Part 2

Materials

Part 2 Materials

Chapter 2.1

Concrete and its reinforcement

CONTENTS

SCOPE

This Chapter gives guidance on meeting the Technical Requirements and recommendations for concrete mixes suitable for various locations in and around dwellings.

DESIGN STANDARDS

2.1 - D1 Design shall meet the Technical Requirements

Design that follows the guidance below will be acceptable for concrete and its reinforcement.

SUITABILITY OF CONCRETE

2.1 - D2 Concrete shall be suitable for its intended use

Concrete should be in accordance with relevant Building Regulations and other statutory requirements.

Items to be taken into account include:

(a) compliance with recognised design standards
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 following guidance will be acceptable. (This applies to plain and reinforced concrete whether precast or in-situ.)

Tables 1, 2a and 2b of Appendix 2.1-A list uses of concrete, mix specifications and the mix proportions for Standardised Prescribed mixes as described in BS 8500 and BS EN 206. Table 3 of Appendix 2.1-A describes the exposure environments and examples where they may occur. Tables 4a and 4b in Appendix 2.1-A give guidance on selecting mixes for concrete elements in aggressive ground.

(b) choice of supplier of ready-mixed concrete
Ready-mixed concrete will only be acceptable from suppliers who operate a full quality control system which ensures that the concrete specified is delivered.

Suppliers of ready-mixed concrete who operate under the Quality Scheme for Ready-Mixed Concrete (QSRMC) or BSI Kitemark scheme are acceptable. Other suppliers of ready-mixed concrete may be accepted if their operations are to an equivalent quality standard acceptable to NHBC.

MIX DESIGN

2.1 - D3 The concrete mix shall be specified correctly

Concrete mixes should be specified in accordance with BS 8500-1. Concrete mixes for particular end uses in housing applications may be selected from Table 1 in Appendix 2.1-A or Table A.7 of BS 8500-1 as either:

- Designated mix, which is supplied ready mixed, or
- Standardised prescribed mix for site mixing.

Equivalent Designated and Standardised Prescribed mixes are listed as suitable for particular end uses, for example:

unreinforced ground bearing garage floor slabs can use either:

- a GEN3 Designated mix, or
- a ST4 Standardised Prescribed mix.

2.1 - D4 Mix design shall ensure adequate durability

Items to be taken into account include:

(a) mix proportions
The various uses of concrete are shown in Table 1 in Appendix 2.1-A. Designated mixes should conform to Table 7 of BS 8500-2.

Standardised Prescribed mixes conform to either Table 2a or 2b in Appendix 2.1-A which are derived from Tables 10 and 12 respectively of BS 8500-2.

(b) sulfates and acids in ground or groundwater
Sulfates and other chemicals can cause expansion and disruption of concrete. Also, high acidity, for example in peat, or permeable soil with acidic groundwater, can cause damage to concrete. Where concrete is at risk from chemical attack from the ground or where the ground water is highly mobile the level of sulfate and other chemicals should be determined, in terms of the ACEC Class (Aggressive Chemical Environment for Concrete Class) in accordance with BRE Special Digest 1. For the higher ACEC classes specialist advice should be sought to determine the Design Chemical Class (DC Class) for the concrete element and any appropriate Additional Protective Measures (APM) which may be required. The mix specification should then be selected from Table A.7 of BS 8500-1.

For lower levels of ACEC Class (AC-1, AC-1s, AC-2, AC-2s and AC-2z) the mix specification may be selected using Tables 4a and 4b in Appendix 2.1-A.

(c) chlorides
Chlorides in concrete are likely to increase the risk of corrosion of embedded metal and can also reduce the resistance of concrete to chemical attack.

All concrete materials contain some chlorides. For concrete mixes, the limits on chloride content in fresh concrete are given in BS EN 206-1, Table 10.

Cured concrete may also be damaged by exposure to:

- chlorides in the ground
- sea spray, or
- products used for de-icing highways.

Where these conditions might occur, follow the guidance in relevant documents.

(d) 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, as described in BRE Digest 357.

(e) alkali-silica reaction
Certain aggregates may be susceptible to attack from alkalis originating in the cement or other sources. The reaction causes expansion and subsequent cracking and disruption of the concrete.

The total alkali content of the concrete arising from all sources, calculated in accordance with BRE Digest 330 or Concrete Society Report 30 should not exceed 3.0kg/m^3.

Where unfamiliar aggregate materials are used, special precautions may be required. Damage will normally only occur when all three of the following conditions exist:

- there is a high moisture level in the concrete, and
- there is an alkali source, and
- the aggregate contains an alkali reactive constituent.

(f) exposure to climate and atmosphere
Exposure classes related to environmental conditions are given in Table 3 of Appendix 2.1-A which corresponds to Table 4.1 of BS EN 1992-1-1. Table 1 of Appendix 2.1-A gives guidance on the strength class of concrete suitable for particular exposures for superstructure elements. Further guidance may be obtained from BS 8500-1.

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.

The higher the concrete grade, the greater its resistance to:

- chemical attack, and
- mechanical wear.

Air entraining agents can effectively reduce the risk of frost damage to cured concrete.

(g) overall performance
In addition to the items listed above, durability of concrete is dependent upon:

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

REINFORCED CONCRETE

2.1 - D5 Reinforced concrete shall be designed to ensure adequate durability

Items to be taken into account include:

(a) loading
Reinforced concrete should be designed by an Engineer in accordance with Technical Requirement R5.

BS 8103-4 can be used for the design of suspended ground floors in houses, bungalows and garages.

(b) 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.

(c) cover
For concrete not designed by an Engineer in accordance with Technical Requirement R5, the minimum cover for reinforcement should be:

Position of the concrete	Minimum cover [mm]
Incontact with the ground	75
Inexternal conditions	50
Castagainst a dpm on sand blinding	40
Againstadequate blinding concrete	40
Inprotected or internal conditions	25

(d) fire resistance
Concrete cover to reinforcement should be adequate not only for the exposure conditions but also, where necessary, 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 fire resistance for columns, simply supported beams and floors.

(e) blinding
Blinding concrete should be used only in the following situations:
- to protect the bottom of the trench/ excavation if there is a delay in pouring structural concrete
- to provide sufficient support to ensure that cover to reinforcement is maintained
- where the foundation has been slightly overdug
- where localised soft spots have been removed.

(f) carbonation
Carbonation is of concern in reinforced concrete because it reduces the corrosion protection given to the reinforcement by the concrete.

The effects of carbonation on concrete are to increase porosity and decrease alkalinity. When alkalinity is reduced below a certain level steel reinforcement can rust.

Carbonation cannot be prevented. The risk of reinforcement corroding can be reduced by providing as great a concrete cover as possible; and by ensuring that wet concrete is of good quality and properly compacted, so reducing the rate of carbonation.

2.1 - D6 Reinforcing steelwork shall be properly and clearly detailed, specified and scheduled

The steel specification should indicate the steel type, grade and size. Drawings and bending schedules should be prepared in accordance with BS 4466 and include all necessary dimensions for completion of the sitework.

SPECIAL TYPES OF CONCRETE

2.1 - D7 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 their conditions of use.

If used for a structural purpose, the design should be in accordance with Technical Requirement R5, and the concrete mix design should be properly detailed.

If no-fines concrete is used, a render, cover coat or cladding should be applied to the finished structure, unless otherwise acceptable under Technical Requirement R3.

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

ADMIXTURES

2.1 - D8 Admixtures shall only be used to enhance the performance and durability of concrete

Items to be taken into account include:

(a) improved workability
(b) waterproofing
(c) foaming agents
(d) accelerated strength
(e) retardation
(f) chlorides

Admixtures should only be specified in full knowledge of how each one works, and any limitations on their use.

Admixtures are permitted in accordance with BS EN 206-1.

Where admixtures are permitted, they should be used strictly in accordance with the manufacturer's recommendations, including the stated dosage.

Air entraining agents increase the air void content and thereby the frost resistance of cured concrete, but do not prevent fresh concrete freezing in cold weather.

Admixtures should not be relied upon to prevent freezing.

Retarding agents can, in fact, increase the risk of frost damage.

Admixtures containing chloride should never be used in reinforced concrete.

PROVISION OF INFORMATION

2.1 - D9 Designs and specifications shall be produced in a clearly understandable format and include all relevant information

Items to be taken into account include:

(a) ground aggressivity
Any ground aggressivity to concrete should be indicated as:
- Design Sulfate Class (DS Class)
- Aggressive Chemical Environment for Concrete Class (ACEC Class)

(b) strength and durability
Concrete performance depends as much on how the cured concrete element is produced as on the composition of the concrete.

The concrete specification should indicate clearly any requirements which are of specific importance, such as:
- strength
- maximum free water/cement ratio and/ or minimum cement content
- consistence class (e.g slump)
- air content (if required)
- aggregate size
- colour.

(c) mix design and Additional Protective Measures (APM)
Drawings and specifications for concrete work should include:
- specification of mix designs (concrete strength class)
- details of any Additional Protective Measures.

(d) reinforcement and movement joints
Drawings and specifications for concrete work should include:
- cover to reinforcement
- reinforcement, plans, sections and bending schedules
- reinforcement details at supporting edges
- camber in beams and slabs, where appropriate
- reinforcement around openings
- movement joints.

(e) formwork
Information should be included on:
- formwork materials and features
- joints
- mould release agents
- holes for services.

Concrete which is 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.

(f) finish
Information should include details of final finishing treatment.

(g) testing
Information should include:
- number and frequency of samples to be taken
- test laboratory arrangements
- recording of results.

(h) curing and protection
Information should include:
- requirements for curing and striking formwork
- minimum period that should elapse before striking/removal of formwork
- minimum periods of curing
- minimum periods of protection.

2.1 - D10 All relevant information shall be distributed to appropriate personnel

Ensure that design and specification information is issued to site supervisors and relevant specialist subcontractors and/or suppliers.

MATERIALS STANDARDS

2.1 - M1 All materials shall:
(a) meet the Technical Requirements
(b) take account of the design

Materials that comply with the design and the guidance below will be acceptable for concrete and its reinforcement.

Materials for concrete and its reinforcement should comply with all relevant standards, including those listed below. Where no standard exists, Technical Requirement R3 applies (see Chapter 1.1 'Introduction to the Standards and Technical Requirements').

References to British Standards and Codes of Practice include those made under the Construction Products Directive (89/106/EEC) and, in particular, appropriate European Technical Specifications approved by a European Committee for Standardisation (CEN).

READY-MIXED CONCRETE

2.1 - M2 Ready-mixed concrete shall be in accordance with the design and shall be chosen to ensure sufficient strength and durability

Ready-mixed concrete should be ordered to a detailed specification conforming to BS 8500 and BS EN 206-1.

When Designated mixes are used, the ready-mix supplier will only require the mix designation, and consistence class

SITE-MIXED CONCRETE

2.1 - M3 Materials for site-mixed concrete shall be in accordance with the design and shall be chosen to ensure sufficient strength and durability

Items to be taken into account include:

(a) cement or cementitious material
Cement and combination and combination types should be as:

Table 1 of BS 8500-2 and should conform to the Standards quoted therein and in the case of combinations to Annex A of BS 8500-2.

(b) aggregates
Aggregates should comply with:

BS EN 12620 Aggregates for concrete.

Aggregates should consist of any types of coarse and/or fine aggregate as specified. Aggregates supplied as a mixture of different sizes should be proportioned to ensure a reasonable consistency.

Certain types of aggregate are shrinkable and require special precautions in mixing as described in BRE Digest 357.

Certain types of aggregate may be susceptible to alkali attack or excessive moisture movement. Unfamiliar materials should be checked and precautions taken, where necessary. Aggregate Carbon Range (ACR) should not exceed the specified limits if required for use in concrete subject to aggressive sulfate ground conditions.

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

(c) water
Water from the mains is acceptable. Water from other sources should meet:BS EN 1008 Mixing water for concrete.

(d) admixtures
Admixtures, other than air-entraining admixtures, should comply with:
BS EN 934-2 Admixtures for concrete mortar and grout - Concrete admixtures - Definitions, requirements, conformity, marking and labelling.

Air entraining admixtures should not be used in Standardized Prescribed concrete mixes.

REINFORCEMENT

2.1 - M4 Reinforcement shall be in accordance with the design

Reinforcement should comply with:

BS4449	Specification for carbon steel bars for the reinforcementof concrete
BS4482	Specification for cold reduced steel wire for thereinforcement of concrete
BS4483	Specification for steel fabric for the reinforcement ofconcrete
BS6744	Specification for austenitic stainless steel bars for thereinforcement of concrete.

SITEWORK STANDARDS

2.1 - S1 All sitework shall:
(a) meet the Technical Requirements
(b) take account of the design
(c) follow established good practice and workmanship

Sitework that complies with the design and the guidance below will be acceptable for the use of concrete and its reinforcement.

Adequate concrete performance depends as much on how the cured concrete element is produced as on the composition of the concrete.

STORAGE OF MATERIALS

2.1 - S2 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:
- store cement in a dry place
- store each type of cement separately
- follow the cement manufacturer's recommendations on maximum storage time
- store different sizes of aggregate in separate bays
- keep sand and aggregate clean
- keep sand and aggregate dry - where this is not possible, allowance must be made in the concrete batching for moisture in the sand and aggregate.

For precautions during cold weather, reference should be made to Chapter 1.4 'Cold weather working'.

BLINDING CONCRETE

2.1 - S3 Blinding concrete shall be used, where required, to aid construction

Blinding concrete should only be used in the following situations:

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

FORMWORK

2.1 - S4 Formwork shall be structurally adequate and constructed in a workmanlike manner

Items to be taken into account include:

(a) setting out
Where formwork is necessary, it should be set out in relation to relevant reference lines and benchmarks. Accuracy is essential to ensure that the cover to the reinforcement is as specified.

(b) support of working loads
The formwork and its supports should be rigid enough to maintain the correct position and to withstand all extra loads and accidental knocks likely to occur when concrete is placed and compacted.

Wedges, inserts and boxes should be firmly secured to avoid displacement during vibration.

(c) finish
For concrete which is to be left untreated or with minimum finishing, the tightness of formwork joints is particularly important to avoid grout loss and resulting 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.

(d) striking
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 loadbearing 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.

REINFORCEMENT

2.1 - S5 All reinforcement shall be in accordance with the design

Items to be taken into account include:

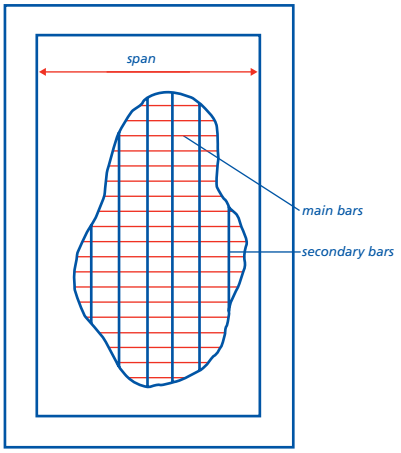
(a) condition of reinforcement
Check that reinforcing bars are clean, and free from loose rust and contaminants (especially shutter releasing agents and oils) before, during and after placement.

(b) shape of bars
Site bending should be carried out with the proper machinery for the job, whether hand-operated or powered.

(c) placing of bars
Bars should be bent and placed as shown on the drawings.

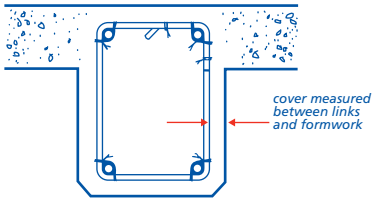
Reinforcement should be laid so that the main reinforcing bars are parallel to the span or as detailed in the design.

Slab reinforcement should be located near the bottom of the slab, with the main reinforcing bars usually placed first and the secondary bars on top. For beams, the main reinforcing bars should be placed inside the links.



(d) lapping bars and mesh
Reinforcing bars or mesh should always be lapped in accordance with their size and type, as indicated by the designer, to ensure that the loading is fully transferred across the lap. Any additional laps require the designer's approval.

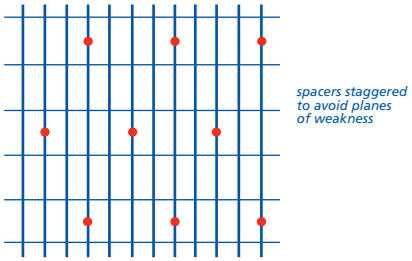
(e) cover for bars
Particular attention should be given to maintaining adequate cover for the reinforcement, especially for concrete in exposed positions or in the ground. Check that the cover is adequate for stirrups as well as for the main bars, and that no ties or clips protrude into the cover.



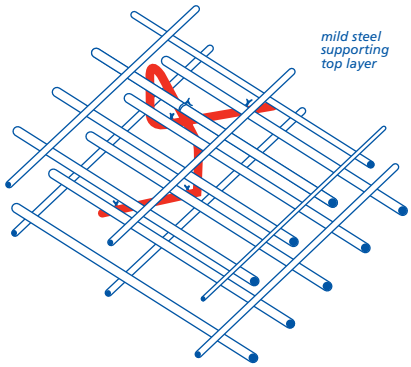
(f) support of reinforcement
Cover spacers should be made of concrete (eg broken concrete paving slabs) or ready made of steel or plastic. Concrete cover spacers should be not more than 50 x 50mm.

Supports should be placed not 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).



For details of reinforcement for suspended ground floor slabs, reference should be made to Chapter 5.2 'Suspended ground floors' (Design).

2.1 - S6 All 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 installed and, where appropriate, tested.

All inserts, box-outs, cast-in fixings, etc should be checked for correct positioning and secured.

The formwork should be cleaned out and checked for fallen debris, especially nails and wire clippings. The completed reinforcement should be checked and, where necessary, approved by the designer or his representative.

READY-MIXED CONCRETE

2.1 - S7 Ready-mixed concrete shall be ordered to ensure it achieves the required design strength and durability

When ordering ready-mixed concrete all requirements according to the design, including reference to Appendix 2.1-A, should be specified.

The concrete should be a GEN mix, FND mix or RC mix ordered in accordance with Appendix 2.1-A Tables 1 and 4b.

Check the delivery ticket to ensure that the concrete meets the requirements given in the design.

ON-SITE CONCRETE MIXING

2.1 - S8 Concrete shall be mixed to achieve the required design strength and durability

Items to be taken into account include:

(a) mixing methods
Except for very small quantities, a mechanical mixer should be used. If hand mixing, add an extra 10% of cement to the quantities shown in Tables 2a and 2b in Appendix 2.1-A.

(b) admixtures
Admixtures should be used only where permitted in the specification. Dosages should be strictly in accordance with the manufacturer's instructions and should be tested in trial mixes, where necessary. Admixtures should, wherever possible, be added to the mix water to ensure complete dispersal.

Do not overdose concrete with admixtures - use the correct dosage.

Plasticizers can improve concrete cohesion and the bond with reinforcement.

Air entraining agents increase the air void content of the cured concrete and can help produce a more frost resistant surface. They are recommended for paths, drives and pavements which are likely to be exposed to freezing conditions.

Accelerators produce early setting of the concrete. No admixture should be relied upon as an anti-freeze for fresh concrete. For details about concreting at low temperatures, reference should be made to Chapter 1.4 'Cold weather working'.

Admixtures containing chlorides can cause metal corrosion and should never be used in reinforced concrete.

TESTING

2.1 - S9 Testing, where required, shall be carried out to the full satisfaction of NHBC

Where testing is necessary to ensure that concrete is to the strength required by the design, ie with Designed mixes, UKAS approved laboratories should be used.

Concrete test cubes should be prepared as requested by the Engineer. These should be marked, cured and stored safely until testing. Tests should be carried out in accordance with BS EN 12390.

Proof of testing with reports and certificates, should be kept for later reference. Proof of testing, with allied documentation, should be made available to NHBC upon request. A ready-mix concrete supplier should take test cubes, as required, for his quality assurance procedures.

CASTING

2.1 - S10 Concrete shall be cast so as to achieve the required design strength and durability

Items to be taken into account include:

(a) transportation
Concrete should be deposited as close as possible to its final location. Transportation on site should be as fast and efficient as possible in order to avoid segregation and to ensure full compaction of the placed concrete.

(b) low temperatures
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. Freezing can cause internal damage that is not immediately obvious During cold weather, either stop working or follow the recommendations given in Chapter 1.4 'Cold weather working'.

(c) placing
Site-mixed concrete should be placed within 30 minutes, and ready-mixed concrete within 2 hours, of water being added to the cement.

Additional water should not be added to ready-mixed concrete unless under the supervision and approval of the supplier. Concrete should not be placed in or under water, unless it has been specially designed for that use.

Concreting should, wherever possible, be carried out in one operation, taking account of:
- weather conditions,
- available daylight, and
- time to allow for surface finishing.

(d) avoiding construction joints
Concrete cast in one operation (ie without construction joints) should not be greater than the following, and should always be as square in shape as possible:
- reinforced concrete 60m^2
- unreinforced concrete 16m^2.

Sufficient concrete should be mixed/ ordered, so that it can be placed in a continuous process. Construction joints should be formed only if unavoidable and then in consultation with the Engineer. Before work continues beyond the joint, all shuttering should be removed.

(e) joints in foundations
Joints should not be positioned next to a return in the foundation.

(f) compaction
Concrete should be consolidated according to the design and specification requirements.

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 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.

(g) protection after placing
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. An alternative is to apply a curing agent to the surface of concrete.

CURING

2.1 - S11 Concrete shall be adequately cured to achieve full design strength

Check the design to see if there are any special requirements for curing concrete.

No load should be allowed on 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 4 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 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 be 7 days and the concrete structure should not be loaded during this period.

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, as described in Chapter 1.4 'Cold weather working'.

APPENDIX 2.1-A

Table 1 - General purpose concrete mixes - minimum concrete specification (non-hazardous conditions)

Use	BS 8500 and BS EN 206-1		
	Ready-mixed concrete (Designated mix)	**Site-mixed concrete (Standardised Prescribedmix)**	**Consistence class**
Substructure and ground floors • rough blinding (non-structural) • infill • unreinforced oversite concrete below timber floors	GEN1	ST2	S3
• structural blinding and overbreak • 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 carpet	 GEN1 GEN2	 ST2 ST3	 S2 S2
• 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	RC35	ST5[2]	S2
Superstructure • general reinforced concrete exposure class[3] to BS 8500-1 - nominal cover to reinforcement of 35mm (which is the minimum cover of 25mm plus an allowance in desgin for deviation of 10mm) - XC1 (dry) and XC2 (wet, rarely dry) - 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) - Any exposure class (XC1-4 and XF1)	 RC30 RC40 RC35	 [4] - [5]	 S2 S2 S2
In-situ external concrete • drives and paths • foundations 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 an ST4 mix may be used but 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 but 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 (see Chapter 6.1 Appendix B). This is equivalent to Exposure Class XC4 above.

Tables 2a, 2b and 2c - Site-mixed concrete for Standardised Prescribed Mixes

Table 2a - Mix proportions by weight

This table 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%.

Standardised Prescribed Mix	Consistence Class (see Table 2c)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
ST1	S1	230	770	1155
ST2	S2	265	760	1135
ST2	S3	285	735	1105
ST2	S4	300	815	990
ST3	S2	295	745	1120
ST4	S2	330	735*	1100
ST5	S2	375	720*	1080

Table 2b - Mix proportions by volume

This table applies to 20mm maximum aggregate size

Cement strength class	Standardised Prescribed Mix	Consistence Class (see Table 2c)	Number of (25 kg) bags of cement	Fine aggregate (litres)	Coarse aggregate (litres)
32.5	ST1	S1	1	60	85
	ST2	S2	1	50	75
	ST2	S3	1	45	70
	ST2	S4	1	50	60
	ST3	S2	1	45	65
42.5 or higher	ST1	S1	1	65	95
	ST2	S2	1	55	80
	ST2	S3	1	50	75
	ST2	S4	1	55	65
	ST3	S2	1	50	75

Table 2c - Consistence classes

Consistence class	Consistence (slump) in mm
S1	10 to 40
S2	50 to 90
S3	100 to 150
S4	160 to 210

Notes

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

Table 3 - Exposure classes

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 andfreezing

Notes

This table is based on Table 1 of BS EN 206-1

Tables 4a and 4b - Buried concrete in aggressive ground

Tables 4a and 4b are based on extracts from BS 8500-1 & 2 and BRE Special Digest 1. They cover the lower range of chemical aggressiveness. For concrete exposed to more aggressive conditions, specialist advice should be sought. For the purposes of Chapter 2.1 the following terminology is used. Other related terms, which might be encountered in specialist reports, are described in BRE Special Digest 1.

Table 4a - Aggressive Chemical Environment for Concrete (ACEC) site classification[1]
This table 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		Groundwater		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		5.5-6.5	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		5.5-6.5	AC-3z
									4.5-5.5	AC-4z
									<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 Part C 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 (SO4) which may result from the oxidation of sulphides 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 15 mg/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 Additional Protective Measures 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.

Table 4b - Design guide for concrete elements in the ground

Concrete element	ACEC Class[1]	Designated mix
Stripor trenchfill foundation, raft foundation, pile[3] and ground beams	AC-1,AC1s	AsTable 1
	AC-2,AC2s	FND2[2]
	AC-2z	FND2z[2]

Notes

1 For all other ACEC Classes refer to BS 8500-1 Table A.4 or follow specialist advice.
2 Portland limestone cement may only be used if the Design Sulfate Class (see Table 4a) of the site does not exceed DS-1.
3 Applies to cast-in-situ piles only and for other types of pile refer to BRE Special Digest 1 or follow specialist advice.

Glossary of terms

Aggressive Chemical Environment for Concrete Classification (ACEC Class) - A new 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) - It is 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 ground water. The threshold ground permeability is greater than 10^{-6} m/s (i.e. 86 mm/day).

Static groundwater - The sites where the free flow of water is confined due to either permanently dry condition or the soil is 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.

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