Examples of specification of designated 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.

PROCEDURE

The procedure by which a designated 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, and they make reference to the steps in the procedure.

Before using this publication, it may be helpful to have read other publications from this series, in particular, *Concrete for normal uses* and *Concrete resistant to chemical attack*. These will explain some of the terms and concepts used in BS EN 206–1/BS 8500.

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Association of Concrete Industrial Flooring Contractors
Association of Lightweight Aggregate Manufacturers
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A full list of the publications in this series is given on the back page.

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

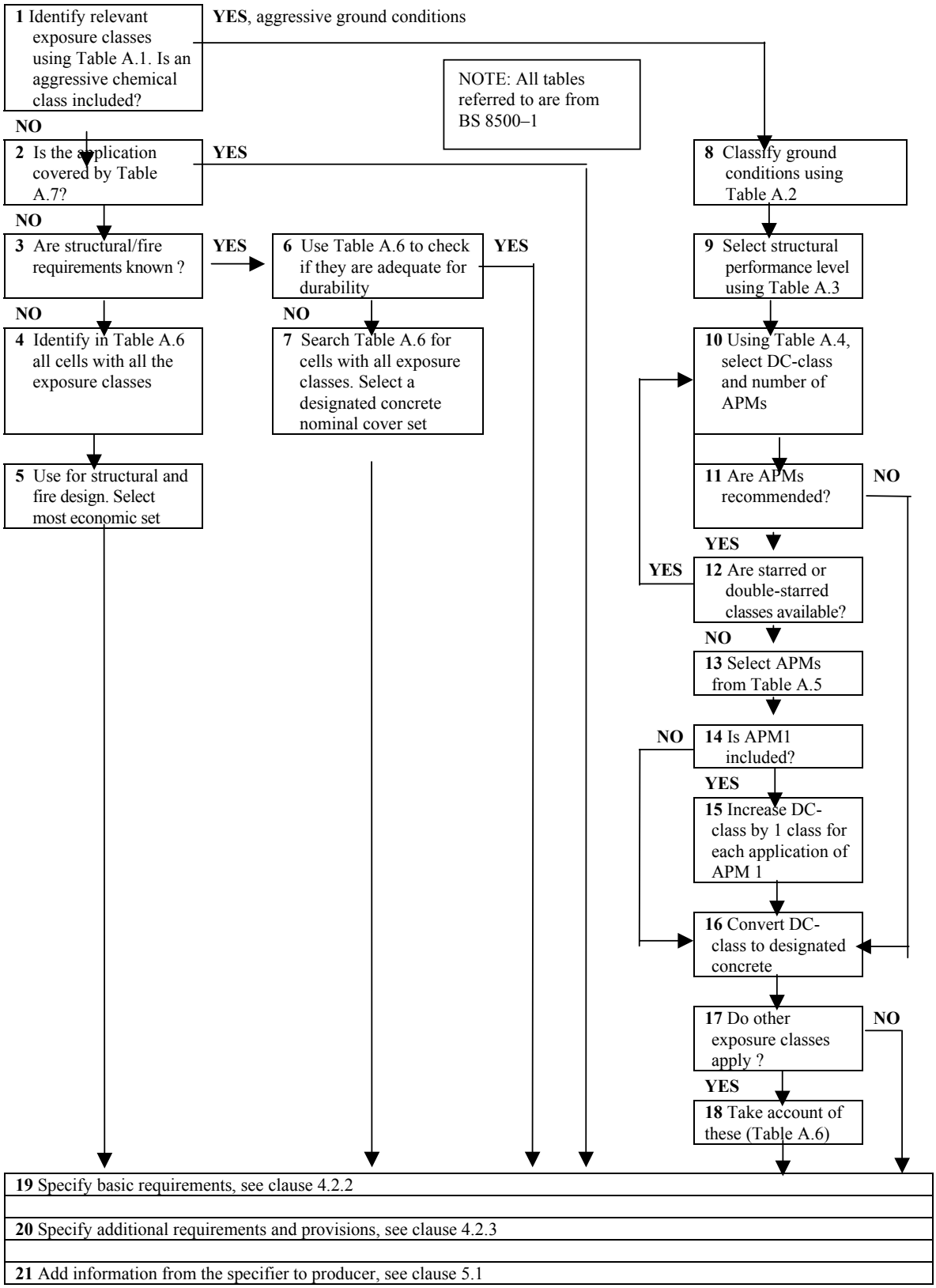


Table 1: Process for the specification of a designated concrete

Step	Description	Action
1	Using clause A.2 and in Table A.1, identify all relevant exposure classes. NOTE. If they include an XD or XS exposure, change the method of specification to **designed** concrete. Do they include aggressive ground conditions (an aggressive chemical classes)? Yes No	 Go to 8 Go to 2
2	Turn to Table A.7 of BS 8500-1. Is the application covered by Table A.7? Yes No	Go to 19 Go to 3
3	Are requirements for structural and fire design (nominal cover, the margin (Δc) and compressive strength class) known? Yes No 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 6 Go to 4
4	Using Table A.6, identify cells that contain all the identified exposure classes. The co-ordinates of these cells give recommended sets of designated concrete/nominal cover. If none of the cells in Table A.6 contain all the identified exposure classes, change to a **designed** concrete specification.	Go to 5
5	Select one of the designated concrete/nominal cover sets and use it in the structural design and check that it is adequate for fire resistance purposes. If it is not suitable, select another set until a suitable set (or the most economic set) is found.	Go to 19
6	Use Table A.8 to convert the compressive strength class to a designated concrete. Using the nominal cover, the margin (Δc) and the designated concrete, does the cell in Table A.6 contain all the identified exposure classes? Yes No	Go to 19 Go to 7
7	Search Table A.6 for cells that contain all the identified exposure classes. Select the most economic set of designated concrete/nominal cover. If none of the cells contain all the identified exposure classes, change to a **designed** concrete specification. NOTE 1. If you do not wish to refine the structural/fire design, it may be simpler to keep the nominal cover unchanged and increase the concrete quality. NOTE 2. Consider whether you wish to refine the structural/fire design using the new designated concrete/nominal cover.	Go to 19
8	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 9
9	Using Table A.3, select the structural performance level.	Go to 10
10	Check that the hydrostatic head is not greater than 5 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). Using Table A.4 and the determined ACEC-class, structural performance level and section width, select the DC-class and the number of APMs, if any. NOTE. The section width means the least dimension of the section.	Go to 11

11	Are there APMs recommended? Yes No	 Go to 12 Go to 16
12	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 and consequently, their availability should be checked. Read footnotes b) and c) to Table A.4 and check the local availability of the starred or double-starred designated 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 10 Go to 13
13	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 APM 1 are selected, they should be included in the contract documentation, as they do not form part of the concrete specification.	 Go to 14
14	Do they include APM 1: *Enhanced concrete quality*? Yes No	 Go to 15 Go to 16
15	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 16
16	Convert the DC-class into a designated concrete using Table A.7	Go to 17
17	Do other exposure classes apply (Step 1)? Yes No	 Go to 18 Go to 19
18	If Step 16 led to RC30, use the RC30 row in Table A.6 to determine the cells that contain the other exposure classes and select a nominal cover. If these are not covered in this row, go to Step 4. If Step 16 led to a 'FND' designated concrete, use the RC35 row in Table A.6 to determine the cells that contain the other exposure classes and select a nominal cover. If these are not covered in this row, change to a designed concrete specification.	 Go to 19
19	Specify the basic requirements, see clause 4.2.2: • a requirement to conform to BS 8500–2 and BS EN 206–1; • the designated concrete required from Table A.6 or A.7 [a)]; • the maximum aggregate size when other than the default value of 20mm; • the consistence class (see clause A.6 and Table A.7 for guidance)	 Go to 20
20	Specify any additional requirements and provisions. Using clause 4.2.3 as a checklist, decide if any of the additional requirements and provisions are necessary and, if so, add the requirements to the specification.	 Go to 21
21	Add, where relevant, information from the specifier to the producer using clause 5.1 as a checklist.	

NOTE

a) Where this is for a housing application, consider if you wish to provide, as an alternative, a specification for a standardized prescribed concrete.

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

Unreinforced concrete house floor where some rooms are to be fitted with bonded ceramic tiles and some rooms carpeted. The floor is to be cast in a single operation onto a damp proof membrane.

Step	Outcome
1	As the slab is unreinforced, protected from below with a damp proof membrane and protected above by ceramic tiles or carpet, the relevant exposure class is X0. Go to Step 2.
2	Application is covered in Table A.7. Different designated concretes are recommended for floors with an applied permanent finish, e.g. bonded ceramic tiles and floors where no permanent finish is to be added, e.g. carpeted areas, but as the floor is being cast in a single operation, the higher concrete quality is selected. Table A.8 shows that GEN2 is stronger than GEN1 and consequently, GEN2 is selected. The recommended consistence class in Table A.7 of S2 was accepted as being appropriate for the method of placing and finishing, see clause A.6. Go to Step 19.
19	Basic specification requirements: a) The concrete shall conform to BS 8500-2 and BS EN 206-1; b) Designated concrete GEN2; (If the concrete may be site batched or supplied from a ready-mixed concrete producer without third party certification, an alternative standardized prescribed concrete should be provided. If needed, select this from Table A.7 and prepare an alternative standardized prescribed concrete specification, see clause 4.5.) c) (As a maximum aggregate size of 20mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S2 (If an equivalent to a traditional workability is required, use BS EN 206-1, Tables 3 to 6 to find the equivalent consistence class) Go to Step 20
20	The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA_{40}. Go to Step 21.
21	Information from the specifier to the producer: The concrete will be directly discharged from the truck into the floor, compacted with a beam vibrator and finished with a bull-float.

Example 2

a) *Suspended reinforced concrete internal office slab that will be carpeted. The concrete will be pumped. The columns of this building require designated concrete RC40.*

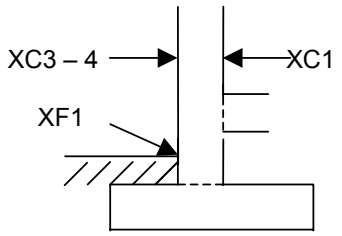
Step	Outcome
1	As the slab is carpeted, there are no abrasion considerations. From Table A.1, the only relevant exposure class is XC1.
2	Application is not covered in Table A.7.
3	No preliminary scheme design proposals are available at this stage.
4	From Table A.6, the lowest designated concrete/nominal cover set is RC25/(15 + 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. They indicate 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 5mm for Δc is selected.
5	RC 25 with a nominal cover of (15 + 5) mm is selected.
19	Basic specification requirements: a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Designated concrete RC25; c) (As a maximum aggregate size of 20 mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S3
20	The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA_{40}. Go to Step 21
21	Information from the specifier to the producer: The concrete will be pumped, compacted with a beam vibrator and finished with a bull-float.

b) *As Example 2a, but the contractor wishes to remove the formwork and supports as quickly as possible.*

Step	Outcome
1	As the slab is carpeted, there are no abrasion considerations. From Table A.1, the only relevant exposure class is XC1.
2	Application is not covered in Table A.7.
3	No preliminary scheme design proposals are available at this stage.
4	From Table A.6, the lowest designated concrete/nominal cover set is RC25/(15 + Δc). As this is an internal environment with no real durability concerns, the designer selects a Δc of 5mm.
5	Using *Guidance on additional requirements for designed concrete* in this series, look at the options to increase the early strength to give 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 were the most practical options. The designer and contractor decide to fix the nominal cover at 20 mm and look at the options of using RC25 to RC40 on the slab thickness and the speed at which the forms can be removed. The higher strength concrete only reduced the slab thickness by 5 mm compared with the RC25 designated concrete, but the contractor estimated that they could save 5 days on the formwork striking times by changing from RC25 to RC40. However, taking other programming restraints into account, a RC30 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*). In addition to specifying a higher concrete strength class, they opt to select cements/combinations that have high early strength, i.e. I and IIA, and to measure the strength of the in-situ concrete using the pull-out test.
19	Basic specification requirements: a) The concrete shall conform to BS 8500-2 and BS EN 206-1; b) Designated concrete RC30; c) (As a maximum aggregate size of 20mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S3
20	Additional specification requirements and provisions: The cement/combination shall be I or IIA (Note. The use of the shorthand IIA includes all cements and combinations of type IIA given in BS 8500-2, Table 1). The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA_{40}. Go to Step 21.
21	Information from the specifier to the producer: The concrete will be pumped, compacted with a beam vibrator and finished with a bull-float.

Example 3

External in-situ reinforced concrete wall of a heated warehouse. The walls will be pumped.

Step	Outcome
1	The relevant exposure classes are shown in Figure 2.  **Figure 2**: Relevant exposure classes
2	Application is not covered in Table A.7.
3	Yes, preliminary scheme design data are available. The preliminary scheme design is based on EN 1992–1 and gives a compressive strength of 25N/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 equates to a compressive strength class of C25/30 (BS EN 206–1, Table 7) and designated concrete RC30 (Table A.8 of BS 8500–1).
6	From the RC30 row in Table A.6, there is no cell that contains all three relevant exposure classes.
7	Sets of recommendations that do contain all three exposure classes include: RC35/(30 + Δc) RC40/(25 + Δc) Either of these combinations of designated concrete and nominal cover could therefore be specified. As the preliminary scheme design gave, in effect, RC30 at a nominal cover of 40 mm with a Δc of 10 mm, a simple solution is to leave the reinforcement/section thickness design unchanged and increase the concrete specification to RC35. However, some economies are possible by refining the design. When using RC35, the nominal cover to the outer face is unchanged, but the inner face is only exposed to a XC1 environment. As such, Table A.6 shows that the cover can be reduced to (15 + Δc). As there are no real durability problems with the XC1 environment, the designer decides to use a margin of 5 mm. This reduces the nominal cover to 20 mm, the section thickness by 20 mm and increases the lettable space. However, the possibility of errors during construction due to different covers on opposite faces have to be considered.
19	Basic specification requirements: a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Designated concrete RC35; c) (As a maximum aggregate size of 20 mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S3
20	The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA $_{40}$. Go to Step 21
21	Information from the specifier to the producer: The concrete will be pumped and compacted with an internal vibrator. A textured surfacing will be applied to the outside face, but the internal face will be “as-struck”.

Example 4

A 600 mm wide by 1.8 m deep unreinforced trench fill house foundation. No site investigation has been carried out, but the Building Control Officer has indicated that the clay soil in the area of construction is 'Design sulfate class 2' and the pH >5.5. The site is part of the level garden of an existing house and the ground is classed as natural.

Step	Outcome
1	As the concrete is in contact with the ground, an aggressive chemical class is relevant. As the trench is unreinforced and the top of the trench fill foundation is buried, no other exposure classes apply.
8	Enter Table A.2 at the row that gives DS-2 (Design sulfate class 2) in the 6th column. Move over to the natural soil column. As there is no information available, the groundwater should be assumed to be mobile even with a clay soil and therefore select the mobile water column. For a pH >5.5, Table A.2 gives an ACEC-class of AC-2.
9	As this is a house foundation, Table A.3 classifies it as having a low structural performance.
10	As the ground water is mobile, it is assumed that it will flow around the foundation and the pressures will be approximately equal on both sides of the trench fill and consequently Table A.4, footnote a) does not apply. Table A.4 for AC-2, low structural performance and a section width >450 mm gives DC-1/0. NOTE Even if this assumption was incorrect, the hydrostatic head could only be 3 times the section thickness (1.8 m/0.6 m) as the site is level and there would be no artesian water pressure.
11	There are no APMs.
16	From Table A.7, trench fill requiring DC-1 concrete recommends GEN1 with a consistence class of S4.
17	No other exposure classes apply, see Step 1.
19	Basic specification requirements: a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Designated concrete GEN1; (There is no alternative standardized prescribed concrete for slump class S4. If an alternative standardized prescribed concrete with a lower slump class of S3 is specified, there will be the temptation to add water on site reducing the strength and durability of the concrete. Consequently this alternative is not recommended) c) (As a maximum aggregate size of 20 mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S4
20	The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA $_{40.}$ Go to Step 21
21	Information from the specifier to the producer The concrete will be discharged at one corner of the trench and expected to flow around the complete foundation with some manual help. It will not be vibrated and it will be levelled with shovels and trowels.

Example 5

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.

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.
8	Using the total potential sulfate of 1.0% SO_4, brownfield site with mobile water with a pH of 6.1, Table A.2 gives an ACEC-class of AC-4.
9	Table A.3 classifies an office block as having a normal structural performance
10	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.
11	Yes, APMs are recommended
12	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.
10	Re-visiting Table A.4 and applying footnote b) leads to DC-4*/1.
11	Yes, there is still 1 APM.
12	As you have already been through this loop, move to Step 13.
13	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. APM 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 the surface protection may be damaged during subsequent 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.
14	APM 1 is not used.
16	From Table A.7, DC-4* requires designated concrete FND4*.
17	Yes, exposure class XC2 applies, see Step 1.
18	In Table A.6, row RC35, the lowest nominal cover for XC2 is (25 + Δc). The original sizing had assumed a nominal cover of 100 mm (25 mm plus the margin recommended in EN 1992–1 of 75 mm for concrete cast against the ground). 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.
19	Basic specification requirements: a) The concrete shall conform to BS 8500–2 and BS EN 206–1; b) Designated concrete FND4*; c) (As a maximum aggregate size of 20 mm is suitable, this item does not need to be specified as it is the default value); d) Consistence class S3 (There is no equivalent standardized prescribed concrete).
20	The recommendation for resistance to fragmentation given in *Additional requirements for designed concrete* is this series is followed: The BS EN 12620 Los Angeles category of the coarse aggregate shall not be greater than LA_{40}. Go to Step 21
21	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.

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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- *Guide to the selection of concrete quality and cover for reinforcement for normal concrete structures*
- *Examples of the specification of designated concrete*
- *Examples of the specification of designed concrete*
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