

SECTION 4. COVER TO REINFORCEMENT

A fundamental and most critical aspect of the durability of any reinforced concrete member, or any masonry member containing reinforcement, is the provision of adequate cover to the reinforcement. It is also an important aspect of achieving a fire rating for a reinforced masonry member in terms of structural adequacy.

4.1 Cover requirements for durability

BS 5628-2:2005 Clause 10.1 addresses durability. The opening statement in Clause 10.1.2.1 is that

“adequate durability may be ensured either by selecting appropriately protected reinforcement, or by providing sufficient concrete cover of the appropriate quality.”

BS 5628-2:2005 Clause 10.1.2.2 lists four exposure situations that are used to determine the level of protection required:

Exposure situation E1.

- Internal work, or
- The inner skin of ungrouted external cavity walls, or
- Masonry behind surfaces protected by an impervious coating that can readily be inspected, or
- External parts built where the exposure category given in BS 5628-3:2005, Table 10 is Sheltered or Very Sheltered. (As can be seen in the table below however, Table 10 does not have a “very sheltered” category.)

Exposure situation E2.

- Buried masonry, or
- Masonry continually submerged in fresh water, or
- External parts built where the exposure category given in BS 5628-3:2005, Table 10 is Sheltered/Moderate or Moderate/Severe.

Exposure situation E3.

- Masonry exposed to freezing whilst wet, or
- Masonry subjected to heavy condensation, or
- Masonry exposed to cycles of wetting by fresh water and drying out or
- External parts built where the exposure category given in BS 5628-3:2005, Table 10 is Severe or Very Severe.

Exposure situation E4.

- Masonry exposed to salt or moorland water, or
- Masonry exposed to corrosive fumes, abrasion or the salt used for de-icing.

BS 5628-3:2005 Table 10 lists four categories of exposure that relate to the exposure to local wind-driven rain:

Category of Exposure		Calculated quantity of wind-driven rain Litres/square metre per spell
1	Sheltered	Less than 33
2	Moderate	33 to less than 56.5
3	Severe	56.5 to less than 100
4	Very Severe	Not less than 100

In the above table, the calculated quantity of wind-driven rain is the maximum wall spell index calculated using the local spell index method specified in BS 8104.

BRE Report BR 262 provides a simplified procedure for assessing exposure to wind-driven rain for walls up to 12m high. It is primarily intended for low-rise domestic buildings, but it can also be used for other categories of buildings of a similar scale.

BS 5628-2:2005 Clause 10.1.2.6 permits the use of different types of reinforcement to provide adequate durability. It states that when austenitic stainless steel reinforcement is used, or when carbon steel coated with at least 1mm of austenitic stainless steel is used, then there is no minimum cover required to ensure durability. Sufficient cover to develop bond stress is all that is required.

The Code is really quite convoluted in its reinforcement cover requirements for grouted hollow block construction.

BS 5628-2:2005 Clause 10.1.2.6 states that for grouted-cavity and Quetta bond construction (it does not mention grouted hollow block) the minimum cover to reinforcement selected using Table 14 should be as follows:

- a) carbon steel reinforcement used in internal walls and exposure situation E1: 20mm mortar or concrete;
- b) carbon steel reinforcement used in exposure situation E2: 20mm concrete;
- c) galvanised steel reinforcement: 20mm mortar or concrete
- d) stainless steel reinforcement: not required for durability.

Note that this is the minimum cover and in the case of Exposure Situation E2 according to Table 15 the minimum cover only applies if C40/50 concrete is used for the core filling grout. Note also that with **mortarless** masonry, mortar cover to reinforcement does not apply.

With respect to **mortarless** masonry construction, BS 5628-2:2005 Table 14 specifies the following for the selection of reinforcement for the four exposure situations:

Exposure Situation E1: carbon steel

Exposure Situation E2: carbon steel

Exposure Situation E3: carbon steel galvanized in accordance with BS EN ISO 1461 with a minimum mass of zinc coating of 940g/m²

Exposure Situation E4: austenitic stainless steel in accordance with BS EN 10088 or carbon steel coated with at least 1mm of stainless steel, the stainless steel grade being selected according to the exposure and the environmental aggression applicable.

The interpretation of Clause 10.1.2.6 and Table 14 is that the minimum 20mm cover for galvanised reinforcement applies to any exposure situation in which galvanised reinforcement is permitted (i.e. exposure classifications E1, E2 and E3) regardless of the concrete grade. As 20mm cover is permitted in exposure classification E1 for carbon steel reinforcement and all concrete strengths, and as galvanised reinforcement is the minimum required for exposure classification E3, then it can be deduced that upgrading to galvanised reinforcement for exposure classification E2 will reduce the cover requirement shown in BS 5628-2:2005 Table 15 for the lower grades of concrete (see table below).

BS 5628-2:2005 Table 15 provides details of the minimum concrete cover to carbon steel reinforcement for a range of concrete strengths as shown below:

BS 5628-2:2005 Table 15 - Minimum concrete cover for carbon steel reinforcement					
Exposure Situation	Concrete grade in BS EN 206-1 and BS 8500				
	C25/30	C28/35	C32/40	C35/45	C40/50
	Minimum cement content (kg/m ³) (coarse aggregate max 10mm)				
	315	340	365	390	440
	Minimum free water/cement ratio				
	0.65	0.60	0.55	0.50	0.45
Thickness of concrete cover (mm) (coarse aggregate max 10mm)					
E1	20	20	15	15	15
E2	-	35	30	25	20
E3	-	-	40	30	25
E4	-	-	-	60*	50

* If the core filling grout might be subjected to freezing whilst wet, air entrainment should also be used.

It is somewhat confusing that Table 15 infers that carbon steel reinforcement is acceptable for Exposure Situations E3 and E4 when high strength concrete is used, however Table 14 does not permit the use of carbon steel reinforcement in these Exposure Situations. Under these circumstances it is recommended that designers err on the conservative side and adhere to the recommendations in Table 14.

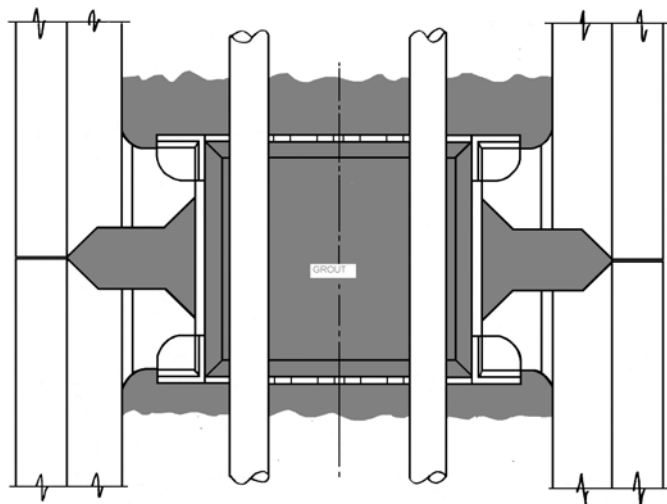
It is also confusing that Table 15 shows a minimum cover of 20mm for concrete with a maximum aggregate size of 20mm whereas Clause 6.9.1 requires that the maximum size of the aggregate should not exceed the cover to any reinforcement less 5mm.

For Exposure Situations E1 and E2 above, Carbon steel reinforcement is permitted, however as explained above upgrading to galvanized reinforcement in exposure situation E2 will reduce the cover requirement to 20mm for all grades of concrete.

According to BS 5628-2:2005 Fig 5, the concrete cover required is to be measured independent of the block shell.

As will be seen in Section 5 the recommended core filling grout for *mortarless* masonry has a maximum aggregate size of 5mm. This is reflected in the figures given in the reproduction of Table 15 above.

Most mortarless systems provide totally inadequate cover in the vicinity of the perpends and many also provide totally inadequate cover in the vicinity of the bed joints, but this issue has been addressed in the Mortarless Pty Ltd *mortarless* masonry units.



Plan view on connector joining two 200 mortarless blocks and supporting two horizontal bars, showing the shaping of the ends of the blocks to maximize grout penetration into the perpend

The **mortarless** masonry of Mortarless Pty Ltd is arguably the only concrete block system available that can provide an adequate level of certainty in the accurate placing of reinforcement, and this means that it is arguably the only concrete block system with which there can be a satisfactory degree of confidence in the cover that is being provided to the reinforcement, particularly the cover to vertical reinforcing bars.

4.2 Cover requirements for fire resistance (structural adequacy)

Mortarless masonry must always be fully grouted, however it can be designed as reinforced or unreinforced as required. It is anticipated that most **mortarless** masonry elements will be designed as reinforced masonry for bending and in plane shear. As such it is also anticipated that most mortarless masonry elements will be considered reinforced masonry elements for the purposes of assessing fire resistance.

BS 5628-2:2005 Clause 10.2 provides for the fire resistance of reinforced masonry to be determined in accordance with the requirements of BS 8110-2:1985 but it specifically permits the block shell to be included in the measurement of cover to reinforcement.