Part 3

General

Chapter

3.1

NHBC

Concrete and its reinforcement

This chapter gives guidance on meeting the Technical Requirements for concrete and its reinforcement.

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Introduction

Concrete design and specification should comply with the relevant British Standards. Mix design should take account of strength and durability, and follow recognised standards and practices. Alternatively, mixes in accordance with the guidance in this chapter will be acceptable. This applies to plain and reinforced concrete, whether precast or in-situ.

3.1.1 Compliance

Also see: Chapter 2.1, BS 8500 and BS EN 206

Concrete and its reinforcement shall comply with the Technical Requirements.

Concrete and its reinforcement that complies with the guidance in this chapter, which covers plain and reinforced concrete, precast or in-situ, will generally be acceptable.

Mix design should take account of strength and durability, and comply with the relevant British Standards.

3.1.2 Provision of information

Designs and specifications shall be produced in a clearly understandable format, include all relevant information and be distributed to appropriate personnel.

Design and specification information should be issued to site supervisors, relevant specialist subcontractors and suppliers, and include the following information:

Ground aggressivity	• design sulfate class (DS class)	• aggressive chemical environment for concrete class (ACEC class)
Strength and durability	• strength • maximum free water/cement ratio and/or minimum cement content • consistence class (eg slump)	• air content (where required) • aggregate size • colour
Mix design and additional protective measures (APM)	• specification of mix designs (concrete strength class)	• details of any APM
Reinforcement and movement joints	• cover to reinforcement • reinforcement, plans, sections and bending schedules • reinforcement details at supporting edges • camber in beams and slabs, where appropriate	• reinforcement around openings • drawings and bending schedules should be prepared in accordance with BS 8666 • movement joints
Formwork	• formwork materials and features • joints	• mould release agents • holes for services
Finishing treatments	• concrete to be left untouched or with minimum finishing may require detailed formwork drawings indicating the position and detail of joints between shutters, corners and other critical junctions	
Testing	• number and frequency of samples to be taken • test laboratory details	• recording of results
Curing and protection	• requirements for curing and striking formwork	• minimum period for striking/removal of formwork, curing and protection

3.1.3 Storage of materials

Also see: Chapter 3.2

Materials shall be properly stored to avoid impairing the performance of the finished concrete.

Where materials need to be stored, the following precautions should be taken:

- follow manufacturer's recommendations on maximum storage time
- store cement in a dry place and keep each type separate
- store different sizes of aggregate in separate bays
- keep sand and aggregate clean and dry (allowance should be made in the concrete batching for moisture in the sand and aggregate).

3.1.4 Site-mixed concrete

Site-mixed concrete shall be designed and mixed to ensure sufficient strength and durability.

Concrete should be mixed using an appropriate method to achieve the required strength and durability. Except for very small quantities, a mechanical mixer should be used. Where hand mixing, add an extra 10% of cement to the quantities shown in Tables 2 and 3.

Table 1: Guidance for site-mixed concrete

Material	Guidance
Cement or cementitious material	• BS 8500-2 2023 including Annexes A and B
Air-entraining admixtures	• should not be used in standardised prescribed concrete mixes
Admixtures, other than air-entraining admixtures	• BS EN 934-2
Water	• mains supply water, or in accordance with BS EN 1008
Aggregates	• compliant with BS EN 12620 Aggregates for concrete • mixed and precautions taken, as described in BRE Digest 357 • fine and/or of coarse proportions mixed as specified • proportioned to ensure a reasonable consistency, when supplied as a mixture • checked and precautions taken when shrinkable aggregates, aggregates susceptible to alkali attack or excessive moisture movement, or unfamiliar materials are used • within the limits of the aggregate carbon range (ACR), when subject to aggressive sulfate ground conditions • assessed in accordance with Technical Requirement R3 where materials are recovered or proprietary

The information below applies to cement strength class 32.5 and 20mm maximum aggregate size. Where cement strength class 42.5 or higher is used, the cement weight should be decreased by 10%.

Table 2: Mix proportions by weight

Standardised prescribed mix	Consistence class (slump in mm)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
ST1	S1 (10-40)	230	770	1,155
ST2	S2 (50-90)	265	760	1,135
ST2	S3 (100-150)	285	735	1,105
ST2	S4 (160-210)	300	815	990
ST3	S2 (50-90)	295	745	1,120
ST4	S2 (50-90)	330	735*	1,100
ST5	S2 (50-90)	375	720*	1,080

* Fine aggregate grading to be grades CP or MP only of BS EN 12620.

Table 3: Mix proportions by volume using a maximum 20mm aggregate size

Cement strength class	Standardised prescribed mix	Consistence class (slump in mm)	Number of (25kg) bags of cement	Fine aggregate (litres)	Coarse aggregate (litres)
32.5	ST1	S1 (10-40)	1	50	80
	ST2	S2 (50-90)	1	45	65
	ST2	S3 (100-150)	1	45*	55
	ST2	S4 (160-210)	1	45*	50
	ST3	S2 (50-90)	1	40	55
42.5 or higher	ST1	S1 (10-40)	1	60	90
	ST2	S2 (50-90)	1	50	75
	ST2	S3 (100-150)	1	50*	65
	ST2	S4 (160-210)	1	45*	60
	ST3	S2 (50-90)	1	45	65

*Fine aggregate grading to be grades CP or MP only to BS EN 12620.

3.1.5 Ready-mixed concrete

Ready-mixed concrete shall be from a supplier operating under a quality control system acceptable to NHBC and be of sufficient strength and durability.

Ready-mixed concrete is acceptable from suppliers who operate under a full quality control scheme such as:

- the Quality Scheme for Ready Mixed Concrete (QSRMC), or
- the BSI Kitemark scheme.

Other suppliers may be suitable if they operate to an equivalent quality standard acceptable to NHBC.

Ready-mixed concrete should be ordered to a detailed specification conforming to BS 8500 and BS EN 206.

When designated mixes are used, the ready-mix supplier will only require the mix designation and consistence class (see Clause 3.1.6 Table 4).

Delivery information should be checked to ensure that the concrete meets the requirements given in the design.

3.1.6 Concrete specification

Also see: BRE Digest 357, BRE Special Digest 1, BS 8500-1, BS 8500-2 and BS EN 206

Concrete shall be specified correctly to ensure adequate strength and durability. Issues to be taken into account include:

1) **concrete in non-hazardous conditions**
2) **exposure to climatic and atmospheric conditions**
3) **exposure to aggressive ground conditions**
4) **exposure to sulfates and acids in groundwater**
5) **effects of chlorides**
6) **effects of alkali-silica reaction**
7) **aggregates.**

Concrete mixes should be suitable for particular end uses and specified in accordance with BS 8500-1 as either:

- designated mix, which is supplied ready mixed, or
- standardised prescribed mix for site mixing.

Designated mixes should conform to Table 7 of BS 8500-2 2023. Standardised prescribed mixes should conform to Tables 2 and 3 in this chapter.

Mixes should also be designed for the expected conditions of the geographical location of the site and the location of the concrete element in the structure. Higher-grade concrete has greater resistance to chemical and mechanical damage and should be specified accordingly.

In addition to the issues in this section, durability is reliant on:

- correct control of the water:cement ratio
- full compaction of the placed concrete
- good curing.

3.1.6.1 Concrete in non-hazardous conditions

Table 4: Minimum specifications for general purpose concrete mixes

Location and use	BS 8500 and BS EN 206		
	Ready-mixed concrete (designated mix)	Site-mixed concrete (standardised prescribed mix)	Consistence class
Substructure and ground floors • rough blinding (non-structural) • infill • unreinforced oversite concrete below timber floors	GEN1	ST2	S3
• structural blinding and over break • strip foundations • trench fill • other mass concrete foundations • fill to wall cavity • solid filling under steps	GEN1	ST2	S3/S4(1)
• house floors not designed as suspended and not reinforced: – permanent finish to be added, eg screed or floating floor – no permanent finish to be added, eg power float finished and carpeted	 GEN1 GEN2	 ST2 ST3	 S2 S2

Table 4 (continued): Minimum specifications for general purpose concrete mixes

Location and use	BS 8500 and BS EN 206		
	Ready-mixed concrete (designated mix)	Site-mixed concrete (standardised prescribed mix)	Consistence class
• garage floors not designed as suspended and not reinforced	GEN3	ST4	S2
• house and garage ground floor slabs: – fully or nominally reinforced, either ground-bearing, suspended or over sub-floor voids	RC28/35	ST5[2]	S2
Superstructure			
• general reinforced concrete exposure class[3] to BS8500-1: – nominal cover to reinforcement of 35mm (which is the minimum cover of 25mm plus an allowance in design for deviation of 10mm) a) XC1 (dry) and XC2 (wet, rarely dry) b) XC3 (moderate humidity), XC4 (cyclic wet and dry) and XF1 (freeze/thaw attack and no de-icing agent) – nominal cover to reinforcement of 40mm (which is the minimum cover of 30mm plus an allowance in design for deviation of 10mm) c) any exposure class (XC1-4 and XF1)	 RC25/30 RC32/40 RC28/35	 [4] - [5]	 S2 S2 S2
In-situ external concrete			
• drives and paths • bedding for precast concrete paving slabs	PAV1 GEN1	ST5[6] ST1	S2 S1

Notes

1. Consistence class S3 should be used for strip foundation concrete and consistence class S4 should be used for trench fill foundation concrete.
2. ST4 mix for house and garage floors may only be used in conjunction with Chapter 5.2 Suspended ground floors. In all other cases, the designated mix should be used.
3. Exposure classes (XC1-4 and XF1) are defined in BS 8500-1 Table A.1.
4. In this situation, ST4 mix may be used only for small quantities of concrete. In all other cases, the appropriate designated mix should be used.
5. In this situation, an ST5 mix may be used only for small quantities of concrete. In all other cases, the appropriate designated mix should be used.
6. Not suitable in areas of severe exposure to frost attack. This is equivalent to exposure class XC4 above.

3.1.6.2 Exposure to climatic and atmospheric conditions

Any concrete mix should be designed for the conditions expected at the geographical location of the site and at the location of the element in the structure.

Table 5: Exposure classes and examples of where they may occur, based on Table 1 of BS EN 206

Exposure class	Environment	Exposure conditions
XC1	Dry or permanently wet	• concrete inside buildings with low air humidity • concrete permanently submerged in water
XC2	Wet, rarely dry	• concrete surfaces subject to long-term water contact. Many foundations
XC3	Moderate humidity	• concrete inside buildings with moderate or high air humidity • external concrete sheltered from rain
XC4	Cyclic wet and dry	• concrete surfaces subject to water contact, not within exposure class XC2
XF1	Moderate water saturation, without de-icing agent	• vertical concrete surfaces exposed to rain and freezing

3.1.6.3 Concrete in aggressive ground

Mixes should conform to BS 8500. The information in this section describes minimum specifications for lower range 'chemical aggressiveness'. Specialist advice should be sought for more aggressive conditions.

Table 6: ACEC site classification[1] and applies to concrete exposed to ground with a pH value greater than 2.5

Sulfate and magnesium				Natural soil		Brownfield [3]				ACEC class for site
Design sulfate class for site	2:1 water/ soil extract	Ground water	Total potential sulfate [2]	Static water	Mobile water	Static water		Mobile water		
1	2	3	4	5	6	7	8	9	10	11
	SO_4	Mg	SO_4	Mg	SO_4	pH	pH	pH[5]	pH[5]	
	mg/l	mg/l	mg/l	mg/l	%					
DS-1	<500	All Mg values	<400	All Mg values	<0.24	>2.5		>2.5		AC-1s
							>5.5[6]		>6.5	AC-1
							2.5 -5.5		5.6-6.5	AC-2z
									4.5-5.5	AC-3z
									2.5-4.5	AC-4z
DS-2	500-1500	All Mg values	400-1400	All Mg values	0.24-0.6	>3.5		>5.5		AC-1s
							>5.5		>6.5	AC-2
						2.5-3.5		2.5-5.5		AC-2s
							2.5-5.5		5.6-6.5	AC-3z
									4.5-5.5	AC-4z
									2.5-4.5	AC-5z

Notes

1. For concrete quality and APM for ACEC classes above AC-2z, follow specialist advice. For the full list of ACEC classes, refer to Table A.2 of BS 8500-1 or BRE Special Digest 1 Table C1 for natural ground locations, and Table C2 for brownfield locations.
2. Applies only to sites where concrete will be exposed to sulfate ions (SO_4), which may result from the oxidation of sulfides such as pyrite, following ground disturbance.
3. Applies to locations on sites that comprise either undisturbed ground that is in its natural state or clean fill derived from such ground.
4. 'Brownfield' is defined as sites which may contain chemical residues remaining from previous industrial use or from imported wastes.
5. An additional account is taken of hydrochloric and nitric acids by adjustment to sulfate content.
6. For flowing water that is potentially aggressive to concrete owing to high purity or an aggressive carbon dioxide level greater than 15mg/l, increase the ACEC class to AC-2z.

Explanation of suffix symbols to ACEC class number:

- suffix 's' indicates that, as the water has been classified as static, no APM are generally necessary
- concrete placed in ACEC classes which include the suffix 'z' have primarily to resist acid conditions and may be made with any of the cements or combinations listed in Table D2 of BRE Special Digest 1.

This table is based on Tables C1 and C2 of BRE Special Digest 1.

The information in Table 7 provides guidance on selecting mixes for concrete elements in aggressive ground.

Table 7: Design guide for concrete elements in the ground

Concrete element	ACEC class [1]	Designated mix
Strip or trench fill foundation, raft foundation, pile[3] and ground beams	AC-1, AC-1s	As Table 4
	AC-2, AC-2s	FND2[2]
	AC-2z	FND2z[2]

Notes

1. For all other ACEC classes, follow specialist advice.
2. Portland limestone cement may only be used where the design sulfate class (see Table 5) of the site does not exceed DS-1.
3. Applies to cast-in-situ piles only — for other types of pile refer to BRE Special Digest 1 or follow specialist advice.

3.1.6.4 Exposure to sulfates and acids in groundwater

Sulfates, chemicals and high acidity can cause expansion, cracking and damage to concrete. Where groundwater is highly mobile, or where concrete is at risk from chemical attack, the level of sulfate and other chemicals should be determined according to the ACEC class and BRE Special Digest 1.

For higher ACEC classes, specialist advice should determine the design chemical class (DC class) and appropriate APM where required. Table A.10 of BS 8500-1 should be used to select the mix specification.

For lower ACEC classes (AC-1, AC-1s, AC-2, AC-2s and AC-2z), information in Tables 6 and 7 should be used to select the mix specification.

3.1.6.5 Effects of chlorides

Chlorides, which are contained in all concrete materials, increase the risk of corrosion in metal and can reduce the chemical resistance of concrete. Therefore chloride content of fresh concrete should be limited in accordance with BS EN 206 Table 15.

Cured concrete can be damaged by chlorides in the ground, sea spray or products used for de-icing highways, and specialist guidance should be followed.

3.1.6.6 Effects of alkali-silica reaction

Alkalis can cause expansion, cracking and damage to concrete. Damage can occur when all the following conditions are present:

- a source of alkali
- a high moisture content
- where the aggregate is alkali reactive.

Alkali content calculated in accordance with BRE Digest 330 or Concrete Society Technical Report 30 should not exceed 3kg/m^3. Where unfamiliar aggregate materials are used, special precautions may be required.

Standardised prescribed mixes should conform to BS 8500.

3.1.6.7 Aggregates

Aggregates should be of a grade which ensures adequate durability of the concrete. Certain types of aggregate are shrinkable and require special precautions in mixing. Certain types of aggregate may be susceptible to alkali attack or excessive moisture movement.

Proprietary and recovered aggregates should only be specified where they have been assessed in accordance with Technical Requirement R3.

3.1.7 Admixtures

Admixtures shall only be used to enhance the performance and durability of concrete.

Issues that should be taken into account include:

- improved workability
- waterproofing
- foaming agents
- accelerated strength
- retardation
- chlorides.

Admixtures should comply with BS EN 934-2 Admixtures for concrete, mortar and grout — Concrete admixtures — Definitions, requirements, conformity, marking and labelling, should be used in accordance with BS EN 206 and:

- specified only with full knowledge of their limitations and effects
- used only where permitted in the specification
- tested in trial mixes, where necessary
- added to the mix water to ensure complete dispersal
- dosed correctly
- used strictly in accordance with the manufacturer's instructions.

Accelerators produce early setting of the concrete, and plasticisers can improve concrete cohesion and the bond with reinforcement.

Air-entraining agents should not be used as an anti-freeze for fresh concrete. However, they can increase the frost resistance of cured concrete and are recommended for paths, drives and pavements which are likely to be exposed to freezing conditions.

Retarding agents can increase the risk of frost damage.

Admixtures containing chlorides can cause metal corrosion and should not be used in reinforced concrete.

3.1.8 Special types of concrete

Special types of concrete shall be appropriate for their use.

Proprietary concrete, no-fines or lightweight concrete should be of a quality and density appropriate for the conditions and use. Where no-fines concrete is used, a render, cover coat or cladding should be applied to the finished structure.

Proprietary methods of reinforcement, eg glass fibre, should be assessed in accordance with Technical Requirement R3.

Structural design should be in accordance with Technical Requirement R5 and the mix properly detailed.

3.1.9 Design of reinforced concrete

Reinforced concrete shall be suitable for its intended use. Issues to take into account include:

1) **compliance with appropriate standards**
2) **end restraint**
3) **concrete cover**
4) **fire resistance**
5) **carbonation.**

Reinforced concrete should be designed by an engineer in accordance with Technical Requirement R5. BS 8103-1 can be used for the design of suspended ground floors in homes and garages.

3.1.9.1 Compliance with appropriate standards

The steel specification should indicate the steel type, grade and size. Drawings and bending schedules should be prepared in accordance with BS 8666 and include all necessary dimensions for completion of the sitework. Reinforcement should comply with the standards listed below.

BS EN 1992-1	Design of concrete structures
BS 4449	Steel for the reinforcement of concrete. Specification
BS 4482	Steel wire for the reinforcement of concrete products. Specification
BS 4483	Steel fabric for the reinforcement of concrete. Specification
BS 6744	Stainless steel bars. Reinforcement of concrete. Requirements and test methods
BS 8103-1	Structural design of low-rise buildings. Code of practice for stability, site investigation, foundations, precast concrete floors and ground floor slabs for housing

3.1.9.2 End restraint

Where the ends of slabs are cast monolithically with concrete members, surface cracking may develop over the supports. Reinforcement should therefore be provided in accordance with BS EN 1992-1-1.

3.1.9.3 Concrete cover

There should be adequate cover to the reinforcement, especially where it is exposed or in contact with the ground. Cover should be adequate for all reinforcement, including main bars and stirrups. No ties or clips should protrude into the concrete cover.

For concrete not designed by an engineer, the minimum cover for reinforcement should be in accordance with Table 8.

Figure 1: Concrete cover

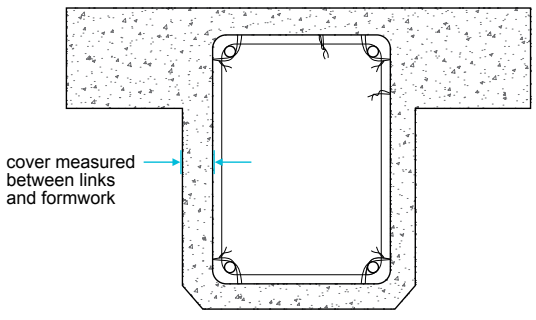


Table 8: Minimum cover for reinforcement for concrete not designed by an engineer

Position of the concrete	Minimum cover (mm)
In contact with the ground	75
External conditions	50
Cast against a DPM on sand blinding	40
Against adequate blinding concrete	40
Protected or internal conditions	25

3.1.9.4 Fire resistance

Concrete cover to reinforcement should be adequate to resist fire. Requirements for fire resistance are given in BS EN 1992-1-2. Cover required by BS EN 1992-1-1 will normally provide up to one hour of fire resistance for columns, simply supported beams and floors.

3.1.9.5 Carbonation

Carbonation reduces the corrosion protection of the reinforcement by increasing porosity and decreasing alkalinity. Such corrosion can be reduced by providing as much concrete cover as possible, and by ensuring that the wet concrete is of good quality and properly compacted to reduce the rate of carbonation.

3.1.10 Installation of reinforcement

Also see: Chapter 5.2

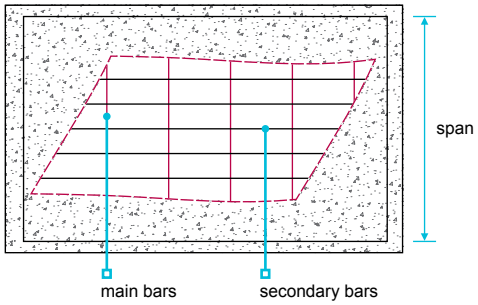
Reinforcement shall be installed in accordance with the design. Issues to take into account include:

1) **shape, placing and condition of reinforcement bars**
2) **lapping bars and mesh**
3) **support for reinforcement.**

3.1.10.1 Shape, placing and condition of reinforcement bars

Main reinforcing bars	Should be parallel to the span, or as detailed in the design
Slab reinforcement	Should be located near the bottom of the slab, with the main reinforcing bars placed first and the secondary bars on top
Beams	Should have the main reinforcing bars placed inside the links

Figure 2: Reinforcement layout



Reinforcement should be:

- bent using appropriate equipment and placed in accordance with the design
- clean and free from loose rust and contaminants, especially shutter-releasing agents and oil.

3.1.10.2 Lapping bars and mesh

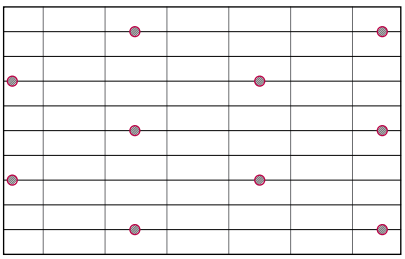
Reinforcing bars or mesh should be lapped according to type and size as indicated by the designer to ensure that loads are fully transferred across the lap. Particular care should be taken when lapping mesh reinforcement to ensure both the correct cover is achieved and bars are laid in the correct layers. Depths of cover may need to be increased to accommodate this or use pre-cut sheets with 'flying ends' to avoid nestling or additional loose continuity bars detailed and/or agreed by the designer.

3.1.10.3 Support for reinforcement

Spacers should be either concrete blocks (no more than 50 x 50mm) or ready-made of steel or plastic. Supports should be placed no more than one metre apart, or closer where necessary.

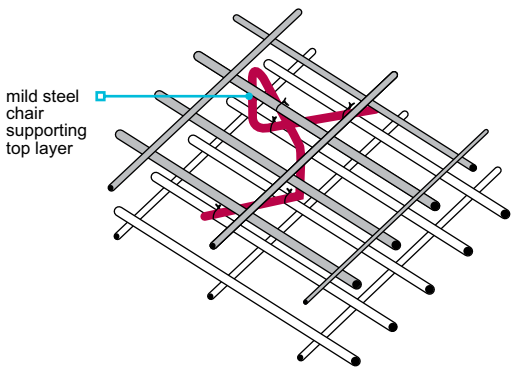
Spacers for parallel bars should be staggered to avoid creating a plane of weakness in the concrete. Supports for top steel should be chairs, or other proprietary products.

Figure 3: Spacer layout



spacers staggered to avoid planes of weakness

Figure 4: Mild steel chair

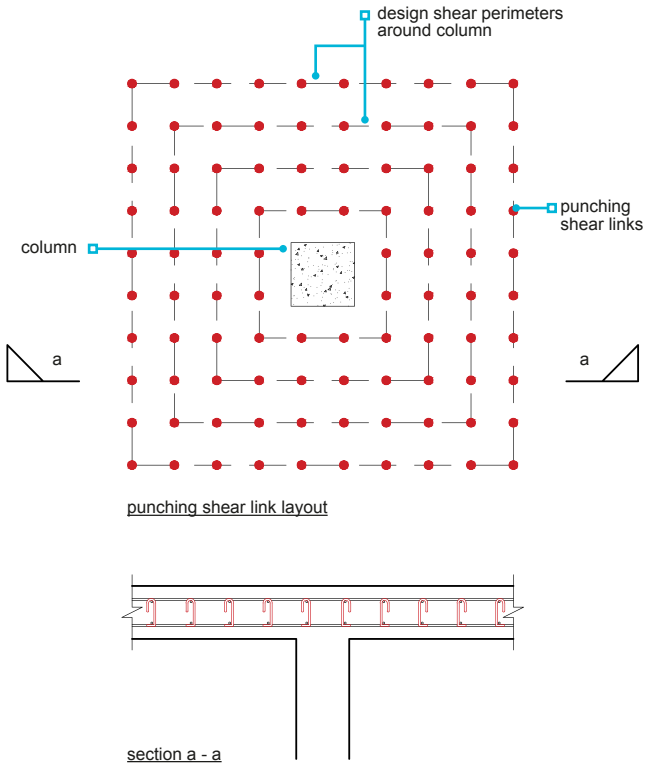


Punching shear reinforcement

Punching shear occurs when a slab is subjected to concentrated forces, for example where a column is offset from a supporting column or columns below and loads must be transferred by the slab.

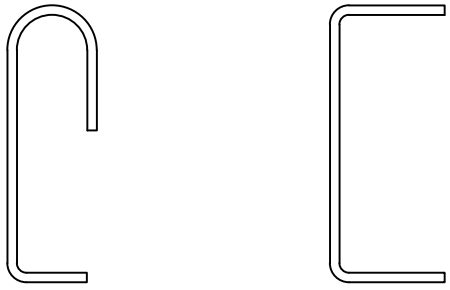
Design for punching is covered in BS EN 1992-1-1. Where concrete stresses are exceeded, additional reinforcement is locally required. This will either be within the top or bottom (or both) layers of the slab reinforcement and/or be by including shear links joining these layers or additional lacer bars at regular centres around several spaced perimeters about the head or base of columns.

Figure 5: Punching shear reinforcement



The additional reinforcement will typically be loose bars scheduled to BS 8666 that suit the structural design, with their location, spacing and cover requirements identified on engineers reinforcement detailing drawings. Bars will typically be either straight when included in the top and/or bottom layers, or 'bob-and-hook' or 'U-bars' as shear links.

Figure 6: Typical punching shear link reinforcement



However, there are several proprietary solutions for punching shear reinforcement, and these are commonly used in flat slabs in medium- and high-rise residential buildings. These include stud rail systems, shear ladders and structural steel shear heads, amongst others. These may often be spaced at centres relaxed compared to those required for traditional shear links. Such systems should be:

- independently assessed in accordance with Technical Requirement R3
- assessed according to the intended use
- used strictly in accordance with the manufacturer's recommendations and the independent assessment
- fully detailed and co-ordinated on engineers reinforcement detailing drawings.

3.1.11 Blinding concrete

Blinding concrete shall be used where required to aid construction.

Blinding concrete should only be used:

- to protect the bottom of the trench/excavation where there is a delay in pouring structural concrete
- where the foundation has been slightly overdug
- to provide sufficient support to ensure cover to reinforcement is maintained, or
- where localised soft spots have been removed.

3.1.12 Formwork

Formwork shall be structurally adequate and constructed in a workmanlike manner.

Formwork should be accurately set out in relation to relevant reference lines and benchmarks. Accuracy is essential to ensure that the correct cover to the reinforcement is maintained.

Formwork and its supports should be rigid enough to maintain the correct position and to withstand extra loads and accidental knocks likely to occur during placement and compacting. Wedges, inserts and boxes should be firmly secured to avoid displacement during vibration.

For concrete which is to be left untreated, or with minimum finishing, formwork joints should be tight to avoid grout loss and ragged edges. Joints between shutters should be constructed for easy stripping. Any holes for bolts or spacers should be drilled with care to avoid disfiguring or splintering the formwork surface and giving a poor finish.

Formwork should be capable of being struck without damage to the concrete. Formwork should be dismantled without shock, disturbance or damage to the concrete. Support for load-bearing elements should not be removed until the concrete has achieved sufficient strength, as detailed by the designer. Props under suspended floors or beams should be released from the centre, outwards, to avoid overloading.

3.1.13 Before concreting

Installations and final preparations shall be completed before concreting starts.

Before concreting starts:

- all services, ducts, inserts, etc to be embedded in the concrete should be securely installed in the correct position and, where appropriate, tested
- completed reinforcement should be checked and, where necessary, inspected and accepted by the designer or their representative
- formwork should be cleaned out and checked for fallen debris, especially nails and wire clippings.

3.1.14 Casting

Also see: Chapter 3.2

Concrete shall be cast so as to achieve the required design strength and durability.

The temperature of the concrete at the point of use should not be less than 5°C (41°F). Fresh concrete is susceptible to frost damage, and freezing can cause internal damage that is not immediately obvious.

Concrete should not be placed in or under water, unless it has been specially designed for that use.

Sufficient concrete should be mixed or ordered, so that it can be placed in a continuous process.

Concrete should be placed directly into its final location. Where this is not practicable, it should be deposited close to its final location and transported and placed as fast and efficiently as possible to avoid segregation and to ensure full compaction of the placed concrete.

Site mixed concrete should be placed within 30 minutes, and ready-mixed concrete within the time period recommended by the supplier or required by the specification. Additional water should not be added to ready-mixed concrete unless under the supervision and agreement of the supplier

Concreting should, wherever possible, be carried out in one operation, taking account of:

- weather conditions
- available daylight
- time to allow for surface finishing.

Concrete cast in one operation (ie, without construction joints) should always be as square in shape as possible and not greater than:

- reinforced concrete 60m^2
- unreinforced concrete 16m^2.

Construction joints should be formed only where unavoidable and in consultation with the engineer. These should not be positioned next to a return in the foundation. Before work continues beyond the joint, shuttering used to form the joint should be removed.

Reinforced concrete should be fully compacted using poker vibration unless the design states otherwise. Poker vibration should be carried out by experienced operators to ensure complete coverage and to avoid honeycombing. Vibrating beams or hand tamping may be used to consolidate slabs up to 150mm thick, unless the design details otherwise. Excessive use of vibration can cause segregation and prevent concrete reaching an adequate strength.

3.1.15 Curing

Also see: Chapter 3.2

Concrete shall be adequately cured to achieve full design strength.

Concrete performance relies on the curing process. The design should clearly indicate where there are any special requirements for curing concrete.

Freshly poured concrete should be kept moist by covering as soon as the surface is hard enough to resist damage. This is particularly important in hot, windy or cold weather to prevent the surface drying out too rapidly, or freezing. Damp hessian, damp sharp sand or an impervious sheet (such as polyethylene) are acceptable as surface coverings. Alternatively, a curing agent can be applied to the surface.

In addition when concreting in hot weather (air temperature above 30°C), account should be taken of avoiding reductions in the working life of fresh concrete due to loss of mix water by accelerated hydration and/or evaporation and preventing high temperature rise within the concrete element that could lead to unacceptable levels of early-age thermal cracking, reduction in the ultimate quality of the concrete and delayed ettringite formation (ie, crystallisation that occurs within setting concrete).

However, there are ways in which the concrete can be modified to help counter hot weather effects, such as:

- increasing the initial workability and/or retarding the hydration process using admixtures. Note: a retarder does not compensate for stiffening by moisture loss
- spraying the formwork/base with water before concreting
- using a cement or combination cement that has low heat evolution
- avoiding concreting during the middle of the day when temperatures peak
- specifying a maximum temperature of fresh concrete less than 35°C — see BS 8500-2. Note: temperature of fresh concrete is measured as described in BS EN 12350-1.

Other methods are available, for example pre-cooling the mix constituents and/or the use of embedded cooling pipes (latter only likely to be considered for larger/deeper concrete pours), but these should only be used following specialist's advice.

No load should be applied to the work until the concrete has cured sufficiently. It is recommended that plain unreinforced concrete made with ordinary Portland cement is left for at least four days to cure.

It is possible to proceed with substructure masonry above strip or trench fill foundations on unreinforced ordinary Portland cement concrete at an early stage, provided that care is taken to protect the surface from damage.

Reinforced concrete or concrete containing cement replacements, such as PFA, will require a longer curing period. This will normally take seven days, during which the concrete structure should not be loaded.

Any curing agents should comply with Technical Requirement R3 and should be applied strictly in accordance with the manufacturer's instructions. Curing agents should never be used on floors which are to receive either a topping or a screed, as it could affect the future bond. Curing periods may be extended at low temperatures.

3.1.16 Testing

Testing shall be carried out to the full satisfaction of NHBC.

Testing, where required, shall be conducted to BS EN 12390 by UKAS accredited laboratories. Test cubes should be prepared as requested by the engineer. These should be marked, cured and stored safely until testing.

Proof of testing, with reports, certificates and allied documentation, should be kept for reference and made available to NHBC upon request.

Ready-mixed concrete suppliers should prepare test cubes in accordance with quality assurance procedures.

3.1.17 Glossary

Aggressive chemical environment for concrete classification (ACEC class)	A system for the classification of aggressive ground conditions that are derived from design sulfate class. It takes into account the site (natural or brownfield) and the mobility and pH of groundwater. Brownfield, 'mobile' water and low pH (acidic) conditions may have adverse effects on buried concrete and hence result in a more severe ACEC class.
Additional protective measures (APM)	These are defined as the extra measures that could be taken to protect concrete where the basic concrete specification might not give adequate resistance to chemical attack.
Design chemical class (DC class)	This defines the qualities of concrete that are required to resist chemical attack. The DC class is derived from the ACEC class of the ground and other factors, including the type of concrete element and its required structural performance.
Design sulfate class (DS class)	A site classification based on the determined sulfate (including potential sulfate) contents of the ground and/or groundwater. It is also dependent on the type of site, presence or absence of magnesium ions, pyrite and, for pH less than 5.5, chloride and nitrate ions. Five levels of classification are given that are equivalent to those given in BRE Digest 363 (now superseded).
Enhanced concrete quality	An incremental step in concrete quality that could be used as an Additional Protective Measure (APM). Each increment in concrete quality is counted as an extra APM.
Mobile groundwater	Sites where water is free to flow into an excavation to give a standing water level are affected by mobile groundwater. The threshold ground permeability is greater than 10^{-6} m/s (ie, 86mm/day).
Static groundwater	The sites where the free flow of water is confined due to either permanently dry conditions or the soil being relatively impermeable (of permeability less than 10^{-6} m/s).
Total potential sulfate (TPS)	The total potential sulfate content is the result of the combination of sulfates already present in the ground and that which may be added due to the oxidation of pyrite in the ground.

3.1.18 Further information

- *BRE Digest 357 Shrinkage of natural aggregates in concrete (January 1991)*
- *BS EN 206:2013+A2:2021 Concrete — Specification, performance, production and conformity*
- *BS 8500-1:2023 Concrete — Complementary British Standard to BS EN 206 — Part 1: Method of specifying and guidance for the specifier*
- *BS 8500-2:2023 Concrete — Complementary British Standard to BS EN 206 — Part 2: Specification for constituent materials and concrete*

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