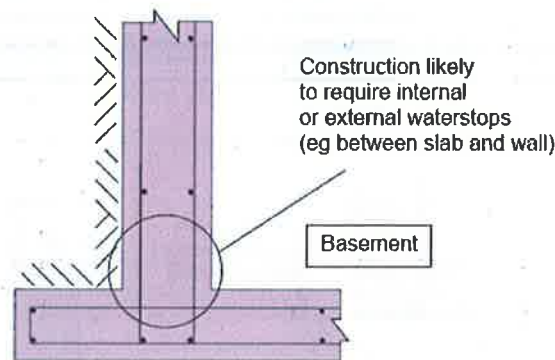
Figure 2 – Type A Structures – BCA “Approved Document Basement For Dwellings”

If the waterproofing is applied externally, hydrostatic pressures will keep it firmly in place. However, should any defects occur in the waterproof membrane, access is severely restricted and it may prove difficult to rectify them. Alternatively, it may be applied to the internal face of the walls; although they are more readily accessible they are at greater risk of damage or being driven off the face of the walls by hydrostatic pressure from ground water. This can be overcome by sandwiching the membrane between an internal skin of blockwork and the external wall, it also allows for fixings to the internal face without penetrating the membrane.

TYPE B STRUCTURES

Type B structures can be considered as ‘structurally integrated protection.’ The waterproofing is provided by the structural walls, which are invariably built of dense monolithic concrete using high quality reinforced or prestressed concrete, designed within certain strict parameters including the use of good materials, good workmanship, and attention to design detail and on site methods to ensure it is water-resistant. Most designs are carried out in accordance with the recommendations of BS8007 or BS 8110, which gives guidance on grades of concrete and steel spacing.

This form of construction may not be as resistant to water vapour and therefore the addition of a waterproof coating lining or tanking should be used.



Type B structure - structurally integral protection (water-resistant concrete)
 (water resistance reliant specifically on the the concrete construction
 but may be combined with additional waterproofing)

Figure 3 – Type B Structures – BCA “Approved Document Basement For Dwellings”

The watertightness of dense concrete mixes depends on two factors:

- Water/cement ratio
- Degree of compaction

The hydration of cement during the hardening process produces heat, therefore to prevent early stage cracking the temperature changes within the hardening concrete must be kept to a minimum. The greater the cement content the more heat is generated; therefore the mix should contain no more cement than is necessary to fulfil design requirements. Concrete with a free water/cement ratio of 0.5 is watertight and although the permeability is three times more at a ratio of 0.6 it is for practical purposes still watertight, anything above this ratio and the concrete becomes progressively less watertight.

For lower water/cement ratios the workability of the mix would have to be increased, typically by adding more cement, to enable the concrete to be fully compacted.

If the elements of good design, materials and workmanship are adhered to, watertight concrete can be produced without the use of admixtures. If they are used they must be carefully chosen and used to obtain a specific objective:

- Water reducing admixtures – used to improve workability
- Retarding admixtures – to slow down the rate of hardening
- Accelerating admixtures – to increase the rate of hardening. Can be useful for low temperatures, however calcium chloride is not suitable for reinforced concrete
- Water-repelling admixtures - to block or impede the flow of water through the natural capillaries in hardened concrete. Will not improve poor quality or porous mixes

- Air-entraining admixtures - cause tiny air bubbles to stabilise within the cement paste, increasing workability and lowering the water content.

JOINTS

Joints are formed in basement construction to provide for movement accommodation (expansion joints) or to create a convenient stopping point in the construction process (construction joints). Joints are lines of weakness which will leak unless carefully designed and constructed, therefore, they should be simple in concept and easy to construct.

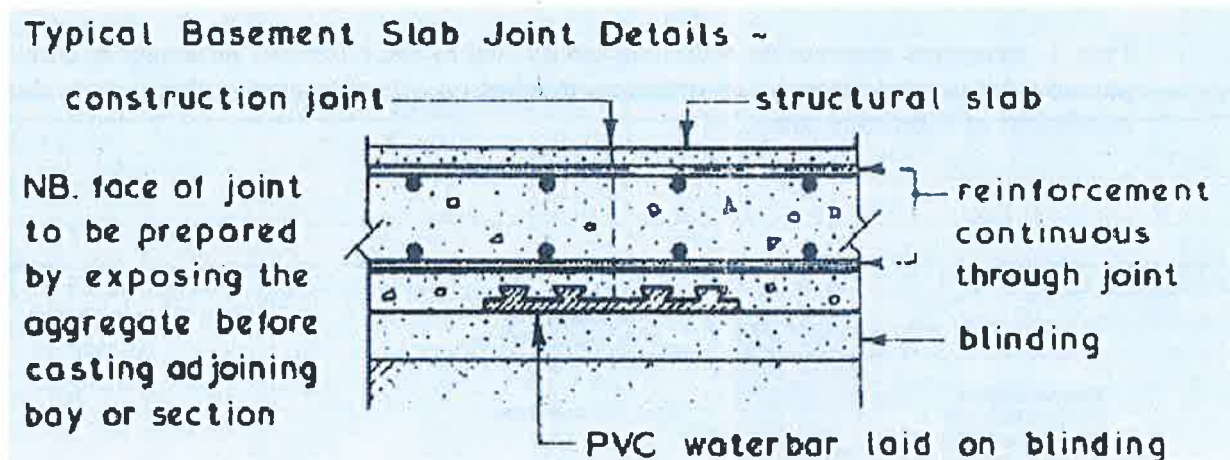


Figure 4 – Basement Slab Joint Details - Chudley "Construction Handbook."

Basement slabs are typically designed to span in two directions and as a consequence have relatively heavy top and bottom reinforcement. To enable them to fulfil their basic functions they usually have a depth in excess of 250mm. Construction joints should be kept to a minimum and if waterbars are specified they must be placed to ensure complete compaction of the concrete is achieved.

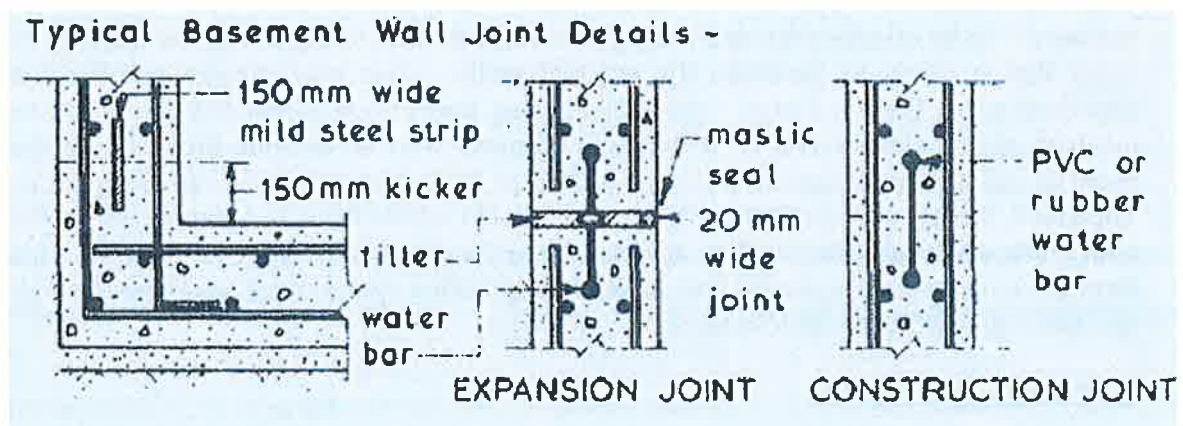


Figure 5 – Basement Wall Joint Details - Chudley "Construction Handbook."

Joints can be horizontal and /or vertical according to design requirements. A suitable waterbar should be incorporated in the joint to prevent the ingress of water. The top surface of a kicker used in conjunction with single lift pouring, if adequately prepared by exposing the aggregate, should not require a waterbar but if one is specified it should be either placed on the rear face or consist of a centrally placed mild steel strip inserted into the kicker whilst the concrete is still in a plastic state.

TYPE C STRUCTURES

Type C structures incorporate a drained cavity within the basement structure to allow groundwater to pass through the structure; it relies on effective gravity drainage or the installation of a drainage sump.

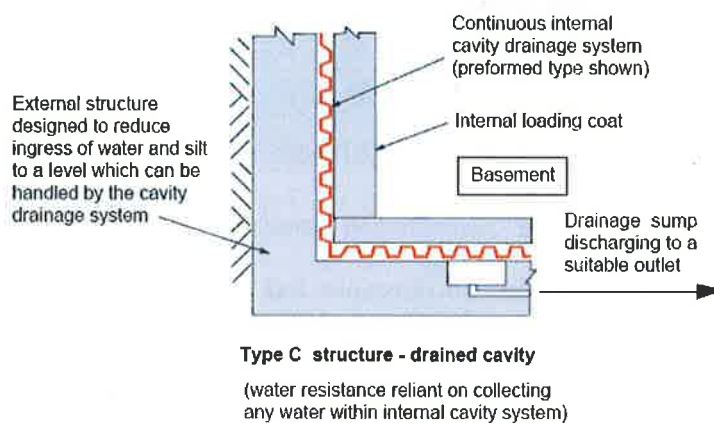


Figure 6 – Type C Structures – BCA “Approved Document Basement For Dwellings”

Structural walls for Type C Structures may be prestressed, reinforced concrete or masonry. To be effective the drainage system must be able to cope with the quantity of water that is likely to penetrate the external walls. This may present problems in situations where there is a high water table; during storm/flood conditions; failure of the mechanical pumping system or if drainage channels were to become blocked. In the event of any of these situations arising, flooding of the basement would inevitably occur. Therefore, this type of structure tends to be selected where there is a free draining site with a low water table unless they are used in conjunction with a type B structure. This form of construction can, depending on the waterproofing system used, also provide high resistance to water vapour movement.

WATERPROOFING SYSTEMS

There are ranges of waterproofing systems available; many are proprietary forms that have been developed as a complete waterproofing package. It is essential that any waterproofing system is continuous and must retain its integrity, particularly, where

elements of the structure and building services penetrate the walls and floors. All materials can provide adequate protection; however, they are dependant on good quality workmanship.

Waterproof systems can be categorised as follows:

1. *Bonded sheet membranes* - cold-applied or heat-bonded to the finished structural walls. Made from modified bitumen they can be applied internally or externally and can accommodate small movements and shrinkage.
2. *Cavity drain membranes* – high density ridged or dimpled polyethylene sheets installed internally after the basement has been constructed and form a cavity between the structure and the internal shell allowing draining of moisture to pass through the walls.
3. *Bentonite clay active membranes* - sheets of sodium bentonite clay are sandwiched between layers of biodegradable cardboard. Used externally, the clay swells when it comes into contact with water sealing any gaps.
4. *Liquid-applied membranes* – epoxy, polymer or bitumen solutions applied cold to walls internally or externally. Due to their elastic and flexible nature they cope well with complex profiles or shapes.
5. *Mastic asphalt membranes* - the hot mastic liquid is applied internally or externally and cools to form a hard, waterproof coating that is still fairly flexible. The application of multiple coats reduce the risk of defects in the total membrane.
6. *Cementitious crystallisation active systems* – applied as a slurry internally or externally. They react with free lime in concrete, renders or mortars in the presence of water to seal cracks or fissures.
7. *Proprietary cementitious multi-coat renders, topping and coatings* – typically used internally and applied in layers to provide a thick waterproof membrane inside the basement. These cope well with variable surface and can be used for remedial treatments for existing basements.

WATERSTOPS

Waterstops or water bars are required to prevent the ingress of water in in-situ reinforced concrete construction. Typically for expansion joints or where construction joints are formed during the casting process. There are several types available which prevent water penetration in different ways.

Rubber or flexible waterstops

There are a wide range of these waterbars to suit varying requirements which can be placed, internally or externally. The most common forms include extruded sections designed to provide a continuous barrier to the ingress of water through joints in the concrete structure. Strips of rubber or plastics, dovetailed on one side are fixed to the face of formwork and cast into the wet concrete. Waterstops should be securely fixed to prevent movement and care should be taken to avoid puncturing the waterstop.

Water-swellaable waterstops

Swellable waterstops or hydrophilic waterstops swell on contact with water providing an in-situ watertight seal. In strip form they are placed against a concrete joint before the next pour. They can be attached to PVC or rubber waterstops to provide a combined system.

Cementitious crystallisation waterstopping

A slurry of cement, fillers and chemicals mixed on site and applied to the face of the concrete before the next pour. Salt crystallisation within the pores of the concrete causes expansion on contact with water providing waterstopping.

Post-injected waterstopping

A perforated or permeable tube is positioned in the centre of the joint during the first pour of concrete, leaving open ends accessible. The second pour is made and when the concrete has sufficiently hardened a polyurethane or proprietary fluid is injected into the tube to seal and cracks or fissures in the construction joint.

REFERENCES.

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AUR507 Construction Technology 2

CYLLUN GWAITH SCHEME OF WORK 2017-18

WS WK	Dyddiad Date	WS WK	Testun Topic	Dyddiad Date	WS WK	notes
1	31-Jul-17			31-Jul-17		
2	07-Aug-17		Thurs. 10th Aug. re-submission deadline	07-Aug-17		
3	14-Aug-17		exams	14-Aug-17		
4	21-Aug-17		marking	21-Aug-17		
5	28-Aug-17		bank holiday Assessment Boards	28-Aug-17		
6	04-Sep-17		Assessment Boards	04-Sep-17		
7	11-Sep-17		Assessment Boards	11-Sep-17		
8	18-Sep-17			18-Sep-17		
9	25-Sep-17		Enrolment and induction	25-Sep-17		
10	02-Oct-17	1	introduction	02-Oct-17	1	
11	09-Oct-17	2	performance regiments of comm., indst. & multi-occ. resdlt. Bldgs	09-Oct-17	2	
12	16-Oct-17	3	forms of construction	16-Oct-17	3	
13	23-Oct-17	4	forms of construction	23-Oct-17	4	
14	30-Oct-17	5	directed study	30-Oct-17	5	
15	06-Nov-17	6	substructure - ground investigation	06-Nov-17	6	
16	13-Nov-17	7	ground improvement	13-Nov-17	7	
17	20-Nov-17	8	foundations and basements	20-Nov-17	8	
18	27-Nov-17	9	superstructure - structural masonry	27-Nov-17	9	
19	04-Dec-17	10	structural timber	04-Dec-17	10	
20	11-Dec-17	11	portal frames	11-Dec-17	11	
21	18-Dec-17		Christmas (University closes Fri. 22nd)	18-Dec-17		
22	25-Dec-17		Christmas	25-Dec-17		
23	01-Jan-18		Christmas (University open Tues. 2nd)	01-Jan-18		
24	08-Jan-18	12	structural concrete	08-Jan-18	12	
25	15-Jan-18	13	structural iron and steel	15-Jan-18	13	
26	22-Jan-18		exams	22-Jan-18		
27	29-Jan-18	1	Building Services	29-Jan-18	1	
28	05-Feb-18	2	Assessment boards measuring the external environment	05-Feb-18	2	
29	12-Feb-18	3	directed study	12-Feb-18	3	
30	19-Feb-18	4	Assessment Boards Assessment 1, in-class test	19-Feb-18	4	
31	26-Feb-18	5	environmental bldg services strategies	26-Feb-18	5	
32	05-Mar-18	6	emergency building services	05-Mar-18	6	
33	12-Mar-18	7	mechanical services systems	12-Mar-18	7	

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