Examples of specification of designed concrete

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The new standards for concrete, BS EN 206–1 and BS 8500 will co-exist and have equal status to the existing BS 5328 until its withdrawal in December 2003. However, BSI recommends that BS 5328 is used for specifications until the end of 2003 and BS EN 206–1/BS 8500 is used from 2004.

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Association of Concrete Industrial Flooring Contractors
Association of Lightweight Aggregate Manufacturers
British Cement Association
British Standards Institution
Building Research Establishment
Cement Admixtures Association
Cementitious Slag Makers Association
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Ready-mixed Concrete Bureau
RMC Readymix
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United Kingdom Quality Ash Association

A full list of the publications in this series is given on the back page.

PROCEDURE

Before using this publication, you should be familiar with the concepts presented in *Concrete for normal uses* and *Concrete resistant to chemical attack* in this series. It would also be useful to have at hand the module *Guidance on additional requirements for designed concrete*.

The procedure by which a designed concrete should be specified is given in the flowchart, Figure 1. The steps in the flowchart are further explained in the process chart, Table 1. All references to tables and clauses are to BS 8500–1:2002 unless stated otherwise. A number of examples are given to illustrate this process. The examples make reference to the steps in the flowchart.

For normal building structures, an alternative approach would be to use the tables in *Guide to the selection of concrete quality and cover to reinforcement for normal building structures* in this series. The steps are the same as those in the flowchart, the only difference being the source of the information.

When there are multiple exposure classes, the selection of the appropriate specification can often be quite complex. A software package for concrete specification, ConSpec, is under development and this will make the process simpler and faster. For details contact the Ready-mixed Concrete Bureau (info@rcb.org.uk).

Figure 1: Flow chart (Starting point (Step 1) is Table A.1 of BS 8500–1)

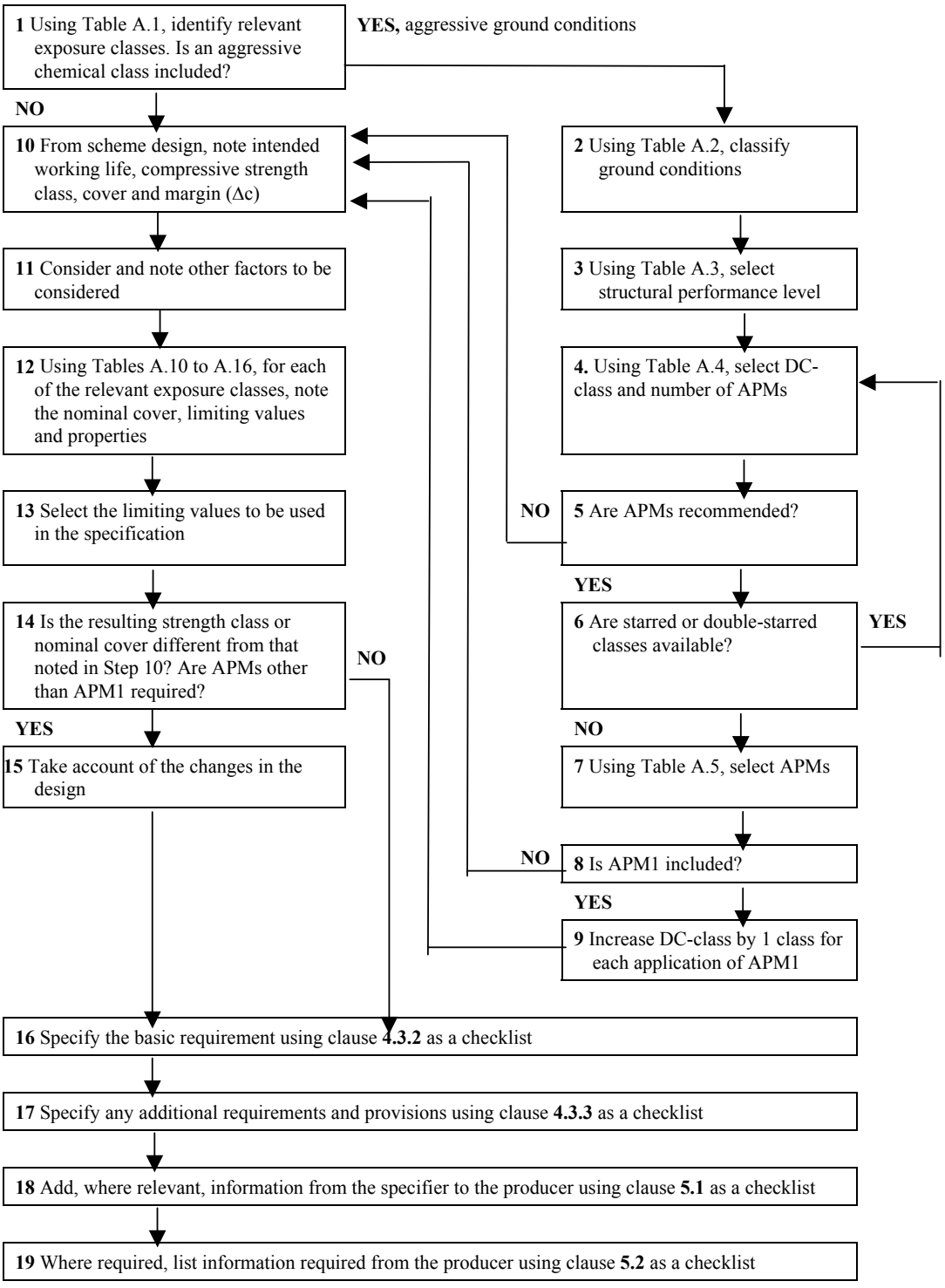


Table 1: Process for the specification of a designed concrete

Step	Description	Action
1	Turn to BS 8500–1, **A.2.** Identify all relevant exposure classes using guidance in Table A.1. Do they include aggressive ground conditions? Yes No	 Go to 2 Go to 10
2	Using Table A.2, determine the aggressiveness of the site (the ACEC-class). Using the soil/groundwater analysis, the type of site, the mobility of the groundwater and its pH, select the ACEC-class.	Go to 3
3	Using Table A.3, select the structural performance level.	Go to 4
4	Check that the hydrostatic head is not greater than five times the concrete thickness. If it is, apply Table A.4, footnote a. Determine the concrete quality (expressed as a DC-class) and the number of additional protective measures (APMs) by using Table A.4, the determined ACEC-class, the structural performance level and the section width to select the DC-class and the number of APMs, if any. NOTE. The section width means the least dimension of the section.	Go to 5
5	Are there APMs recommended? Yes No	Go to 6 Go to 10
6	The number of APMs can be reduced by 1 if medium carbonate range aggregates are used and by 2 if low carbonate range aggregates are used. Consequently, their availability should be checked. Read Table A.4, footnotes b and c and check the local availability of the starred or double-starred designed concretes, i.e. concrete with medium (starred) or low (double-starred) carbonate aggregates. If available, do you wish (have) to use them? Yes No	 Go to 4 Go to 7
7	Using Table A.5, identify acceptable APMs. Read carefully the relevant footnotes to Table A.4 and select the appropriate APMs. NOTE. Where APMs other than APM1 are selected, they should be included in the contract documentation, as they do not form part of the concrete specification (see Step 15).	Go to 8
8	Do they include APM 1: *Enhanced concrete quality*? Yes No	Go to 9 Go to 10
9	Increase the DC-class by 1 class for each time APM 1 is applied, e.g. from DC-2 to DC-3 if APM 1 is applied once. See Table A.4, footnotes b) and c).	Go to 10
10	From the scheme design information, make a note of the intended working life, compressive strength class, nominal cover and the margin (Δc). NOTE. Where the design is based on a single compressive strength, i.e. either cylinder or cube strength, it is essential to identify which it is and convert it to an equivalent compressive strength class using BS EN 206–1, Tables 7 or 8. EN 1992–1 uses the cylinder strength and BS 8110 uses the cube strength.	Go to 11

11	Consider all other factors that may have an influence on the concrete specification, see *Guidance on additional requirements for designed concrete* in this series. Make a note of any needs or options selected. This should include the maximum aggregate size and the consistence class (or target value).	Go to 12
12	Using Tables A.10 to A.16, for each of the relevant exposure classes and the intended working life make a note of the nominal cover and the concrete limiting values and properties. NOTE. Making informed choices to eliminate certain options at this stage may reduce the number of options and make analysis of this information easier.	Go to 13
13	Taking into account the requirements identified in Steps 10 and 11 and the nominal cover and concrete limiting values and properties identified in Step 12, compare each limiting value and select in general for the specification the highest strength class, the lowest maximum w/c ratio, the highest minimum cement/combination content and cement/combination types that are suitable for all the identified exposures. (See NOTE 1 for the exception.) NOTE 1. Where exposure class XF1, XF2, XF3 or XF4 is required in conjunction with one or more other exposure classes with a higher minimum strength class than recommended in Table A.14, the higher minimum strength class may be reduced by one class for air-entrained concrete provided that all other limiting values are maintained. NOTE 2. The choice of the values for the specification may be provisional and depend on the results of Step 15. NOTE 3. Where the limiting values are those for the DC-class, it is recommended that the DC-class is specified and not the limiting values.	Go to 14
14	Is the resulting strength class or nominal cover different to that noted in Step 10? Are APMs other than APM 1 required?	
		Yes — Go to 15 No — Go to 16
15	Take account of the changes in the design.	Go to 16
16	Specify the basic requirements using clause **4.3.2** as a checklist.	Go to 17
17	Specify any additional requirements and provisions using clause **4.3.3** as a checklist.	Go to 18
18	Add, where relevant, information from the specifier to the producer using clause **5.1** as a checklist.	Go to 19
19	Where required, list information required from the producer using clause **5.2** as a checklist.	

EXAMPLES OF THE APPLICATION OF THIS PROCESS

These examples follow the flowchart, Figure 1, and the process chart, Table 1. The steps in these examples are those in Figure 1 and Table 1.

Example 1

a) *Suspended reinforced concrete internal office slab that will be carpeted. The concrete will be pumped, compacted with a beam vibrator and finished with a bull-float. The columns of this building require C32/40 concrete.*

Step	Outcome
1	As the slab is carpeted, there are no abrasion considerations. From Table A.1, the only relevant exposure class is XC1. As there are no aggressive chemical classes, go to Step 10.
10	As this is a normal building structure, EN 1990: *Basis of design*, recommends an intended working life of (at least) 50 years. The scheme design was done to BS 8110–1 and this assumed a C30 concrete with 25 mm nominal cover. It is necessary to convert the grade C30 to an equivalent strength class. As the C30 relates to cube strength, the equivalent strength class is C25/30. There is also a need to select the margin and express the nominal cover as a minimum cover plus the margin (Δc). EN 1992–1: *Eurocode 2: Design of concrete structures – Part 1: general rules and rules for buildings* gives guidance on the selection of the margin Δc. It indicates that the value should be a function of the level of control on site. However the consequence of low cover should also be a factor in its selection and as this is an internal environment with no real durability concerns, a value of 5 mm for Δc with normal levels of workmanship is appropriate. A value of 5 mm for Δc is selected. The nominal cover from the scheme design is therefore (20 + 5) mm. Go to Step 11.
11	The specifier should select the maximum aggregate size and the consistence class (or target value). The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable for the pumped concrete. As the concrete will be ready-mixed, the specifier decides that accredited third party certification is required (see Note 2 to clause **4.3.2**). The only other options selected by the specifier are the two recommendations in *Guidance on additional requirements for designed concrete* for aggregates, namely a limit on drying shrinkage and a Los Angeles category. Go to Step 12 .
12	Turn to Table A.10. The limiting values and properties of concrete and the nominal cover to reinforcement for the XC1 exposure is: Nominal cover for durability is (15 + 5) mm and concrete C20/25, 0.70, 240 (from Table A.18 for maximum aggregate size of 20 mm) and all cements/combinations in Table A.17. NOTE. The scheme design should have taken nominal cover requirements for fire and structural performance into account. There are no other exposure classes to consider. Go to Step 13.

13	For a nominal cover of (15 + 5) mm, the limiting values and properties of the concrete are C20/25, 0.70, 240, 20 mm maximum aggregate size and any cement/combination in Table 1 of BS 8500-2. NOTE. Table A.17 of BS 8500–1 and Table 1 of BS 8500–2 are identical but for specification purposes. Table 1 of BS 8500–2:2002 should be cited. Cement or combination types IIIB and IVB are normally specified for situations requiring high resistance to chlorides, sulfates or other aggressive chemicals. They also tend to have low rates of strength development in thin sections. Because the exposure classes do not include XD, XS or aggressive chemicals, cement/combination types IIIB and IVB were discarded at this stage of the process. As SRPC is also a special cement used for producing sulfate-resisting concrete, it is also discarded. Go to Step 14.
14	Yes, there are differences between the durability design and the preliminary scheme design. Go to Step 15
15	The requirements are less onerous than those given in the scheme design, i.e. the strength class is down from C25/30 to C20/25 and the nominal cover is down from 25 mm to 20 mm. The designer then has the choice of leaving the scheme design unchanged or seeing if a more economic design is possible. In this case, a check on the structural design showed that both the cover and concrete strength class could be reduced without material change to member sizes or reinforcement quantities. Hence the reduced cover and concrete strength are adopted. Go to Step 16.
16	Basic specification requirements (clause **4.3.2**): a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Compressive strength class: C20/25; c) Maximum w/c ratio: 0.70; minimum cement/combination content: 240 kg/m^3; d) Cement or combination types I, II, IIIA from BS 8500–2: 2002, Table 1; e) Maximum aggregate size: 20 mm; f) Chloride class: Cl 0,40; g) and h) do not apply; i) Consistence class: S3. Go to Step 17.
17	Additional requirements (see Step 11): The producer shall operate an accredited quality system meeting the requirements of BS EN ISO 9001. When tested in accordance with BS EN 1367–4, the aggregate drying shrinkage shall be not more than 0.075%. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40}. Go to Step 18.
18	Information from the specifier to producer The concrete will be pumped, compacted with a beam vibrator and finished with a bull-float. Go to Step 19.
19	Information required from the concrete producer On checking clause **5.2**, the specifier identifies that items f) and g) are relevant and therefore requests this information as follows: Please supply the following information prior to delivery: a) If RCA or RA is to be used, the type of material and the proportion to be used. b) Where RCA or RA is not classed as highly reactive with respect to alkali-silica reaction, the proof on which the lower classification was based.

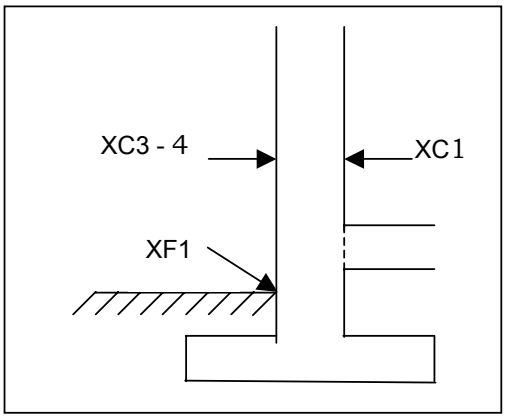
1b) *As Example 1a, but the contractor wishes to remove the formwork and supports as quickly as possible*.

Step	Outcome
	Steps 1 and 10 are the same as in Example 1a. Go to Step 11.
11	Using *Guidance on additional requirements for designed concrete* in this series, look at the options to increase the early strength to achieve early formwork striking. For this particular site, the use of a higher strength class concrete coupled with a requirement for high early strength cements/combinations was considered the most practical option. The designer and contractor decide to fix the nominal cover at 20 mm and look at the options of using concrete of strength classes C20/25 to C32/40 (already being used in the columns) on the slab thickness and the speed at which the forms can be removed. The higher strength concrete reduced the slab thickness by only 5 mm compared with the C20/25 designated concrete, but the contractor estimated that they needed for formwork striking a required strength of 15 N/mm^2 and at a mean air temperature of 10°C, 5 days could be saved on the formwork striking times by changing from C20/25 to C32/40. This would also have the advantage that the concrete for the columns and slabs would be the same. However, taking other programming restraints and cost into account, a C25/30 was selected (this was estimated to save 2 days on the formwork striking time, see CIRIA Report 136: *Formwork striking times – criteria, prediction and methods of assessment*). Any cement or combination that satisfy the strength ratios on which the CIRIA tables were based would be suitable. All cement or combination types I and IIA can be assumed to satisfy these criteria and types IIB and IIIA may satisfy these criteria. However, the contractor plans to measure, before formwork striking, the in-situ strength using a pull-out test. As there are a number of slabs to be cast, the specifier decides to ask for alternatives based on different cement/combination types to give him some flexibility to be able to cope with the ambient conditions at casting. The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable for the pumped concrete. As the concrete will be ready-mixed, the specifier decides that accredited third party certification is required (see Note 2 to clause **4.3.2**). The only other options selected by the specifier are the two recommendations in *Guidance on additional requirements for designed concrete* for aggregates, namely a limit on drying shrinkage, and a Los Angeles category. Go to Step 12.
12	Turn to Table A.10. The nominal cover to reinforcement and the limiting values and properties of concrete for the XC1 exposure is: Nominal cover (15 + 5) mm and concrete C20/25, 0.70, 240 (from Table A.18 for maximum aggregate size of 20 mm) and all cements/combinations in Table A.17. There are no other exposure classes to consider. Go to Step 13.
13	For a nominal cover of (15 + 5) mm, the limiting values and properties of the concrete are C20/25, 0.70, 240, 20 mm maximum aggregate size and any cement/combination in Table 1 of BS 8500–2. However, for formwork striking purposes only, the strength class is being increased to C25/30. As this is a structural requirement and not a durability consideration, there is no requirement in BS 8500–1 that the maximum w/c ratio should be reduced nor the minimum cement/combination content increased. Go to Step 14.

14	Yes, there are differences between the durability design and the preliminary scheme design. Go to Step 15
15	The strength class is the same as that obtained from the preliminary scheme design, but the nominal cover is 5 mm less. This was incorporated into the design drawings without further re-calculation. Go to Step 16.
16	Basic specification requirements (clause **4.3.2**): a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Compressive strength class: C25/30; c) Maximum w/c ratio of 0.70, minimum cement/combination content of 240 kg/m^3; d) Cement/combination type: provide as alternatives concretes using I, IIA, IIB and IIIA. e) Maximum aggregate size: 20 mm; f) Chloride class: Cl 0,40; g) and h) do not apply; i) Consistence class: S3. Go to Step 17.
17	Additional requirements (see Step 11): The producer shall operate an accredited quality system meeting the requirements of BS EN ISO 9001. When tested in accordance with BS EN 1367-4, the aggregate drying shrinkage shall be not more than 0.075%. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40}. Go to Step 18.
18	Information from the specifier to producer The concrete will be pumped, compacted with a beam vibrator and finished with a bull-float. The in-situ strength development will be measured using a pull-out test. Go to Step 19.
19	Information required from the concrete producer On checking clause **5.2**, the specifier identifies that BS EN 206-1, clause **7.2e)** and BS 8500, clause **5.2** items f) and g) are relevant and therefore requests this information as follows: Please supply the following information prior to delivery: a) Strength development of the concrete; b) If RCA or RA is to be used, the type of material and the proportion to be used. c) Where RCA or RA is not classed as highly reactive with respect to alkali-silica reaction, the proof on which the lower classification was based.

Example 2

External in-situ reinforced concrete wall of a heated warehouse. The concrete will be pumped and compacted with an internal vibrator. A textured surfacing (decorative only) will be applied to the outside face, but the internal surface will be 'as-struck'.

Step	Outcome
1	The relevant exposure classes are shown in Figure 2.  **Figure 2: Relevant exposure classes** Whilst the decorative surfacing may in practice provide some additional resistance to carbonation, it should be ignored for the purpose of durability design. NOTE. Some surface coatings are designed specifically to provide resistance to carbonation/chloride penetration. In these cases the specifier can decide if they want to trade this off against cover to reinforcement. However, no guidance is provided in BS 8500 on how this should be done. As there is no aggressive chemical class, go to Step 10.
10	As this is a normal building structure, EN 1990: *Basis of design*, recommends an intended working life of (at least)50 years. The scheme design is based on EN 1992–1 and assumes a compressive strength of 25 N/mm^2 and a nominal cover of 40 mm (both faces) with a margin, Δc, of 10 mm. As this is an EN 1992–1 design, the 25 N/mm^2 is a cylinder strength and it thus equates to a compressive strength class of C25/30 (BS EN 206–1, Table 7).
11	The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable for the pumped concrete. As the concrete will be ready-mixed, the specifier decides that accredited third party certification is required (see Note 2 to clause **4.3.2**). The only other options selected by the specifier are the two recommendations in *Guidance on additional requirements for designed concrete* for aggregates, namely a limit on drying shrinkage and a Los Angeles category.

12 For each of the exposure classes identified in Step 1, the following recommended nominal cover and concrete limiting values and properties are applicable.

Exposure	Table from BS 8500–1	Cover	Strength class	Max. w/c	Min. cement content with 20 mm aggregate	Cement/ combination	Other require-ments
XC3 and XC4	A.10	35+10	C25/30	0.65	260	All except IVB	—
		30+10	C28/35	0.60	280	All except IVB	—
		25+10	C32/40	0.55	300	All except IVB	—
		20+10	C40/50	0.45	340	All except IVB	—
XC1	A.10	15+10	C20/25	0.70	240	All	—
XF1	A.14	–	C28/35	0.60	280	All	—
		–	C25/30[a)]	0.60	280	All	Air-entrained

a) Obtained by the application of footnote b) to Table A.14

13 The specifier decides that the enhanced freeze/thaw resistance given by the air entrainment option in the table above is not necessary and he discarded this option.

On examining all these different requirements, the requirement to resist freeze/thaw conditions (XF1) is the critical case that sets the minimum concrete quality and this concrete quality goes with the scheme design cover to the outer face. The specifier thus decides to select a C28/35, 0.60, 280, all cements/combinations except IVB concrete with a nominal cover of (30+10)mm.

Cement or combination type IVB is not recommended in BS 8500 for this application.

Cement or combination type IIIB is normally specified for situations requiring high resistance to chlorides, sulfates or other aggressive chemicals. Because the exposure classes do not include XD, XS or aggressive chemicals, cement/combination type IIIB is discarded at this stage of the process. As SRPC is also a special cement used for producing sulfate-resisting concrete, it was also discarded.

NOTE**:** For the inner face in the XC1 exposure, the minimum cover could have been reduced to 15 mm and the margin reduced to 5 mm giving a total savings on the cover of 20 mm and an increase in the lettable space. However, possible errors during construction caused by using different covers on opposite faces have also to be considered.

14 Yes, there are differences between the durability design and the preliminary scheme design.

15 The designer decides to leave the cover the same on both faces and, consequently, they do not have to revise the reinforcement drawings.

16 Basic specification requirements (clause **4.3.2**):

a) The concrete shall conform to BS 85002 and BS EN 206–1;

b) Compressive strength class: C28/35;

c) Maximum w/c ratio: 0.60; minimum cement/combination content: 280 kg/m^3;

d) Cement/combination types: I, II or IIIA;

e) Maximum aggregate size: 20mm;

f) Chloride class: Cl 0,40;

g) and h) do not apply;

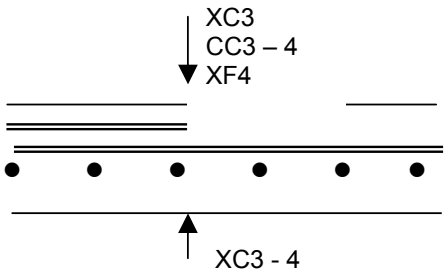
i) Consistence class: S3.

17	Additional requirements (see Step 11): The producer shall operate an accredited quality system meeting the requirements of BS EN ISO 9001. When tested in accordance with BS EN 1367-4, the aggregate drying shrinkage shall be not more than 0.075%. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40}
18	Information from the specifier to producer The concrete will be pumped, compacted with an internal vibrator. A textured surfacing will be applied to the outside face, but the internal surface will be "as-struck".
19	Information required from the concrete producer On checking clause **5.2**, the specifier identifies that items f) and g) are relevant and therefore requests this information as follows: Please supply the following information: a) If RCA or RA is to be used, the type of material and the proportion to be used. b) Where RCA or RA is not classed as highly reactive with respect to alkali-silica reaction, the proof on which the lower classification was based.

Example 3

Suspended reinforced concrete slab to car park. The concrete will be placed by skip, compacted with a beam vibrator and finished with a bull-float.

a) *The concrete is to be supplied from a ready-mixed concrete producer with accredited third party certification.*

Step	Outcome
1	The relevant exposure classes are shown in Figure 3.  **Figure 3: Relevant exposure classes**
10	As this is a normal building structure, EN 1990: B*asis of design*, recommends an intended working life of (at least) 50 years. The scheme structural design assumed C32/40 with a nominal cover of 40mm that included a margin of 10 mm.
11	The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable for the concrete. As the concrete will be ready-mixed, the specifier decides that accredited third party certification is required (see Note 2 to clause **4.3.2**). The only other factors are the two recommendations in *Guidance on additional requirements for designed concrete* for aggregates, namely a limit on drying shrinkage and a Los Angeles category. As this element will be exposed to chlorides, it would be helpful if the specification made it clear that RCA and RA are not permitted.

12 For each of the exposure classes identified in Step 1, the following recommended nominal cover and concrete limiting values and properties are applicable.

Exposure	Table from BS 8500–1	Cover	Strength class	Max. w/c	Min. cement content with 20 mm aggregate	Cement/ combination	Other require-ments
XD3	A.12	50+10	C35/45 C28/35 C25/30	0.45 0.50 0.50	360 340 340	Group 4 Group 5 Group 6	—
		45+10	C40/50 C32/40 C28/35	0.40 0.45 0.45	380 360 360	Group 4 Group 5 Group 6	—
		40+10	C45/55 C35/45 C32/40	0.35 0.40 0.40	380 380 380	Group 4 Group 5 Group 6	—
XC3 and XC4	A.10	35+10	C25/30	0.65	260	All except IVB	—
		30+10	C28/35	0.60	280	All except IVB	—
		25+10	C32/40	0.55	300	All except IVB	—
		20+10	C40/50	0.45	340	All except IVB	—
XF4	A.14	—	C28/35	0.55	300	All except IVB and IIIB (Group 6)	F/T resisting aggregate s. 3.5% air
		—	C40/50	0.45	340	All except IVB and IIIB (Group 6)	F/T resisting aggregate s.

Because of the requirements for XF4 and the fact that the slab surface acts as a pavement, all the Group 6 options in the XD3 provisions can be eliminated (see Table A.14, footnote e)).

Because of the requirement for C28/35 for air entrained concrete, all other rows with, or less than, this value can be eliminated (see Table A.14, footnote c) for explanation).

13 At this point the specifier has to make choices. It needs to be decided if the air-entrained or non-air entrained option is wanted or if they should be offered as alternatives (this will only make sense if the cover requirements are the same for both options).

As the structural requirement is for a C32/40 strength class (Step 10), no value below this should be selected unless the specifier is prepared to review the design. In this case the specifier is not prepared to review the design.

For the air entrained option, the strength classes in the XD3 and XC3-4 rows can be reduced by 1 except for where this reduces the strength below the structural requirement of C32/40, e.g. case b) below. The table in Step 12 reduces to the following options:

a) C32/40, 0.40, 380, Group 5 with (40+10) mm cover to the top reinforcement and (25+10) mm cover to the soffit reinforcement;
OR,

b) C32/40, 0.45, 360, Group 5 with (45+10) mm cover to the top reinforcement and (25+10) mm cover to the soffit reinforcement;

OR,

	c) C32/40, 0.45, 360, Group 4 with (50+10)mm cover to the top reinforcement and (25+10)mm cover to the soffit reinforcement. In all cases the minimum air content is 3.5% and freeze/thaw resisting aggregates are required. For the non-air entrained option, the following is recommended: d) C40/50, 0.40, 380, Group 4 with (45+10) mm cover to the top reinforcement and (20+10) mm cover to the soffit reinforcement; **OR,** e) C40/50, 0.40, 380, Group 5 with (40+10) mm cover to the top reinforcement and (20+10) mm cover to the soffit reinforcement. Solutions a) to e) are all equally technically valid. The designer decides to select option b) and permit as an alternative options d) and e).
14	Yes, there are differences between the durability design and the preliminary scheme design Go to 15.
15	The nominal cover to the lower reinforcement is reduced to 35mm and the cover to the upper reinforcement is increased to 55 mm. This provides a safe solution if the non-air entrained concrete is supplied.
16	Basic specification requirements (clause **4.3.2**): a) The concrete shall conform to BS 8500-2 and BS EN 206–1; b) Compressive strength class: Alternative A – C32/40, Alternative B – C40/50; c) Alternative A: Maximum w/c ratio – 0.45, minimum cement/combination content – 360 kg/m^3. Alternative B: Maximum w/c ratio – 0.40, minimum cement/combination content – 380 kg/m^3. d) Alternative A – Group 5 cement/combination. Alternative B – Group 4 or 5 cement/combination. e) Maximum aggregate size: 20mm; f) Chloride class: Cl 0,40 for all cements/combinations except SRPC where it shall be Cl 0,20; g) and h) do not apply; i) Consistence class: S3.
17	Additional requirements (see Step 11 and right hand column in Step 12): With Alternative A, the concrete shall have a minimum air content of 3.5%. The producer shall operate an accredited quality system meeting the requirements of BS EN ISO 9001. RCA and RA are not permitted. When tested in accordance with BS EN 1367-4, the aggregate drying shrinkage shall be not more than 0.075%. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40} The aggregate shall be freeze/thaw resisting as defined in BS 8500–2: 2002, clause **4.3**.
18	Information from the specifier to producer The concrete will be placed by skip, compacted with a beam vibrator and finished with a bull-float.
19	Information required from the concrete producer On checking clause **5.2**, the specifier identifies that items d) is relevant and therefore requests this information as follows: Please supply the following information: If porous flint aggregates are to be used, evidence of successful use for at least 10 years.

3**b)** *As Example 3a except that at the time of specification, it is not known who will supply the concrete.*

The technical requirements for the concrete are unchanged and the only differences occur in Steps 11, 17 and 18.

Step	Outcome
11	The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable for the concrete. As the supplier of the concrete is not known, the specifier has to make a choice from: a) do not include any requirement for accredited third party certification; b) require accredited third party certification if ready-mixed concrete is used; c) require accredited third party certification and if this results in the producer qualifying the tender, require identity testing as a condition for accepting this qualification. It is recommended that c) should be the norm, but as this was covered by Example 3a, this example is based on choice a). The specifier needs to decide whether identity testing should only be applied where the concrete is not subject to accredited third party certification or to be applied in all cases. In this case, the specifier decides to restrict routine identity testing to concrete without accredited third party certification. Clause 5.1b), requires for routine identity testing, the volume of concrete to be defined and the number of tests on this volume of concrete. Each floor casting makes a sensible volume of concrete to make a decision over whether it should be accepted or rejected, and tests on consistence, air content and strength are all relevant. The specifier decides that 3 sets of tests per volume are appropriate. The only other factors are the two recommendations in Guidance on additional requirements for designed concrete for aggregates, namely a limit on drying shrinkage and a Los Angeles category. As this element will be exposed to chlorides, it would be helpful if the specification made it clear that recycled concrete aggregate and recycled aggregate are not permitted. The steps follow Example 3a until Step 17 is reached.
17	Additional requirements: With Alternative A, the concrete shall have a minimum air content of 3.5%. Recycled concrete aggregate and recycled aggregate are not permitted. When tested in accordance with BS EN 1367–4, the aggregate drying shrinkage shall be not more than 0.075%. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40} The aggregate shall be freeze/thaw resisting as defined in BS 8500–2:2002, clause 4.3.
18	Information from the specifier to producer The specifier would identify that from Clause 5.1 that items a), b) and c) may be relevant. The specifier supplies information as follows: The concrete will be placed by skip, compacted with a beam vibrator and finished with a bull-float. Where the concrete is not covered by accredited third party certification, for each floor slab, identity tests for consistence, air content if it is air-entrained, and compressive strength will be conducted on the first batch, a batch in the middle of the pour and one near the end by staff from an independent accredited laboratory appointed by the client.

Example 4

A 300 mm deep x 900 mm wide reinforced strip footing for an office block to be cast directly into a trench in soil where the potential sulfate is 1.0 % SO_4. It is a brownfield site where the groundwater is mobile and the pH is 6.1.
The concrete will be transported on site by dumper and discharged directly into the trench. It will be vibrated and it will be levelled with shovels and trowels.

Step	Outcome
1	As the concrete is in contact with the ground, an aggressive chemical class applies. As the concrete is reinforced but fully buried, exposure XC2 also applies. As the concrete is fully buried, the risk of freeze/thaw damage is slight and consequently an XF-class need not be selected.
2	Using Table A.2 and the total potential sulfate of 1.0 % SO_4, brownfield site with mobile water with a pH of 6.1, these give an ACEC-class of AC-4.
3	Table A.3 classifies an office block as having a normal structural performance
4	There will be no significant hydrostatic head between the top and the bottom of the strip footing, so Table A.4, footnote a) need not be applied. In the case of this strip footing, the least dimension of the section is 300 mm and this is the value used to select the section width column. Using AC-4, normal structural performance and a section width 150 mm to 450 mm, Table A.4 gives DC-4/2.
5	Yes, APMs are recommended
6	Phone calls to local ready-mixed concrete suppliers show that aggregate carbonate range B is available, i.e. the 'starred' class can be specified without causing any supply or cost difficulties.
4	Re-visiting Table A.4 and applying footnote b) leads to DC-4*/1.
5	Yes, there is still a need for one additional APM.
6	As you have already been through this loop, move to Step 7.
7	Using Table A.5, consider the feasibility of each of the APMs. APM 2: *Controlled permeability formwork* will not provide protection to the upper surface of the foundation. Relevant APMs are 3: *Surface protection,* APM 4: *Sacrificial layer* and APM 5: *Address site drainage* are all possible options. As the plan is to cast directly into the trench, there was concern that surface protection might be damaged during construction. Addressing site drainage was rejected in this case as being too expensive and as a consequence, APM4 was selected, i.e. a 50 mm sacrificial layer on all surfaces. Include this in the contract drawings.
8	APM1 is not used.
10	As this is a normal building structure, EN 1990: *Basis of design*, recommends an intended working life of (at least) 50 years. The scheme design assumed a strength class of C25/30 and a nominal cover of 100 mm comprising 25 mm plus a margin of 75 mm for concrete to be cast against the ground (as recommended in EN 1992–1).
11	The specifier selects a maximum aggregate size of 20 mm. The concrete is reinforced and the specifier decides to follow the guidance in clause **A.9** for the chloride class. From the guidance in clause **A.6**, the specifier selects slump class S3 as being suitable. As the concrete will be ready-mixed, the specifier decides that accredited third party certification is required (see Note 2 to clause **4.3.2**). Another option selected by the specifier is the recommendation in *Guidance on additional requirements for designed concrete* for a Los Angeles category for the aggregate. As the concrete will remained fully buried, drying shrinkage will not be significant and the recommended requirement for drying shrinkage is not needed

	As this element will be exposed to strong sulfate solutions, it would be helpful if the specification made it clear that RCA and RA are not permitted.
12	From Table A.15, a DC-4* requires: (no strength class requirement), 0.40, 400, Groups 2 or 3 and aggregate carbonate range B or C. From Table A.10, for XC2 the recommendations for 20mm maximum aggregate size concrete are: Nominal cover of (25+75) mm, C25/30, 0.65, 260, all cements/combinations.
13	Step 12 shows that the requirements for the design chemical class control the specification and consequently the DC-class can be specified with a strength class of C25/30.
14	There is a need to take account of APM4.
15	The original sizing had assumed a nominal cover of 100 mm. However the application of APM4 will increase the section size from 300 mm x 900 mm to 400 mm x 1000 mm and the nominal cover to 150 mm.
16	Basic specification requirements (clause **4.3.2**): a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Compressive strength class: C25/30; c) and d) Design chemical class: DC-4* e) Maximum aggregate size: 20 mm; f) Chloride class: Cl 0,40 for all cements/combinations except SRPC where it shall be Cl 0,20; g) and h) do not apply; i) Consistence class: S3.
17	Additional requirements (see Step 11): The producer shall operate an accredited quality system meeting the requirements of BS EN ISO 9001. RCA and RA are not permitted. The BS EN 12620 Los Angeles category of the coarse aggregate shall be not be greater than LA_{40}.
18	Information from the specifier to the producer The concrete will be transported on site by dumper and discharged directly into the trench. It will be vibrated and it will be levelled with shovels and trowels.
19	Information required from the concrete producer On checking clause **5.2**, the specifier identifies that items c) is relevant and therefore requests this information as follows: Please supply the following information: The aggregate carbonate range.

FURTHER READING

The other publications from this series will be helpful. Visit www.cementindustry.co.uk and click 'information'/'library'/'BCA publications' to check availability and for free download.

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