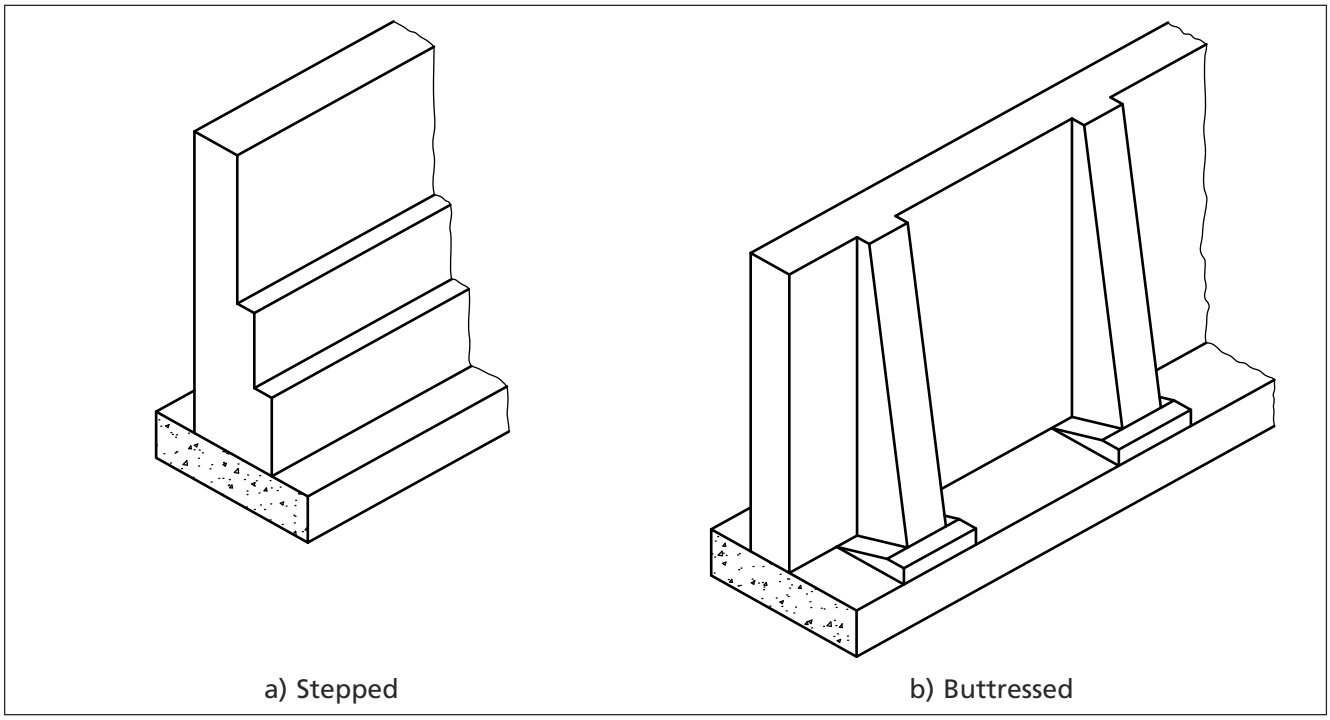
Figure 6 **Examples of unreinforced masonry retaining walls**



a) Stepped b) Buttressed

5.1.4 Gabion walls

*COMMENTARY ON **5.1.4***

Gabion walls are suitable for retained heights typically up to about 10 m. Gabions are large rectangular cages or baskets, made of hexagonal woven steel wire or square welded mesh, filled with stone. Gabions are used to build retaining walls, revetments, and anti-erosion works. Box gabions are normally available in half metre modules of length 2 m to 6 m, width 1 m to 2 m, and in depths of 0.3 m, 0.5 m, and 1 m.

The permeability and flexibility of gabions make them suitable where the retained ground is likely to be saturated and the underlying ground's bearing resistance is low.

Gabions cages can bulge and deform under load, particularly if they have not been filled correctly, and this might affect the serviceability of the structure and the use of the ground it is retaining. Welded gabions are commonly supplied with an increased diameter wire mesh to the front face to stiffen the structure and provide more support.

Figure 7 shows examples of typical gabion retaining walls.

Further information about gabion walls can be found in CIRIA Report C516 *[27] and in* Earth Pressure and Earth-Retaining Structures (3rd edition) *[2].*

5.1.5 Crib walls

*COMMENTARY ON **5.1.5***

Crib walls are suitable for retained heights typically up to about 12 m. They are built with individual units, made of timber or precast concrete, that, when assembled, create a series of box-like structures into which suitable free draining coarse fill is placed. The fill acts in conjunction with the cribwork to support the retained ground.

Crib walls are flexible, open-faced structures that can accommodate differential settlement and movement caused, for example, by seasonal moisture changes.

The depth of the crib units is chosen to suit the overall height of the crib wall and the actions imposed upon it. In some design situations (including those with large retained heights, high loadings or weak soils), units of different depths are used.

Crib walls are normally built with a 1 (horizontal) to 4 (vertical) batter. However, this can vary to suit design requirements and the available space on site. Crib walls are formed with front and rear stretchers that are tied together with headers having notches or rebates.

A precast concrete crib wall uses less concrete than an equivalent mass concrete wall.

Figure 8 shows examples of typical crib walls.

Crib walls may be constructed of timber or precast concrete units.

NOTE Further information about crib walls can be found in CIRIA Report C516 *[27] and in* Earth Pressure and Earth-Retaining Structures *[2].*

Figure 7 **Examples of gabion retaining walls** (1 of 2)

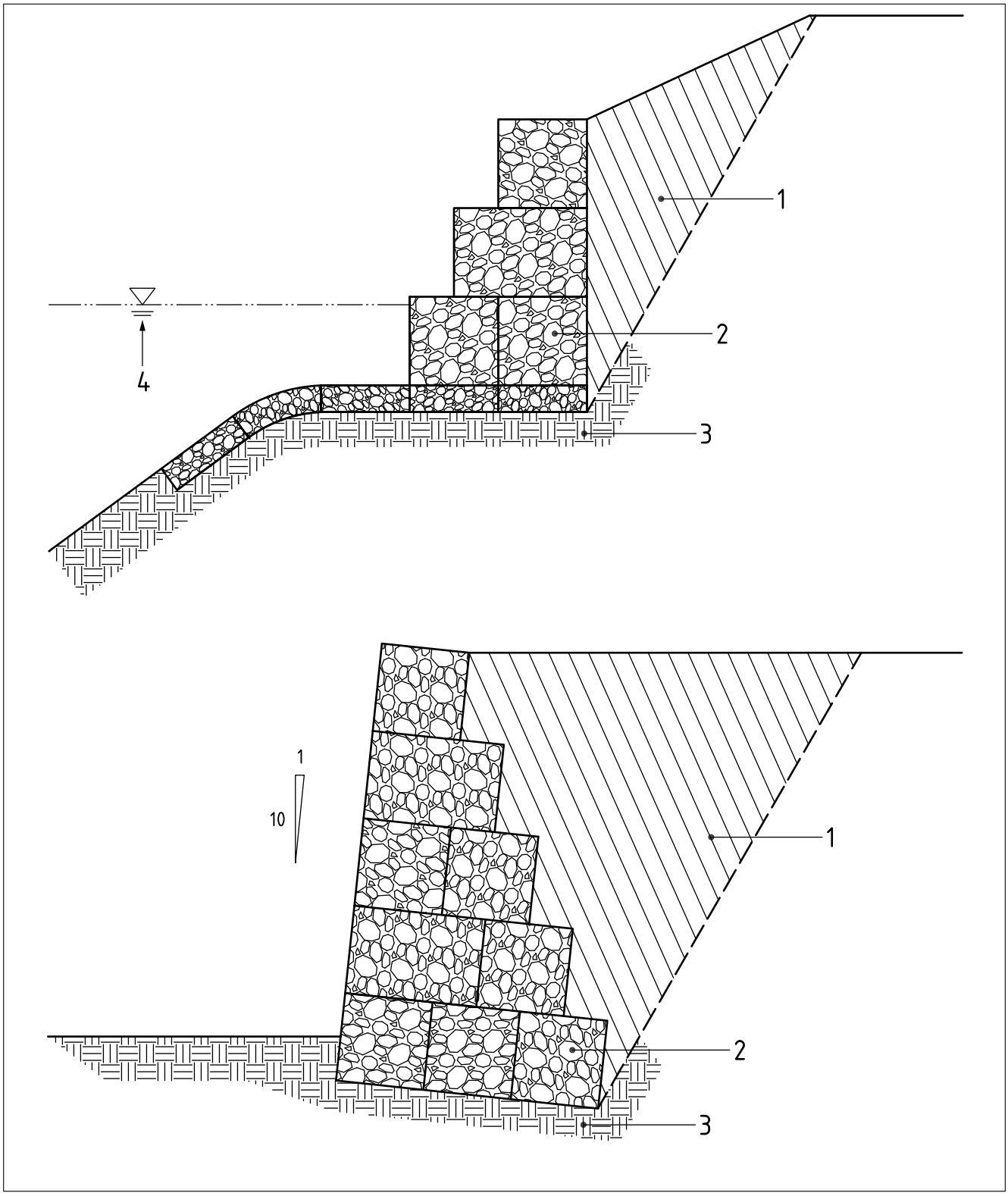
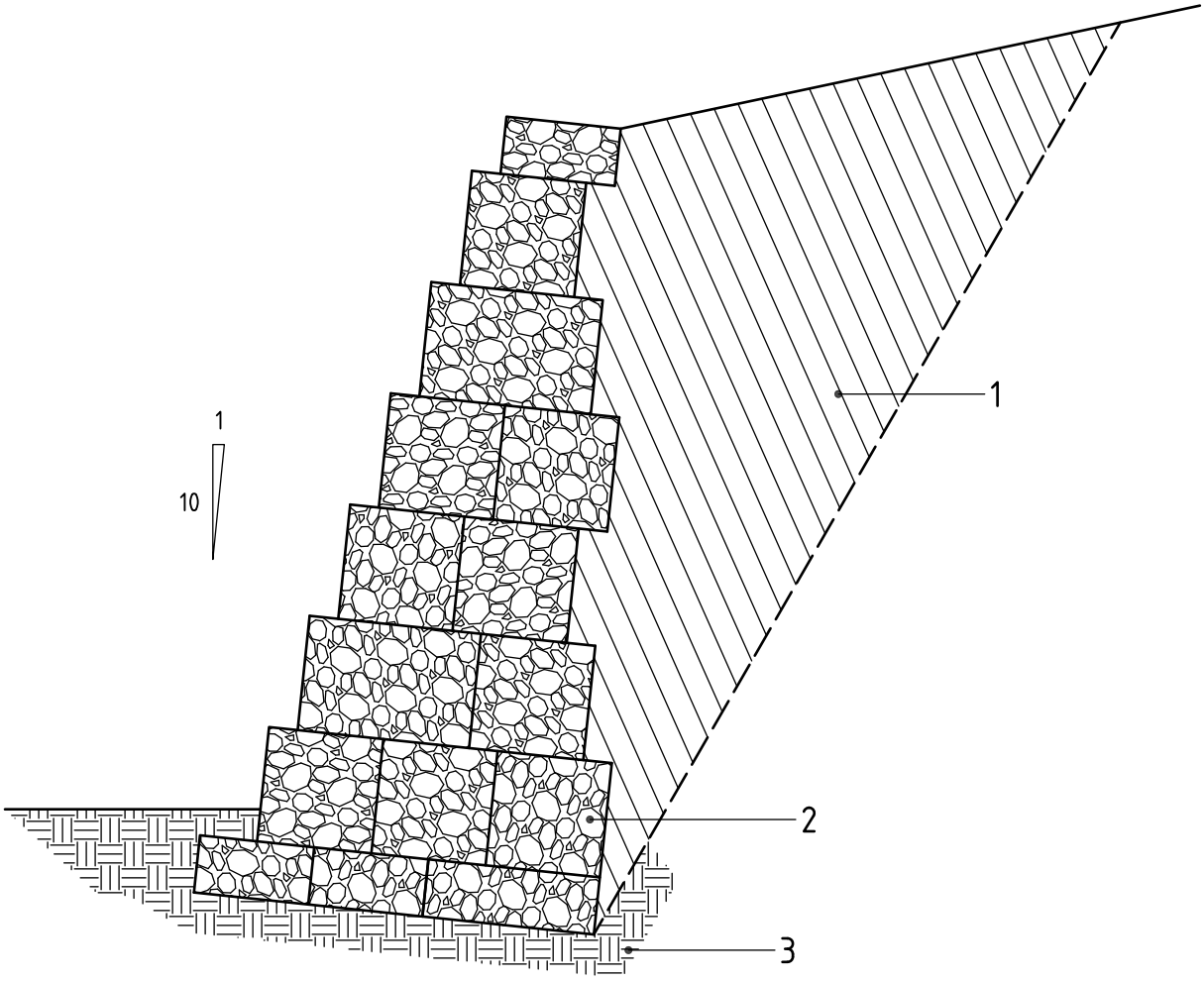


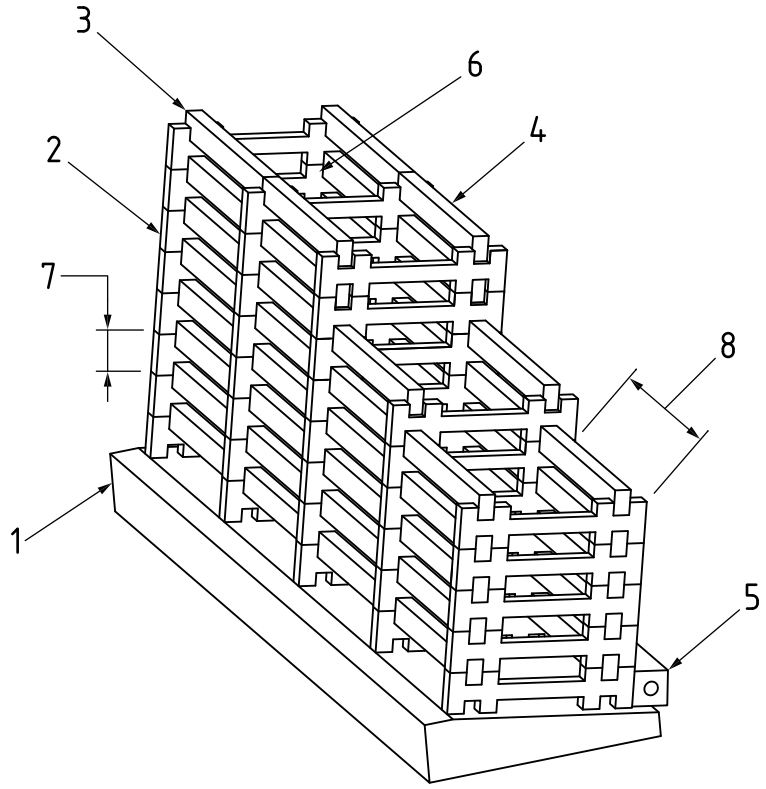
Figure 7 **Examples of gabion retaining walls** (2 of 2)



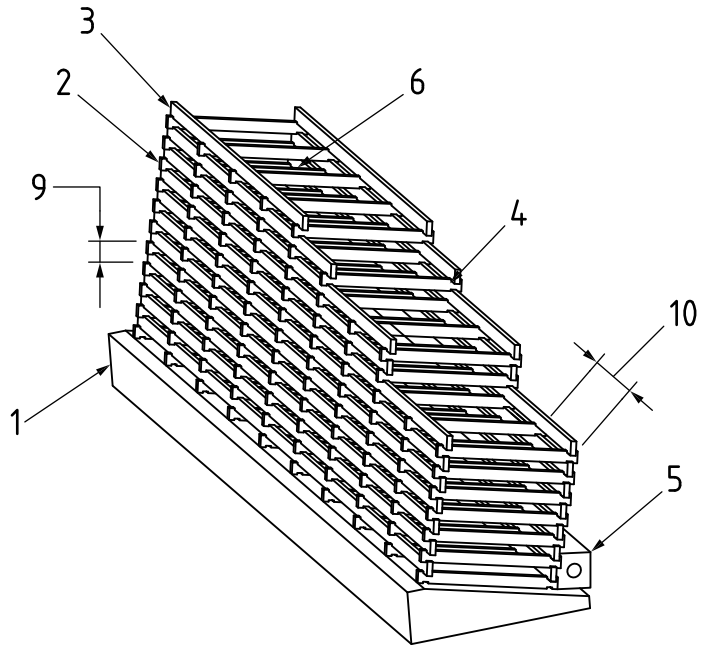
Key

1 Backfill
2 Gabion cage
3 Foundation
4 Standing water level

Figure 8 **Examples of crib walls**



a) Precast concrete



b) Timber

Key

1	Concrete foundation	6	Crib units filled with a suitable granular fill
2	Header	7	Typical course height 300 mm
3	Front stretcher	8	Typical centres 1 500 mm – 1 800 mm
4	Rear stretcher	9	Typical course height 160 mm
5	Drain where required	10	Typical centres 600 mm – 800 mm

5.2 Actions and design situations

5.2.1 Actions for gravity retaining walls should conform to **4.5.1**.

5.2.2 Design situations for gravity retaining walls should conform to **4.2.2**.

5.3 Design considerations

5.3.1 General

To avoid the illusion of tilting forward, the front face of a mass concrete retaining wall should be battered backwards at no less than 1 in 50.

5.3.2 Drainage

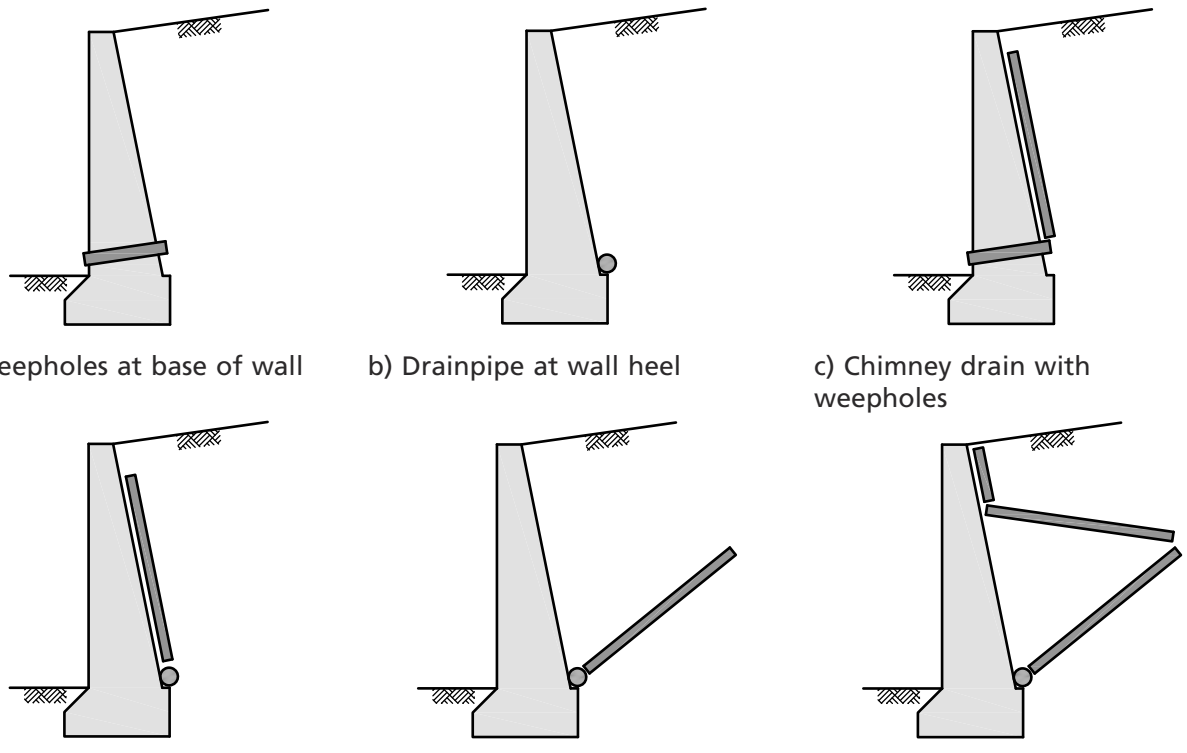
*COMMENTARY ON **5.3.2***

The provision of a drainage system behind a gravity wall can reduce the total pressures that the wall has to resist possibly by more than 30% in granular material.

Figure 9 shows some typical drainage systems behind a gravity retaining wall.

Pipes used in drainage systems behind gravity retaining walls should conform to Table 10.

Figure 9 **Typical drainage systems behind gravity retaining walls**



a) Weepholes at base of wall

b) Drainpipe at wall heel

c) Chimney drain with weepholes

d) Chimney drain with drainpipe

e) Inclined drain

f) Interceptor drains with drainpipe

NOTE *Based on* Earth Pressure and Earth-Retaining Structures *[2].*

Table 10 **Drainage systems for gravity retaining walls**

Location of pipe	Type of pipe	Requirements
Rear of wall	Vitrified clay	Perforated with flexible mechanical joints
	Unplasticized polyvinylchloride (UPVC), polypropylene (PP) or polyethylene (PE)	Diameter 80 mm to 150 mm Perforated with not less than 1 000 mm^2/m of holes per unit length of pipe
	Thermoplastics structured wall pipe	
	Geotextile wrapped land drain	
Drainage connections	Vitrified clay Thermoplastics structured wall pipe	Normal or surface water pipes

5.3.3 Gabion walls

5.3.3.1 The width of the horizontal tread of the steps should not exceed the depth of the gabion.

5.3.3.2 A gabion wall should be built to a batter to increase its resistance to overturning and sliding.

5.3.3.3 Counterforts or buttresses may be incorporated in the construction of gabion walls.

5.3.3.4 In large walls where the cross section is greater than 4 m wide, consideration should be given to using a cellular form of construction.

5.3.3.5 The outer and inner gabion faces should be tied by bulkheads of gabions and the cells between them filled with stone. The size and shape of the cells should be proportioned to achieve internal stability.

5.3.3.6 In rivers and in tidal waters, consideration should be given to installing a filter behind the wall, to prevent the leaching of fines.

5.3.3.7 Gabion boxes with cages longer than 1.5 m should be fitted with transverse vertical diaphragm panels at 1 m centres to prevent undue distortion and stone migration. The edges of any diaphragm panels should be fixed to the sides by lacing or clips with 2.2 mm minimum binding wire, galvanized or PVC coated, to match the gabion mesh.

5.3.3.8 Gabion units should bear down fully on the gabion below and not overhang the unit at the back by more than 150 mm, except in the case of a stepped revetment. Where gabion units do overhang, care should be taken to compact the backfill in the vicinity of and beneath the overhang.

5.3.3.9 Traffic loads may be ignored in the verification of wall stability if they are a distance greater than the wall's retained height behind the back of the wall.

5.3.3.10 Gabion walls may be designed to support traffic loads, provided the wall's flexibility is taken into account.

5.3.3.11 Gabion walls intended to support an existing slope should be built into the slope, after suitable trimming.

5.3.3.12 Foundations for buildings or other structures should not impose loading onto a gabion wall or its foundation.

5.3.4 Crib walls

5.3.4.1 The batter of a crib wall should normally be between 1-in-6 and 1-in-4 (horizontal to vertical).

5.3.4.2 A crib wall retaining up to 2 m of soil may be built with a nominal batter (i.e. near vertical) if its depth is greater than its retained height.

5.3.4.3 Timber crib walls may be built using whole logs or sawn timbers. If whole logs are used, plane faces should be formed at the points of contact to distribute the load and provide anchorage between adjacent members.

5.3.4.4 Timber crib walls should be formed with front and rear stretcher units tied at intervals by headers across the thickness of the wall. Headers should be anchored by notching or spikes so as to tie together the stretcher courses.

5.3.4.5 The face stretchers of a precast reinforced concrete crib wall should be positively anchored over the full thickness of the wall by interlocking headers. The headers should be aligned vertically to transmit load directly throughout the height of the wall without inducing bending moments in the supporting stretcher units.

5.3.4.6 Traffic loads may be ignored in the verification of wall stability if they are a distance greater than the wall's retained height behind the back of the wall.

5.3.4.7 Crib walls may be designed to support traffic loads, provided the wall's flexibility is taken into account.

5.3.4.8 Crib walls intended to support an existing slope should be built into the slope, after suitable trimming.

5.3.4.9 Foundations for buildings or other structures should not impose loading onto a crib wall or its foundation.

5.3.4.10 Weepholes should be provided if the infill is not free draining (for example if lean mix concrete infill has been used to increase stability). The infill zone immediately behind the wall should be built with free-draining material.

5.4 Calculation models

5.4.1 Virtual back of wall

Gravity retaining walls that do not have a planar back surface may be designed with a planar "virtual back", where the virtual back is:

- for a gravity wall with a stepped back: the vertical plane extending from the heel of the wall base to ground surface;
- for a crib wall: along the back of the cribs; and
- for a gabion wall: along a line from the inner bottom corner of the lowest basket to the inner top corner of the top basket.

5.4.2 Interface friction between wall and ground

*COMMENTARY ON **5.4.2***

In gabion walls, separation of the backfill stone and the retained soil is normally achieved by placing a geotextile membrane along the rear face of the wall. The presence of this membrane can reduce interface friction along the rear face.

5.4.2.1 Owing to their surface roughness, the design angle of interface friction, δ_d, between the rear of a gabion wall and the retained ground should be limited to:

$$\delta_d \leq k_{membrane} \times \varphi'_d \quad (27)$$

where:

φ'_d is the design peak angle of shearing resistance of the ground; and

$k_{membrane}$ is a factor that accounts for the reduction of friction caused by the presence of a membrane placed against the rear face of the gabion wall.

5.4.2.2 For geotextile membranes, in the absence of reliable test data, the value of $k_{membrane}$ should be taken as 0.75 where the rear face of the wall is planar; otherwise it may be taken as 1.0. For other types of membrane, $k_{membrane}$ should be determined from test data.

5.4.3 "No tension" criterion for bearing pressure

The cross section of a gabion or crib wall should be proportioned so that the resultant force at any horizontal section lies within the middle third of that section.

5.5 Materials

5.5.1 Concrete

5.5.1.1 Plain (i.e. unreinforced) concrete incorporated into mass concrete retaining walls should conform to BS EN 1992-1-1:2004+A1:2014, Clause **12**.

5.5.1.2 Precast concrete blocks incorporated into crib walls should conform to BS EN 13369.

5.5.2 Steel

5.5.2.1 Steel and related products incorporated into gabion walls should conform to **4.3.7** and this subclause (**5.2.2**).

NOTE Gabions may be constructed using hexagonal woven wire mesh or welded wire mesh.

5.5.2.2 Wire mesh incorporated into gabion walls should conform to BS EN 10218-1 and BS EN 10218-2.

5.5.2.3 Hexagonal steel wire mesh products incorporated into gabion walls should conform to BS EN 10223-3.

5.5.2.4 Welded mesh gabion products incorporated into gabion walls should conform to BS EN 10223-8.

5.5.2.5 Welded joints in gabions should be designed to account for differential settlement of the cages.

5.5.2.6 Organic coatings on steel wire incorporated into gabion walls should conform to BS EN 10245-1, BS EN 10245-2, BS EN 10245-3 and BS EN 10245-5.

5.5.3 Timber

Timber and related products incorporated into crib walls should conform to **4.3.8**.

5.5.4 Masonry

Masonry and related products incorporated into unreinforced masonry retaining walls should conform to **4.3.9**.

5.5.5 Fill

5.5.5.1 Fill placed inside or behind gravity retaining walls should conform to **4.3.3**.

5.5.5.2 Naturally occurring rounded stone or quarried stone may be used as fill material in gabions. The size of the stone should be selected so that it cannot pass though the mesh, but otherwise should be as small and as uniform as possible. The maximum size of fill should not exceed 200 mm.

5.5.5.3 Stone whose size is smaller than the mesh opening may be used provided it is not used at external faces. A mesh panel or fabric should be provided to separate the smaller stone from stone that is larger than the mesh opening.

5.5.5.4 Stone fill used in gabion walls should be hard, angular to round, durable, and of such quality that it cannot deteriorate or fragment due to exposure to water or weathering during the design life of the wall.

5.5.5.5 The density of the infill used in gabion and crib walls should be assessed according to the gradings and proportion of voids after placing.

5.5.5.6 Infill material for cribwork should be durable, inert and free draining. Coarse sand, gravel and rock rubble should be used whenever obtainable. Loss of fill through the openings of the cribwork should be prevented.

NOTE Fill placed behind gravity walls may include lightweight fill, treated marginal fill, recycled fill, pulverized fuel ash, or colliery spoil.

5.6 Durability

5.6.1 Concrete

The durability of gravity concrete retaining walls should conform to **4.4.2**.

5.6.2 Steel

5.6.2.1 The durability of steel used in gravity walls should conform to **4.4.3**.

5.6.2.2 Uncoated wire gabions should only be used for temporary works, unless the wire diameter is at least 5 mm and the expected life of the unprotected steel is sufficient for such gabions to be used for permanent works.

5.6.2.3 Galvanized gabions may be used where the expected life of the galvanized wire exceeds the design life of the structure. If the expected life is insufficient, then polymer (PVC or PA6) coated wire or stainless steel mesh should be used instead.

5.6.2.4 Polymer coated gabions should not be used on coastal foreshores, where large shingle or heavy abrasive material is likely to be thrown against or washed over the structure by wave action.

5.6.2.5 Hexagonal woven mesh gabions should be made from galvanized wire conforming to BS EN 10244-2.

5.6.2.6 The panels of welded mesh gabions should either be made from zinc (95%) aluminium (5%) coating conforming to BS EN 10244-2:2009 (Class A) or should be hot dip galvanized after welding, in accordance with BS EN ISO 1461.