CI/SfB (16.2) F (D)
November 1996

Building brickwork or blockwork retaining walls

GBG 27

good building guide

This guide is for builders, designers and planners. It provides rule of thumb guidance for the stable construction of a range of common types of bonded brickwork and blockwork earth retaining walls to a maximum retained height of 1.725 m. Walls of greater height should be designed by an appropriately qualified person.

For practical purposes, this guide provides a simplified classification of soils which are suitable to found on, and gives foundation and wall dimensions for several wall heights.

Contents

This guide gives advice on building small retaining walls. It complements the guidance given in *Good Building Guides 14* and *19* for building freestanding walls.

It stresses the need for good supervision in construction, not only to prevent premature deterioration but also to ensure the careful co-ordination and execution required for some forms of construction. Building reinforced walls, in particular, requires a number of complex operations to be carried out in sequence.

Warning !

If any of the exclusions in the next column apply, you should seek the advice of a chartered civil or structural engineer, or similarly qualified person.

Retaining walls specifically excluded from this guide are:

- walls higher than 1.725 m above the top of the foundation
- walls higher than 0.25 m above the retained ground
- walls for supporting banked-up soil, stored materials or buildings on the backfill close to the wall
- walls for supporting vehicles or traffic on the backfill close to the wall
- walls for supporting retained soil with a slope steeper than 1:10 immediately behind the wall *(see page 3 for minimum distance)*
- walls supporting a fence of any type other than a simple guard-rail *(see page 11)*
- walls for retaining very wet earth, peat or retained water, for example a garden pond
- walls forming part of, or adjoining, a building
- walls not constructed of bricks or blocks
- walls of dry masonry construction
- walls in areas of mining subsidence or other unstable ground
- walls where the water table lies within 0.5 m of the underside of the foundation.

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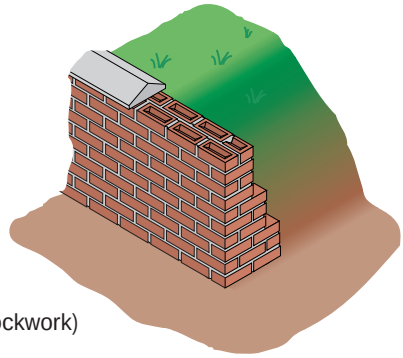
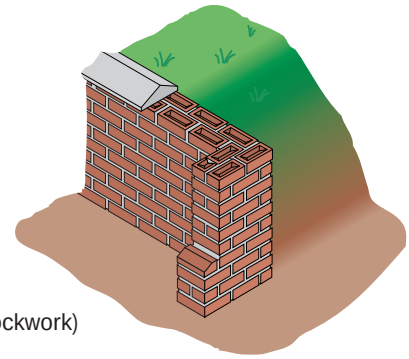
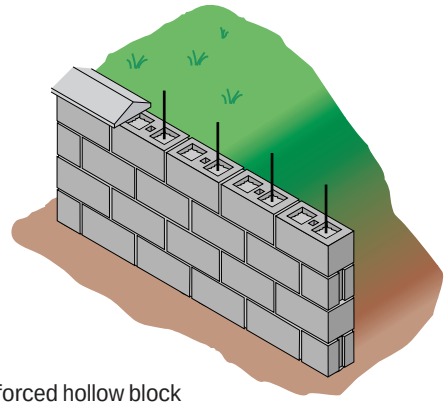
Types of retaining wall



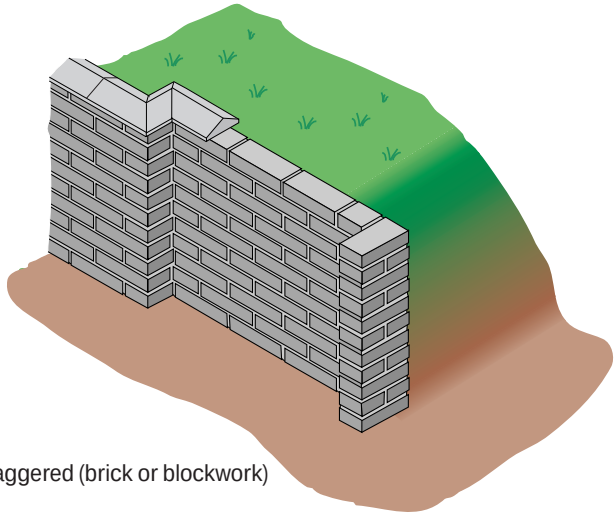
Stepped solid wall (brick or blockwork)



Piered (brick or blockwork)



Reinforced hollow block



Staggered (brick or blockwork)

Simplified classification of soils

Remember !

If you are unsure about the definitions of the soil types,always seek advice from a chartered civil or structural engineer.

For practical purposes, soils which are suitable to found on can be classified simply as **non-cohesive** and **cohesive**.

These two classifications have been used to calculate the foundation width and depth for the different types of wall. The smaller foundation dimensions shown in **red** in the diagrams on pages 6 and 7 may be used **only if the wall is founded on non-cohesive soil**.

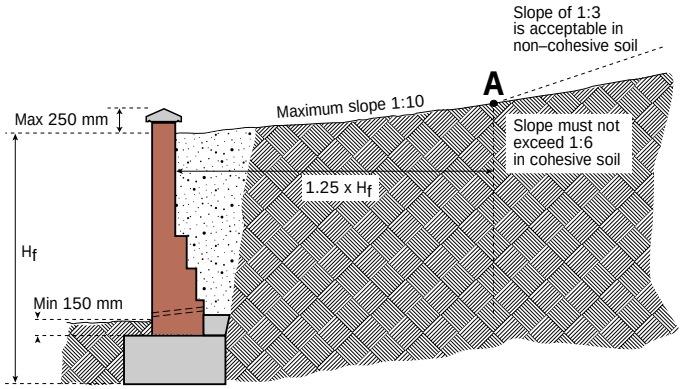
If the soil on which you are building is suitable, but you are not sure whether it is cohesive or non-cohesive, always use the larger foundation dimensions given for cohesive soils.

Soil identification

Digest 363 shows how to recognise and describe soil types and assess their strength.

Soils suitable to found on
Non-cohesive soils and rocks
Dense to loose sand or gravel (can contain up to 15% clay in matrix)
Sound chalk or rock
Cohesive soils
Very stiff clays to soft clays
Sandy clay, gravelly clay
Unsuitable soils
Very soft clays *Very soft clay can readily be identified, as it exudes between the fingers when squeezed in the hand. It is too soft to found on, but if the excavation can be deepened until a suitable soil is reached, it may still be possible to use the advice given in this guide.*
Peat and organic soils
Made ground or fill
Topsoil

Building walls in sloping ground



Remember !

Clay slopes steeper than 1:6 (~10°), especially poorly drained, long clay slopes, may have an instability mode known as a 'slip circle' and, therefore, must be investigated by a chartered civil or structural engineer, or similarly qualified person.

- the minimum distance between the wall and point **A** is $\mathbf{1.25 \times H_f}$ (the total height of the wall including the foundation depth)
- loading the slope beyond **A** does not affect the pressure on the rear of the wall
- in cohesive soils, the slope of the ground beyond **A** must not be steeper than 1:6 (~10°)
- in non-cohesive soils, the slope of ground beyond **A** can be quite steep: a gradient of 1:3 (~18°) is acceptable provided the surface is protected by grass or dense shrubs to prevent erosion

Foundations

The choice of concrete mix is important if foundations are to be strong and durable. Always use clean tap water in preparing the mix.

If the soil conditions generally are dry, a wide range of concrete mixes, including those based on ordinary Portland cement, can be used.

If the soil is wet or constantly damp, the foundations will need to be resistant to any sulfate salts in the water and the choice of mix should be governed by the concentration of salts present.

If the soil is contaminated by industrial waste, an appropriate mix should be used. Check the effects of contaminants on the units with the manufacturer.

For information on concrete mixes see *BS 5328* and *Digest 363*.

If there is any doubt over the stability of the soil, the water table, or the salt or acid content of the soil, you must seek advice from a chartered civil or structural engineer, or similarly qualified person.

Remember !

Do not use the foundation sizes given in this guide if the water table at its highest level lies less than 0.5 m beneath the underside of the proposed foundation. Instead, the foundation must be designed by a chartered civil or structural engineer, or similarly qualified person.

Recommended mixes for unreinforced walls

		Ready-mixed	Site mixed
		to BS 5328	All site mixes must be very carefully batched, preferably by weight
For dry soils, or for wet soils with low sulfate levels		Designated mix GEN 1 with 125 mm nominal slump (75 mm if trench blinding or shuttering is used)	BS 5328 standard mix ST 2 or a 1:8 PC 42.5 mix. For other mixes see *Digest 363* (Table 1)
	Class		
For wet soils with higher sulfate levels (see *Digest 363* for classes)	2	Designated FND2	1:4 PC 42.5 or 1:4½ (SRPC)
	3	Designated FND3	1:4 (SRPC)
	4	Designated FND4	1:3½ (SRPC)

PC 42.5 = Ordinary Portland cement
SRPC = Sulfate-resisting Portland cement

Recommended mixes for reinforced walls

		Ready-mixed to BS 5328	Site mixed
For low sulfate soils		Designated RC35 mix or designed C35 mix (specify maximum water/cement ratio of 0.6 and minimum cement content 300 kg/m^3 for 20 mm maximum aggregate size). Nominal slump 75 mm for either option.	**SITE MIXING IS NOT RECOMMENDED FOR REINFORCED WALLS**
For soils with higher sulfate levels (see *Digest 363* for classes)	**Class**		
	2	Designated FND2	
	3	Designated FND3	
	4	Designated FND4	

Bricks and blocks

Specifications for bricks and blocks

Bricks

Minimum density	1500 kg/m^3

Blocks

Minimum density	1700 kg/m^3
Minimum strength	10.5 N/mm^2

Minimum density and strength for bricks and blocks is shown on the left.

Normally, **calcium silicate bricks** of Class 3 or stronger to BS 187, and **dense concrete blocks** and **concrete brick**s to BS 6073 are sufficiently frost resistant for use in most UK locations.

Use type **MN** or **ML clay bricks** to BS 3921 between the dpcs, but only if the coping/capping and high level dpc provide adequate protection to avoid saturation *(see Good Building Guide 17)*.

Use type **FL** or **FN clay bricks** (or calcium silicate bricks of Class 4 or stronger) throughout the wall if it is difficult to provide rain protection or where there is a high risk of frost attack – for example, in areas with a high driving rain index (see *Climate and brickwork construction notes)*.

Use **frost resistant clay bricks** (or calcium silicate bricks of Class 4 or stronger) above a high-level dpc, and from the top of the foundation to 200 mm above finished ground level in front of the wall.

Remember !

Always check with the building supply merchant or the brick or block supplier that the bricks or blocks to be used provide moderate adhesion.

The sizing of walls given in this guide assumes a moderate degree of adhesion between the mortar and the bricks or blocks. Do not use bricks or blocks which do not provide moderate adhesion. See *BS 5628:Part 3* for advice on adjusting the moisture content of the mortar to achieve the required adhesion. Check after 7 days that using strong hand force only cannot dislodge the units from the wall.

Mortars

Suggested mortar mixes

Designation (i) mix

- 1 part PC 42.5 (OPC)
- $^1/_4$ part lime
- 3 parts sand (Type S to BS 1200)

Designation (ii) mix

- 1 part PC 42.5 (OPC)
- $^1/_2$ part lime
- 4$^1/_2$ parts sand (Type S to BS 1200)

For most locations the **Designation (ii) mortar mix** is recommended for all levels in the wall *(see Digest 362)*. If building in a very wet location, use a **Designation (i) mortar** below the low level dpc.

If normal salt content clay bricks (Designation N) are used, or if sulfates in the soil exceed Class 1 *(see Digest 363)*, the use of sulfate-resisting Portland cement (SRPC) is recommended.

Use Type S (coarser) sands to BS 1199/1200.

Movement joint

Sealing movement joints improves the weather-tightness of the wall and may enhance its appearance. Make sure that the sealant and the backing to the sealant can accommodate the expected movement. See *BS 6093* and *BS 6213* for guidance on selecting and applying sealants.

Steel reinforcement

Steel *(see BS 4449)*
Use high yield Type 2 reinforcement bar (not mild steel). Steel sizes for given height and exposure are shown for reinforced hollow block walls. Starter bars normally are supplied correctly cut and bent to *BS 4466*.

The following steel specification, is recommended.

- In sheltered locations use galvanised steel (galvanised after bending) to *BS 5628:Part 2* or as below.
- In exposed locations use austenitic stainless steel to *BS 6744* (see *BS 5628:Part 2)*.
- In very acidic or corrosive environments, always use austenitic stainless steel.
- Always use the same steel type for bars and tying wire or connectors.

Suggested infill mix

- 1 part PC 42.5
- 0 to 1/4 part lime
- 3 parts sand
- 2 parts aggregate *(maximum aggregate size 10 mm)*
- Plasticiser
- Expanding agent

Infill

For the infill around the reinforcement, use a prescribed mix (shown on the left) or designed Grade 25 mix to *BS 5328*. Use a plasticiser to achieve a workability of 75 mm nominal slump and a proprietary expanding agent, both in accordance with the manufacturers' instructions.

Damp proof courses *(see BS 8215)*

High-level and low-level dpcs are recommended in all walls that are not frost resistant. See *Good Building Guides 14* and *17*, and *Digest 380* for general advice on dpc selection.

High-level dpc

Dpc detailing is more complex in staggered walls and flexible dpcs may be difficult to incorporate unobtrusively. This is because of the large proportion of overlaps necessary and the need to bed on both surfaces. If it is intended to use a flexible dpc at high level it is advisable to check detailing with the brick and dpc manufacturers. Any flexible dpcs incorporated must have good bonding properties.

Low-level dpc

The preferred minimum solution is to build up from the foundation with dpc Type 1 or 2 clay bricks (or equivalent) to one course above the top of the weep-holes.

A more practicable solution is to form the total construction from the top of the foundation to approximately 200 mm above finished ground level with dpc Type 1 or 2 clay bricks (or equivalent).

Remember !

Do not use flexible materials or slate for dpcs at the low level.

Cappings and copings

Choose frost-resistant cappings or copings sized to *BS 4729* or other copings to *BS 5642*. The cappings or copings should incorporate an overhang and drip if the wall is not in a very sheltered location or is not going to be built of frost-resistant bricks. Before choosing a wall type, make sure that a suitable combination of coping and dpc is available for the site conditions (see *Good Building Guide 17*).

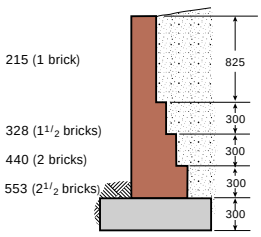
If there is a risk of children playing on walls, or of vandalism, select a wall type which allows the addition of interlocking capping (see *Good Building Guides 17* and *19*).

To accommodate cappings and copings it may be easier to finish piers or sections over staggers higher than the rest of the wall. Also, special bricks or concrete units often are available for cappings and copings at piers.

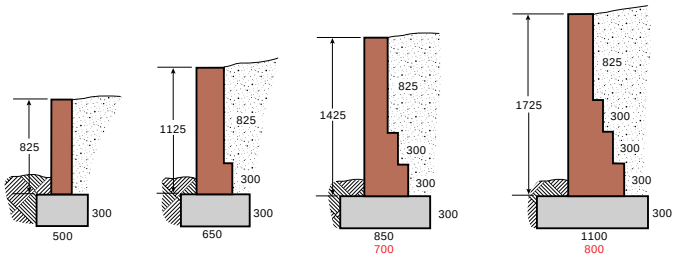
Straight walls

Brickwork

Maximum height of retained soil (mm)	825	1125	1425	1725

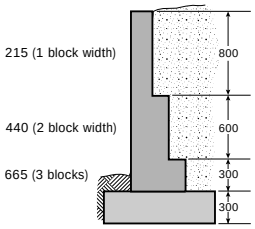


Section showing the stepped increase in wall thickness (mm)

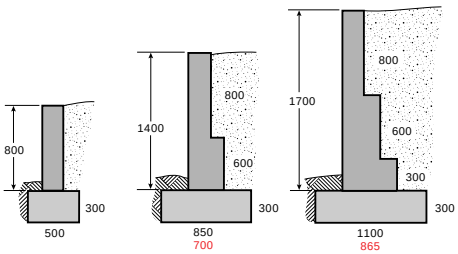


Blockwork (laid flat)

Maximum height of retained soil (mm)	800	1400	1725



Section showing the stepped increase in wall thickness (mm)



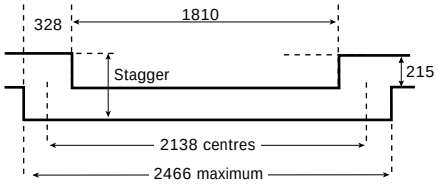
Remember !

The dimensions shown in red may be used **only if the wall is founded on non-cohesive soil** *(see page 2).*

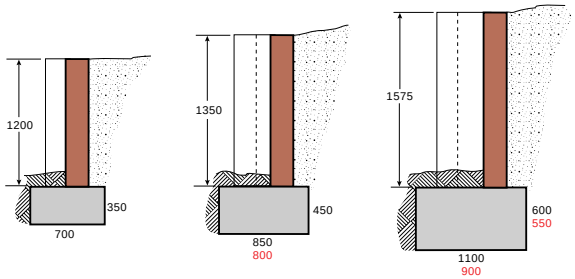
Staggered walls

Brickwork

Maximum height of retained soil (mm)	1200	1350	1575
Stagger (mm)	440	553	665

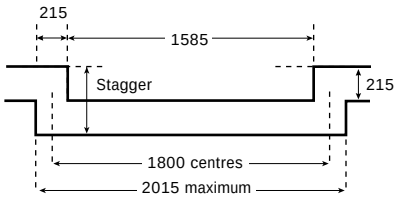


Plan view showing panel dimensions (mm) for staggered brickwork walls

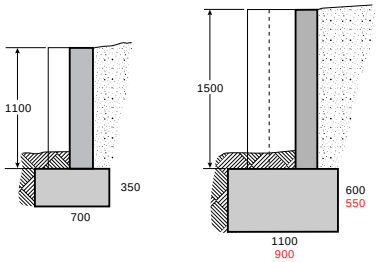


Blockwork (laid flat)

Maximum height of retained soil (mm)	1100	1500
Stagger (mm)	440	665



Plan view showing panel dimensions (mm) for staggered blockwork walls



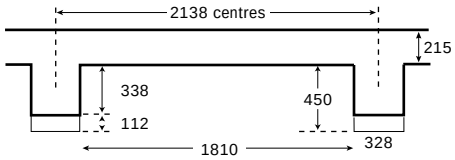
Remember !

The dimensions shown in red may be used **only if the wall is founded on non-cohesive soil** *(see page 2).*

Piered walls

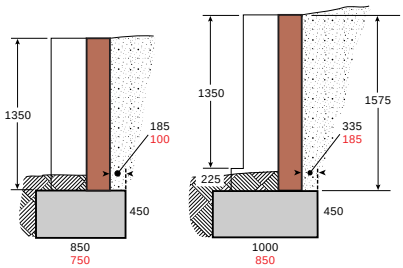
Brickwork

Maximum height of retained soil (mm)	1350	1575



For walls higher than 1425 increase the pier thickness to 450 for the first 3 courses

Plan view showing panel dimensions (mm) for piered brickwork walls

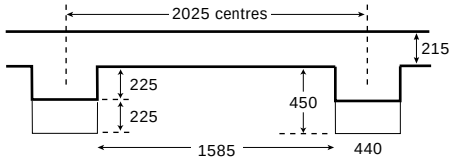


Position of wall

Piered walls are **not** positioned centrally on the foundations. The dimension from the back of the wall to the edge of the foundation is shown on the diagrams.

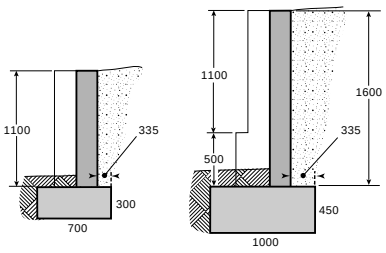
Blockwork (laid flat)

Maximum height of retained soil (mm)	1100	1600



For walls higher than 1100 increase the pier thickness to 450 for the first 5 courses

Plan view showing panel dimensions (mm) for piered blockwork walls

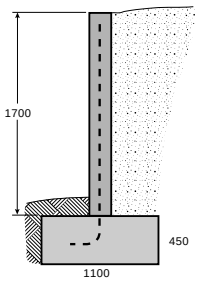


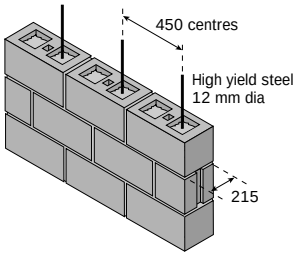
Remember !

The dimensions shown in red may be used **only if the wall is founded on non-cohesive soil** *(see page 2)*.

Reinforced hollow block walls

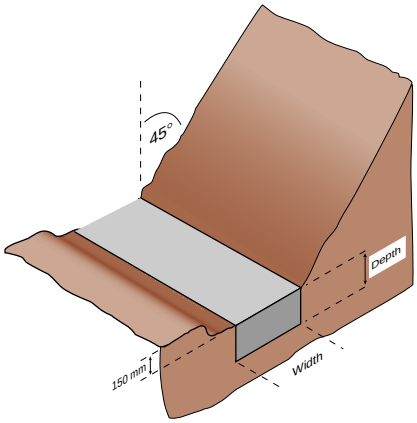
Maximum height of retained soil (mm)	1700





Construction guidelines

Excavation



To avoid ground collapse, excavation of the ground prior to construction of a retaining wall needs to be undertaken with care *(see BS 6031* and *BS 8004)*. Faces higher than 1.2 m should be sloped back to a safe angle as shown on the left. A gradient of 1:1 (45°) is recommended.

Do not leave excavated faces in cohesive soils unsupported for longer than necessary as the risk of instability increases with time. Consider excavating the ground progressively and constructing the wall in panels.

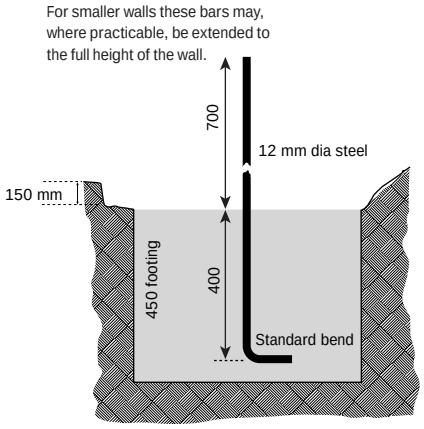
Foundations

Minimum width and thickness for footings are shown for the different wall types in the diagrams on pages 6 and 7. The dimensions given are for the two main soil classifications listed on page 2. If there is any doubt about the soil type, always seek advice from a chartered civil or structural engineer, or similarly qualified person.

Dig the trench so the top of the foundation is 150 mm deeper than the adjacent soil, as shown on the left. Advice on stepped foundations and bridging over drains and tree roots is summarised in *Good Building Guide 14*.

Blind the trench if it has rained or if several days are likely to elapse between digging and placing the footings.

Take particular care when setting out the footings. With the exception of piered walls, the base of all retaining walls must be constructed centrally on their foundations. For piered walls, refer to the diagrams on page 7 for the correct dimension from the rear face of the wall to the rear edge of the foundation.



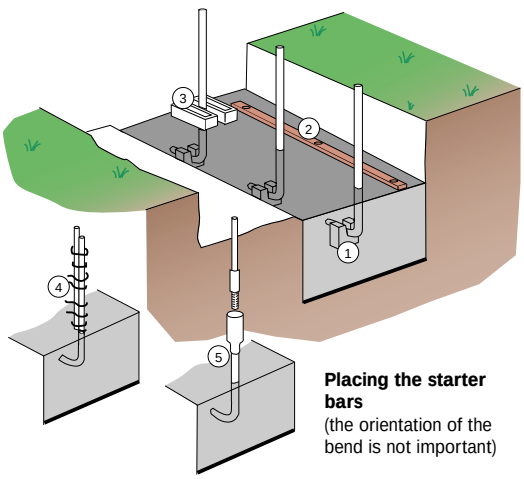
Reinforcement

Starter reinforcing bars should have a bend to optimise anchorage and to enable the steel to be incorporated with adequate concrete cover. The orientation of the bend in the foundation is not important. In the absence of structural advice, the starter shown on the left can be used, provided concrete infill is to be used around the reinforcement.

A more economical use of steel use may be possible by following the detailed guidance given in *BS 8110*.

Steel should be cut and bent according to the recommendations given in *BS 4466*.

Reinforcement — how to proceed



Placing the starter bars
(the orientation of the bend is not important)

- Wire the starter bars to proprietary 50 mm concrete or plastics spacers, ①, and mark the top level of the foundation on each bar with a chalk line.
- Position the bars as carefully as possible ensuring that no part of the reinforcement will have less than 50 mm of concrete cover.
- Pour the footings, steadying the bars to keep them as upright as possible and checking their position against a jig, ②.
- Once the pour is finished use a string to align the starter bars; check their centres against the jig.
- Compact and level the concrete and support the bars, ③, until the concrete has set.
- Once the footings have set, attach the vertical bar to the starter bars. The usual way of providing a structural connection is with steel wire, ④, but mechanical connectors, ⑤, may be necessary where the thickness of a wired lap would result in inadequate concrete cover at the lap.
- The British Cement Association publication, *Concrete on site. 2 – Reinforcement*, gives advice on good practice during reinforcing. During construction, take special care to compact the concrete infill around the reinforcement.

Waterproofing

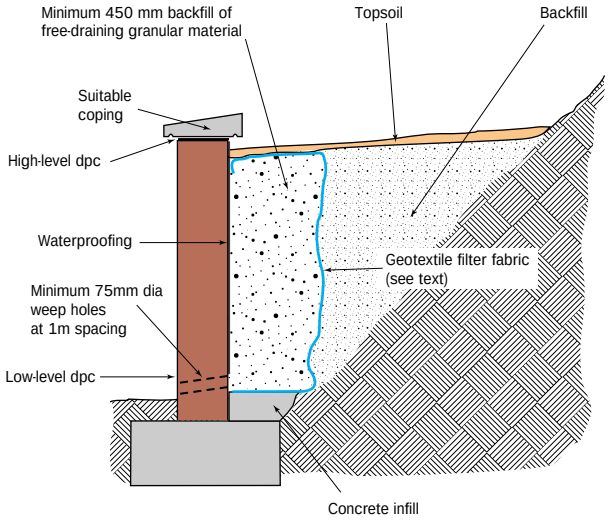
Waterproof the back of a retaining wall with either a bituminous membrane or two coats of bituminous emulsion. Protect the waterproofing with fibre board, or similar, before backfilling.

Backfilling and drainage

The retaining side of the wall should preferably be backfilled with lightly-compacted non-cohesive material. The use of intermediate to high-plasticity clay, or highly organic soils should be avoided *(see Digest 383)*. A drainage layer of free-draining material such as coarse aggregate, clean gravel or crushed stone should be incorporated next to the wall. The drainage layer should be of minimum width 450 mm. If the general backfill consists of fine-grained material, separate it from the drainage layer with a geotextile filter fabric. This will prevent the drainage layer from becoming clogged. Advice on the selection of a suitable geotextile fabric can be obtained from the manufacturers.

The drainage layer must be able to discharge through weep holes in the wall. Weep holes should be at least 75 mm diameter and spaced horizontally at not more than 1 m intervals. Build the weep holes near the base of the wall below, or within, the low-level dpc. To prevent water from reaching the foundations, infill with concrete behind the wall below the weep holes. The infill concrete should have the same mix proportions as that used for the foundations *(see page 3)*.

After construction, it is important to advise the owner to keep the weep holes clear and free from obstruction.



Masonry

Follow accepted good workmanship practice *(see BS 5628:Part 3* and *BS 8000:Part 3)*. A simplified construction sequence is given in *Good Building Guide 14*.

- If the bricks are frogged, lay frog up.
- Finish joints, preferably with a bucket handle profile.
- If the wall is to be rendered, rake the joints back 10 to 12 mm (not necessary on blockwork walls). Advice on choosing appropriate rendering is given in *Good Building Guide 18*.
- To avoid excessive loads on fresh mortar, do not exceed lifts of 1.5 m per day. Protect new masonry from frost, rain and wind.
- Allow 28 days for the mortar to set before backfilling.

Allowing for movement

Movement joints are required in all retaining walls and must be continuous through the dpc, and capping and coping.

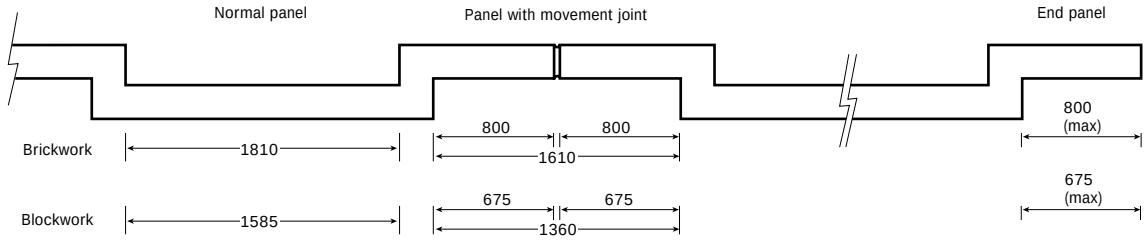
Spacing and width of movement joints

Material	Type of joint	Width of joint	Spacing	Maximum distance from end of wall or corner return
Clay brickwork	Expansion	12–16 mm	10–12 m	6.0 m
Calcium silicate brickwork	Contraction	10–12 mm	6–7 m*	4.5 m*
Concrete brickwork/blockwork	Contraction	10–12 mm	5–6 m*	3.0 m*

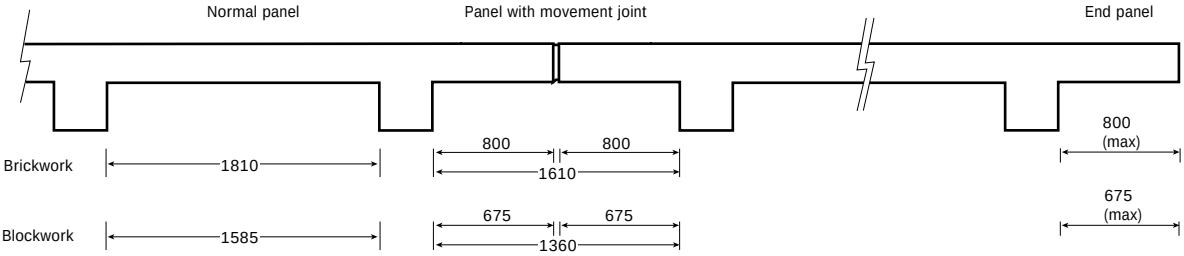
*or 3 times the height of the wall if this is less than the distance given

In staggered or piered walls, movement joints should be built in at the centres of special panels. The dimensions of the panel for these walls are shown below.

Maximum dimensions of movement joint panels and wall ends for staggered walls



Maximum dimensions of movement joint panels and wall ends for piered walls



Ends of walls

Typical retaining wall ends are shown on *page 2*.

Type of wall	Wall end
Stepped solid wall	No special termination required
Staggered brickwork wall	Terminate with a full stagger shape or to 800 mm maximum from stagger *(see diagram above)*
Staggered blockwork wall	Terminate with a full stagger shape or to 675 mm maximum from stagger *(see diagram above)*
Piered brickwork wall	Terminate with a pier equal in size to the others in the wall or to 800 mm maximum from pier *(see diagram above)*
Piered blockwork wall	Terminate with a pier equal in size to the others in the wall or to 675 mm maximum from pier *(see diagram above)*
Reinforced hollow block wall	No special termination needed

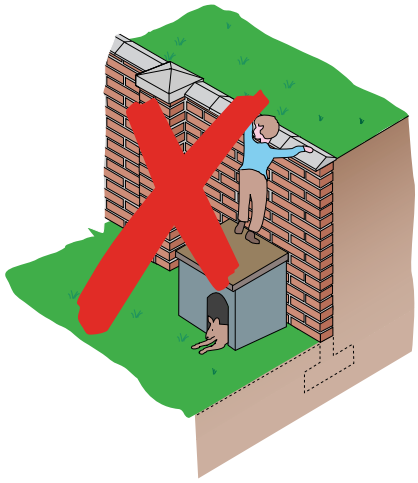
Remember !

It is the builder's responsibility to advise the owner:

- about safety and maintenance of the wall in general, and
- about the dangers of altering in any way either the structure of the wall or the ground in front of, or above, the wall.

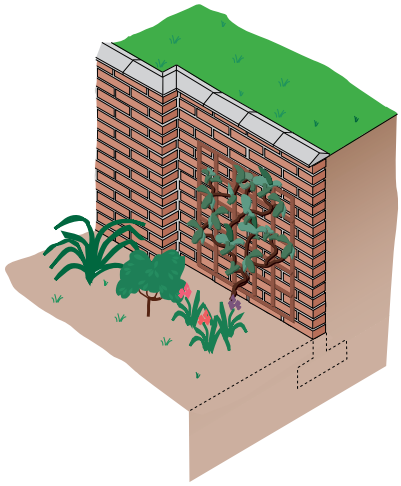
Safety

- If there is a risk of children playing on walls or of vandalism, select a wall type which allows the addition of interlocking capping (see *Good Building Guides 17* and *19*).
- Avoid placing garden furniture, sheds or other objects in a position which encourages children to climb on the wall.
- Don't mount any heavy objects or a fence of any type (other than a simple guard-rail) on a retaining wall unless a structural check has been carried out.
- Don't bank up soil next to the top of the wall.
- Don't dig any trenches immediately in front of the wall.
- Keep the weep holes clear and free from obstruction.



Planting near walls

- Don't dig any trenches for plants immediately in front of the wall.
- Dwarf trees, small shrubs and perennial herbaceous plants can be planted in beds near walls, but trees should be planted at recommended distances away from the wall foundation (see *BS 5837* and *Digest 418)*.
- Climbing plants can be trained up walls on a light climbing trellis, but discourage any direct growth on the wall and cut growth back regularly to prevent development of large root systems.
- As a general rule do not allow plants to climb more than two-thirds up the wall.
- Don't remove bricks or blocks to allow plants to grow through the wall.



Site safety

Current legislation requires all persons to consider the effects of their actions or lack of action on the health and safety of themselves and others. Advice on safety legislation is available from the Health and Safety Executive.

Site operatives should be aware that Portland cement, when wet, releases alkalis which can be harmful to the skin. During site operations take care to avoid skin and eye contact with Portland cement mixes.

Further information

British Standards Institution

BS 187: 1978 Specification for calcium silicate (sandlime and flintlime) bricks
BS 1199 and **1200**: 1976 Specifications for building sands from natural sources
BS 3921: 1985 Specification for clay bricks
BS 4449: 1988 Specification for carbon steel bars for the reinforcement of concrete
BS 4466: 1989 Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
BS 4729: 1990 Specification for dimensions of bricks of special shapes and sizes
BS 5328:– Concrete
Part 1: 1991 Guide to specifying concrete
Part 2: 1991 Methods for specifying concrete mixes
BS 5628:– Code of practice for use of masonry
Part 1: 1992 Structural use of unreinforced masonry
Part 2: 1985 Structural use of reinforced and pre-stressed masonry
Part 3: 1985 Materials and components, design and workmanship
BS 5642:– Sills and copings
Part 2: 1983 Specification for copings of precast concrete, cast stone, clayware, slate and natural stone
BS 5837: 1991 Guide for trees in relation to construction
BS 6031: 1981 Code of practice for earthworks
BS 6073:– Precast concrete masonry units
Part 1: 1981 Specification for precast concrete masonry units
BS 6093: 1993 Code of practice for design of joints and jointing in building construction
BS 6213: 1982 (1992) Guide to selection of constructional sealants
BS 6744: 1986 Specification for austenitic stainless steel bars for the reinforcement of concrete
BS 8000:– Workmanship on building sites
Part 3: 1989 Code of practice for masonry
BS 8002: 1994 Code of practice for earth retaining structures
BS 8004: 1986 Code of practice for foundations
BS 8110:– Structural use of concrete
Part 1: 1985 Code of practice for design and construction
BS 8215: 1991 Code of practice for design and installation of damp-proof courses in masonry construction

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363 Sulfate and acid resistance of concrete in the ground
380 Damp-proof courses
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Good Building Guides

14 Building simple brick or blockwork freestanding walls
17 Freestanding brick walls – repairs to copings and cappings
18 Choosing external rendering
19 Building reinforced, diaphragm and wide plan freestanding walls

Other publications

Climate and brickwork construction notes. London Brick, 1988 (reprinted 1990).
The design of brickwork retaining walls. Brick Development Association, 1991.
Concrete on site. 2 – Reinforcement. British Cement Association, 1991.

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