

**Guide to the use in the UK of
DD ENV 206 : 1992 *Concrete.*
*Performance, production,
placing and compliance
criteria***

Committees responsible for this British Standard

The preparation of this Published Document was entrusted by Technical Committee B/517, Concrete, to Subcommittee B/517/1, Concrete production and testing, upon which the following bodies were represented:

Association of Lightweight Aggregate Manufacturers
 Association of Metropolitan Authorities
 British Aggregate Construction Materials Industries
 British Cement Association
 British Civil Engineering Test Equipment Manufacturers' Association
 British Precast Concrete Federation
 British Ready Mixed Concrete Association
 Building Employers' Confederation
 Cement Admixtures Association
 Cementitious Slag Makers' Association
 Concrete Society
 County Surveyors' Society
 Department of the Environment (Building Research Establishment)
 Department of the Environment (Property Services Agency)
 Department of Transport
 Department of Transport (Transport Research Laboratory)
 Electricity Industry in United Kingdom
 Federation of Civil Engineering Contractors
 Institute of Concrete Technology
 Institution of Civil Engineers
 Institution of Highways and Transportation
 Institution of Structural Engineers
 Institution of Water and Environmental Management
 National House-Building Council
 Quality Ash Association
 Sand and Gravel Association
 Society of Chemical Industry

This Published Document, having been prepared under the direction of the Technical Committee B/517, was published under the authority of the Standards Board and comes into effect on 15 March 1993

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The following BSI reference relates to the work on this standard:
 Committee reference B/517/1

ISBN 0 580 21369 2

Amendments issued since publication

Amd. No.	Date	Text affected

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Foreword

This Published Document has been prepared under the direction of Technical Committee B/517, Concrete. It provides advice on the use in the UK of the European Prestandard for concrete, ENV 206 published in the UK as DD ENV 206 : 1992. It contains guidance on areas where ENV 206 may be unclear or where its requirements may be unfamiliar to UK practitioners.

In the UK ENV 206 has the status of a Draft for Development; it is not to be regarded as a British Standard. Nevertheless, where Eurocode 2 : Part 1 *Design of concrete structures* (ENV 1992-1-1), also having only prestandard status and published as DD ENV 1992-1-1 : 1992, is used as the basis of design, then ENV 206 becomes obligatory as the reference document for concrete as a material and for its placing, compaction and curing. ENV 1992-1-1 also covers some aspects of execution, i.e. the act of constructing works, but these are not written in a form suitable for specification. When ENV 206 is upgraded to a full European Standard, EN 206, it will be published in the UK as BS EN 206 and conflicting British Standards will be withdrawn.

Work is continuing within CEN to develop various areas of ENV 206 into a more generally acceptable form before its transformation into a full European Standard. The UK is represented in the various Task Groups covering the subjects listed in ENV 206. Comments on ENV 206 and suggestions on how it might be improved are welcomed and should be sent to BSI as indicated in DD ENV 206.

In ENV 206 reference is made to EN(V) 197-1 and EN(V) 197-2 (June 1988 drafts), ISO/DP 9690, ISO/DIS 7031 and RILEM Recommendation CPC No. 7; as these documents are not readily available in the UK, they have been reproduced as annexes A, B, C, E and F of this guide. To avoid confusion between the clauses, tables, figures and footnotes in the annexes and those in this guide and in ENV 206, the clauses, tables, figures and footnotes in the annexes have been renumbered. Thus clause 1 of EN(V) 197-1 appears as **A.1**, and table 1 of EN(V) 197-2 appears as table B.1.

In this guide the clauses and references to tables are numbered to correspond with those in ENV 206.

Guide

1 General

1.2 Field of application

ENV 206 is intended to support the structural Eurocodes, in particular Eurocode 2 for concrete structures. However, it can also be used on its own or in conjunction with any other codes or regulations requiring the use of concrete although additional requirements may have to be specified. The national foreword to DD ENV 206 contains advice on its application.

Information on concrete with a closed structure is given in 5.2 of ENV 206. ENV 206 does not apply to materials such as no-fines concrete, foamed concrete or aerated concrete for which the relevant British Standards continue to apply.

The term 'simple structures' is not defined in ENV 206 but may be taken to include agricultural buildings and structures, which are covered by BS 5502, and certain low-rise buildings. For the latter, reference should be made to BS 8103, The Building Regulations Approved Document A[1], Building Standards (Scotland) Regulations [2] and Building Regulations (Northern Ireland) [3].

2 References

NOTE. The publications referred to in this guide are listed on page 53.

2.1 General

The terms 'obligatory', used in this subclause of ENV 206, and 'normative', used in 2.2 of ENV 206, may be taken as having the same meaning.

International standards describing methods of test for concrete have not been commonly used in the UK in the past although some Parts of BS 1881 are technically equivalent. National annex NA of DD ENV 206 : 1992 contains a list of the British Standards which may be used in place of those listed in 2.2 of ENV 206. The results obtained in accordance with these British Standards may be regarded as equivalent to those obtained in accordance with the corresponding international standards. Further information is given throughout this guide.

Where no equivalent British Standard is given then the publication referred to in ENV 206 has to be used.

Users of international standards may find that the reporting requirements are often significantly less than those required by an equivalent or similar British Standard. Practical tolerance levels, needed to enable the equipment used to carry out the test to be calibrated, are often not given in international standards.

Annex A of ENV 206 contains modifications to be made to ISO 1920, ISO 2736 : Part 2, ISO 4012, ISO 4013 and ISO 7031.

Agreement on equivalent or corresponding standards or rules, for use in place of the optional references, should normally be made between the affected parties prior to their use. Suggested equivalent or corresponding standards are covered by 2.3 of this guide.

2.2 Normative references

The corresponding British Standards listed in table I of this guide may be used instead of the international standards referred to in ENV 206. There are no British Standards corresponding to ISO 7031 or ISO 9690; further information on these standards is given in 7.3.1.5 and 6.2.1 of this guide.

2.3 Optional references

ENV 206 permits alternative equivalent standards or rules to be used instead of the optional references. Table II of this guide contains recommended alternative standards for use in the UK, together with information on how they differ from the international standards. Agreement on the use of equivalent standards should be obtained between all concerned parties before the contract is placed.

2.4 Other references

Eurocode 2 : Part 1 has been published by CEN as a European Prestandard, ENV 1992-1-1 : 1991, and is available from the British Standards Institution as DD ENV 1992-1-1 : 1992. At the time of preparation of this guide, Eurocode 4 was only available as a draft. The status of Eurocode 4 is not relevant in the context of ENV 206, however, as the only other reference to Eurocode 4 is in the introductory section on status of the document.

Table I. Relationship between normative references and corresponding British Standards		
International standard	Corresponding British Standard	Comments
ISO 1920 : 1976 ¹⁾	BS 1881 : Part 108 : 1983 (Related) BS 1881 : Part 109 : 1983 (Related) BS 1881 : Part 110 : 1983 (Related)	ISO 1920 specifies dimensions, tolerances and applicability of test specimens. BS 1881 : Part 108 may be used instead for making test cubes, BS 1881 : Part 109 may be used for making test beams and BS 1881 : Part 110 may be used for making test cylinders. These Parts of BS 1881 give a smaller range of suitable specimen sizes, but compliance with them ensures compliance with ISO 1920.
ISO 2736-1 : 1986	BS 1881 : Part 101 : 1983 (Related) BS 1881 : Part 125 : 1986 (Related)	ISO 2736-1 gives methods of sampling fresh concrete. BS 1881 : Part 101 may be used instead for sampling fresh concrete on site and BS 1881 : Part 125 may be used instead for sampling fresh concrete in the laboratory. The minimum sample size depends on the tests to be performed and the specimens to be made but can be less than 0.01 m ³ ; ISO 2736-1 requires a minimum sample size of 0.02 m ³ unless the sample is not intended to be representative of a larger mass of concrete. Provided the sample size is greater than 0.02 m ³ , compliance with these Parts of BS 1881 ensures compliance with ISO 2736-1. The alternative method described in 4.2 of BS 1881 : Part 102 : 1990 for slump testing is a special case, but is not prohibited by ISO 2736-1 as the sample is not taken from the very first part of the discharge where extreme segregation may have occurred.

Table I. Relationship between normative references and corresponding British Standards
(continued)

International standard	Corresponding British Standard	Comments
ISO 2736-2 : 1986 ¹⁾	BS 1881 : Part 108 : 1983 (Related) BS 1881 : Part 109 : 1983 (Related) BS 1881 : Part 110 : 1983 (Related) BS 1881 : Part 111 : 1983 (Related)	ISO 2736-2 gives methods of making and curing test specimens for strength tests. BS 1881 : Part 108 may be used instead for making test cubes, BS 1881 : Part 109 may be used for making test beams, BS 1881 : Part 110 may be used for making test cylinders and BS 1881 : Part 111 may be used for normal curing of test specimens. BS 1881 : Parts 108,109 and 110 give tolerances for dimensions of moulds whereas ISO 2736-2 gives tolerances for the concrete specimens. Checking that specimens conform to the requirements for angles and flatness of the load-bearing surfaces is only required by ISO 2736-2 if there is doubt whether the specimens conform. If the tolerances on the specimen moulds conform to the appropriate British Standards, then provided the specimens are well made they should be deemed to satisfy the ISO 1920 requirements for tolerances on specimens. BS 1881 : Parts 108, 109 and 110 specify a smaller range of suitable specimen sizes and fewer compaction methods, but compliance with them ensures compliance with ISO 2736-2. BS 1881 : Part 111 contains more requirements than ISO 2736-2 but compliance with it ensures compliance with ISO 2736-2. Information on the compaction of test specimens is given in 5.2 of this guide.
ISO 4012 : 1978 ¹⁾	BS 1881 : Part 116 : 1983 (Related)	BS 1881 : Part 116 may be used instead of ISO 4012 for determination of the compressive strength of concrete. BS 1881 : Part 116 is only applicable to concrete cubes, whereas ISO 4012 is applicable to cubes, cylinders and half-prisms. The requirements in ISO 4012 are less onerous than those in BS 1881 : Part 116. However, compliance with BS 1881 : Part 116 ensures compliance with ISO 4012.
ISO 4013 : 1978 ¹⁾	BS 1881 : Part 118 : 1983 (Technically equivalent)	BS 1881 : Part 118 may be used instead of ISO 4013 for determination of flexural strength. The requirements for the testing machine in ISO 4013 are less onerous than those in BS 1881 : Part 118. BS 1881 : Part 118 does not allow the use of centre point loading, whereas ISO 4013 includes it in an annex. However, compliance with BS 1881 : Part 118 using two-point loading ensures compliance with ISO 4013.

Table I. Relationship between normative references and corresponding British Standards
(concluded)

International standard	Corresponding British Standard	Comments
ISO 4108 : 1980 ¹⁾	BS 1881 : Part 117 : 1983 (Related)	BS 1881 : Part 117 may be used instead of ISO 4108 for determination of splitting strength. The loading rate range given in ISO 4848 is different from that given in BS 1881 : Part 106, and ISO 4848 does not require the use of a jig for cylindrical specimens. The requirements for the testing machine in ISO 4848 are less onerous than those in BS 1881 : Part 106. However, compliance with BS 1881 : Part 106 ensures compliance with ISO 4848.
ISO 4848 : 1980	BS 1881 : Part 106 : 1983 (Technically equivalent)	BS 1881 : Part 106 may be used instead of ISO 4848 for determination of air content.

¹⁾ This standard is modified by annex A of ENV 206.

NOTE. '(Identical)' means that the British Standard is identical in every detail with the corresponding international standard.

'(Technically equivalent)' means that the British Standard is in all technical respects the same as the corresponding international standard; the wording and presentation may differ quite extensively. '(Related)' means that the content of the British Standard, to any extent at all short of complete identity or technical equivalence, covers a subject matter similar to that covered by the corresponding international standard.

Table II. Relationship between optional references and corresponding British Standards		
International standard	Corresponding British Standard	Comments
ISO 4109 : 1980	BS 1881 : Part 102 : 1983 (Technically equivalent)	BS 1881 : Part 102 may be used instead of ISO 4109 for the slump test.
ISO 4110 : 1979	BS 1881 : Part 104 : 1983 (Technically equivalent)	BS 1881 : Part 104 may be used instead of ISO 4110 for the Vebe test.
ISO 6275 : 1982	BS 1881 : Part 114 : 1983 (Related)	BS 1881 : Part 114 may be used instead of ISO 6275 for the determination of density of hardened concrete. ISO 6275 requires that the specimen volume is not less than $50d^3$, where d is the nominal maximum aggregate size, and never less than 0.001 m^3 . The minimum specimen volume required in BS 1881 : Part 114 is $40d^3$. Thus for 20 mm aggregate concrete ISO 6275 requires a minimum specimen volume of 0.001 m^3 , which is approximately three times greater than the 0.00032 m^3 required by BS 1881 : Part 114. For specimen volumes of at least $50d^3$, however, compliance with BS 1881 : Part 114 ensures compliance with ISO 6275.
ISO 6276 : 1982	BS 1881 : Part 107 : 1983 (Technically equivalent)	BS 1881 : Part 107 may be used instead of ISO 6276 for the determination of density of fresh concrete.
ISO 6782 : 1982	BS 812 : Part 2 : 1975 (Related)	BS 812 : Part 2 may be used instead of ISO 6782 for the determination of aggregate bulk density. The test methods described in 6.3.4 of BS 812 : Part 2 : 1975 are essentially the same as those in ISO 6782. However, BS 812 : Part 2 states that the method is not applicable to moist fine aggregate, whereas ISO 6782 makes no such restriction. There are considerable differences between the requirements for container size for nominal aggregate sizes less than 31.5 mm. In many cases, BS 812 : Part 2 requires a larger container and the use of such a container is likely to give more accurate results. Nevertheless, for determination of uncompacted bulk density for aggregates of nominal maximum size of 10 mm to 14 mm, the container size in the BS 812 : Part 2 test should be increased from the specified nominal size of 0.007 m^3 to 0.010 m^3 , as specified in ISO 6782. The specified number of compactive blows per layer is generally greater in BS 812 : Part 2, but the effect of this, if any, is to increase the accuracy of the result. There are also differences in the minimum thickness of metal for the construction of the container, but it is unlikely that this would affect the outcome of the test.

Table II. Relationship between optional references and corresponding British Standards
(continued)

International standard	Corresponding British Standard	Comments
ISO 6783 : 1987	BS 812 : Part 2 : 1975 (Related)	BS 812 : Part 2 may be used instead of ISO 6783 for the determination of aggregate particle density. The method given in 5.3 of BS 812 : Part 2 : 1975 for the determination of relative density is essentially the same as that in ISO 6783 for determination of particle density. The method in BS 812 : Part 2 is restricted to aggregate particles that are larger than 10 mm, however, whereas ISO 6783 is applicable to all aggregate particles larger than 4 mm. The apertures in the basket for the test described in BS 812 : Part 2 may be as large as 6.5 mm, whereas according to ISO 6783 they should be between 1 mm and 3 mm. BS 812 : Part 2 also has a stricter requirement for the duration of oven-drying.
ISO 7033 : 1987	BS 812 : Part 2 : 1975 (Related)	BS 812 : Part 2 may be used instead of ISO 7033 for the determination of aggregate density. The method given in 5.5 of BS 812 : Part 2 : 1975 is essentially the same as that in ISO 7033. The method in BS 812 : Part 2 is restricted to aggregate particles that are larger than 10 mm, however, whereas ISO 6783 is applicable to all aggregate particles larger than 4 mm although different drying methods are given for coarse and fine particles. The requirements in BS 812 : Part 2 for soaking and drying times are stricter than those in ISO 7033.
ISO/DIS 7034	BS 1881 : Part 120 : 1975 (Related)	ISO/DIS 7034 is still a draft standard and may not be readily available. BS 1881 : Part 120 is considerably more detailed than ISO/DIS 7034 and should be used instead. Compliance with it ensures compliance with ISO/DIS 7034.
ISO/DIS 8045	BS 1881 : Part 202 : 1986 (Related)	ISO/DIS 8045 is still a draft standard and may not be readily available. BS 1881 : Part 202 may be used instead of ISO/DIS 8045 for the rebound hammer test. ISO/DIS 8045 is written in terms of the type N apparatus but does not preclude the use of the other types of apparatus that are specifically included in BS 1881 : Part 202. Compliance with BS 1881 : Part 202 ensures compliance with ISO/DIS 8045.
ISO/DIS 8046	BS 1881 : Part 207 : 1992 (Related)	ISO/DIS 8046 is still a draft standard and may not be readily available. BS 1881 : Part 207 may be used instead of ISO/DIS 8046 for determination of pull-out strength.

Table II. Relationship between optional references and corresponding British Standards
(concluded)

International standard	Corresponding British Standard	Comments
ISO/DIS 8047	BS 1881 : Part 203 : 1986 (Related)	ISO/DIS 8047 is still a draft standard and may not be readily available. BS 1881 : Part 203 is believed to provide better guidance than ISO/DIS 8047 and should be used instead.
ISO/DP 9812	BS 1881 : Part 105 : 1984 (Related)	ISO/DP 9812 is still a draft proposal and may not be readily available. The method is the same as that in BS 1881 : Part 105 which should be used instead. Compliance with BS 1881 : Part 105 ensures compliance with ISO/DP 9812.
EN 45011 : 1989	BS 7511 : 1989 (Identical)	
EN 45014 : 1989	BS 7514 : 1989 (Identical)	
NOTE. 'Identical' means that the British Standard is identical in every detail with the corresponding international standard. 'Technically equivalent' means that the British Standard is in all technical respects the same as the corresponding international standard; the wording and presentation may differ quite extensively. 'Related' means that the content of the British Standard, to any extent at all short of complete identity or technical equivalence, covers a subject matter similar to that covered by the corresponding international standard.		

3 Definitions

The terms 'purchaser' and 'producer' are not defined in ENV 206 and are indeed not used generally through the text. The terms used are specifier, client, contractor, sub-contractor, manufacturer and user. In many clauses no specific responsibilities are stated. Guidance is given herein wherever difficulties in respect of responsibility are envisaged.

3.1 concrete

In the UK the term mortar should be used for material in which the maximum particle size of the aggregate is 5 mm or less.

3.4 site mixed concrete

The user is not always the same as the body mixing the concrete, e.g. a contractor may mix the concrete before supplying a sub-contractor or specialist.

3.5 ready mixed concrete

Delivery may also be to the purchaser or into a vehicle of the purchaser if, as may sometimes be the case, the purchaser is different from the user.

3.6 normal-weight concrete

The range of densities in ENV 206 is greater than that given in BS 5328 : Part 1 inasmuch as it includes concretes in the range 2600 kg/m³ to 2800 kg/m³.

3.7 light-weight concrete

For the purposes of ENV 206, light-weight concrete is that commonly known in the UK as light-weight

aggregate concrete and does not include other types such as foamed or aerated concrete or no fines concrete, even where light-weight aggregate is used. The density range is the same as that given in BS 5328 : Part 1.

NOTE. See 3.18 of this guide for comments on the definition of light-weight aggregate.

3.8 heavy-weight concrete

The definition of heavy-weight concrete in ENV 206 does not include concretes of densities in the range 2600 kg/m³ to 2800 kg/m³ which are classified as heavy-weight in BS 5328 : Part 1.

3.12 batch

The definition of batch is the same as that in BS 5328 : Part 1.

3.13 delivery

As defined in ENV 206, delivery is the point at which the user, who may also be the purchaser, receives the concrete.

3.14 admixture

This term is used in the same sense as in BS 5328 and BS 8110 : Part 1.

3.15 addition

As defined in ENV 206, this is a generic term for finely divided inorganic material. However, UK practice allows the introduction of some of these materials to replace a proportion of cement in the concrete mix (see 4.1, 4.5 and 5.3 of this guide).

The term 'fly ash' is synonymous with 'pulverized-fuel ash (pfa)'; pfa conforming to BS 3892 : Part 1 : 1982 is classified as a pozzolana. Ground granulated blastfurnace slag (ggbfs) conforming to BS 6699 is classified as a latent hydraulic addition. The following are examples of the classification of materials currently in use within the UK.

- a) *Type 1 additions.* Fly ash conforming to grade B of BS 3892 : Part 2; pigments conforming to BS 1014.
- b) *Type 2 additions.* Fly ash conforming to BS 3892 : Part 1 or grade A of BS 3892 : Part 2; blastfurnace slag conforming to BS 6699; microsilica.

3.17 normal-weight aggregate

The particle density range is the same as that given in BS 8110 : Part 1. Aggregate particle density (in kg/m^3) may be calculated by multiplying the relative density by 1000. The relative density may be determined in accordance with BS 812 : Part 2 instead of ISO 6783 or ISO 7033 as equivalent results are obtained.

3.18 light-weight aggregate

Grains with a porous structure should be taken as meaning particles containing pores, voids or vesicles whether or not they are connected to the surface rendering the particle pervious.

Aggregate particle density (in kg/m^3) may be calculated by multiplying the apparent relative density by 1000. For light-weight aggregate, this method is not equivalent to that in ISO 6783 but is similar to that in ISO 7033.

In the UK, in respect of light-weight aggregate, it is more common to refer to bulk density than particle density, although 6.1.3.1 of BS 8110 : Part 1 : 1985 refers to particle density. The UK definition of light-weight aggregate in BS 6100 : Section 6.3 refers to bulk density and cannot therefore be compared directly with the one in ENV 206.

Some fine aggregates regarded in the UK as light-weight have particle densities greater than 2000 kg/m^3 ; these aggregates should be regarded as normal-weight when using ENV 206.

3.19 heavy-weight aggregate

See 3.17 of this guide on determination of particle density.

In the UK it is more common to refer to bulk density of heavy-weight aggregate than particle density, although 6.1.3.1 of BS 8110 : Part 1 and BS 6100 : Section 6.3 refer to aggregate with a particle density greater than 3000 kg/m^3 .

ENV 206 is not precise in its definition of heavy-weight aggregate because of its use of the expression 'appreciably greater than'. It is recommended that the classification in 6.1.3.1 of BS 8110 : Part 1 : 1985 is used and all aggregates with a particle density greater than 3000 kg/m^3 are considered as heavy-weight.

3.21 effective water content

This is the same as free water content. If some of the aggregates are not in a saturated state at the time of mixing then the effective water content is the quantity of mixing water above that required to saturate the aggregates.

3.22 water/cement ratio

This is the same as free water/cement ratio.

3.25 initial test

An initial test might include a number of individual tests such as measurement of consistence, entrained air content, compressive strength at various ages and resistance to water penetration. Initial tests may be made on concrete from trial mixes or concrete produced through the proposed mixing plant and supplied to a different site.

3.26 entrained air

Where reference is made to a surface active agent, this may be taken as meaning an air-entraining admixture.

3.101 Additional definitions

3.101.1 apparent density

Density of a concrete specimen, at a given moisture content, calculated from its dimensions. This is the same as the as-received density ρ_1 or the saturated density ρ_4 in BS 1881 : Part 114 for cored or cut specimens, depending upon the moisture state of the specimen. Density calculated from the dimensions of cast specimens, ρ_2 or ρ_5 in BS 1881 : Part 114, may also be used provided measured dimensions are used in place of nominal dimensions.

3.101.2 external actions

Generally these are environmental influences which may affect the durability of the concrete or reinforcement.

3.101.3 impermeable concrete

Concrete which conforms to 7.3.1.5 of ENV 206.

3.101.4 internal actions

Influences from within the concrete itself, generally due to its composition, that may affect its durability.

4 Constituent materials

4.1 Cements

All cements and combinations listed in table 1 of BS 5328 : Part 1 : 1991, table 4 of BS 5328 : Part 2 : 1991 and **6.1.2** of BS 8110 : Part 1 : 1985 may be specified in accordance with ENV 206 for both designed and prescribed mixes.

The reference called up by ENV 206 is the June 1988 draft of EN(V) 197. However, this has been superseded by the published ENV 197-1 : 1992 in which the limits on composition differ from those in the June 1988 draft. Nevertheless, the June 1988 draft is the version that should be used with ENV 206. The June 1988 drafts of EN(V) 197-1 and EN(V) 197-2 are reproduced in this guide as annex A and annex B.

NOTE. To avoid confusion between the clauses, tables, figures and footnotes in the annexes and those in this guide and in ENV 206, the clauses, tables, figures and footnotes in the annexes have been renumbered. Thus clause **1** of EN(V) 197-1 appears as **A.1** and table 2 of EN(V) 197-2 appears as table B.2.

4.2 Aggregates

Recommendations for aggregates are given in **3.3** and **4.2.5** of BS 5328 : Part 1 : 1991, clause **11** of BS 5328 : Part 2 : 1991 and **6.1.3** of BS 8110 : Part 1 : 1985.

4.3 Mixing water

Recommendations for mixing water are given in appendix A of BS 3148 : 1980 and **3.7** of BS 5328 : Part 1 : 1991.

4.4 Admixtures

Recommendations for admixtures are given in **3.4** of BS 5328 : Part 1 : 1991 and **6.1.5.2** of BS 8110 : Part 1 : 1985.

4.5 Additions

Requirements for additions are given in BS 3892 : Parts 1 and 2 for pulverized-fuel ash (pfa), BS 6699 for ground granulated blastfurnace slag (ggbfs) and BS 1014 for pigments.

Examples of the classification of materials currently in use in the UK are given in **3.15** of this guide. Other materials may be used as type I additions provided there are satisfactory data on the properties of concrete made with them.

Guidance on the use of ggbfs conforming to BS 6699 or pfa conforming to BS 3892 : Part 1 in concrete is given in **NA.5.3** of DD ENV 206 and **5.3** of this guide.

5 Basic requirements for concrete composition

5.1 General

The purchaser of designed mixes should specify the performance required by using **8.2** of ENV 206 and should ensure that sufficient information is given to

enable the producer to design suitable concrete for the methods used for transporting, placing and compacting the concrete and to permit the concrete to conform to **5.2** to **5.10**, clause **6** and clause **7** of ENV 206.

For prescribed mixes, the purchaser should specify the mix proportions and other requirements in accordance with **8.3** of ENV 206 so that the concrete meets the performance criteria. The purchaser of the fresh concrete should ensure that the specified requirements result in a concrete suitable for the methods used for transporting, placing and compacting the concrete.

Segregation and bleeding of the fresh concrete may be brought about by the subsequent handling of the concrete once it has left the mixer. It should be understood that even well designed concretes segregate and bleed to some extent. The purchaser should inform the producer of any special requirements necessary to minimize segregation and bleeding. There may be occasions when bleeding of the mix may be beneficial to the final properties of the concrete (such as for spun pipes) and the design should take this into account.

A method for determination of bleeding, EN 480-4 is currently in preparation. This test is intended for use in the assessment of admixtures for concrete but is equally applicable to concrete not containing admixtures.

5.2 Structure of concrete

Air content may be measured using the test methods given in ISO 4848 or BS 1881 : Part 106, which are technically similar. Entrained air is not normally present unless an admixture with air-entraining properties has been added. Allowance for the volume of aggregate pores is made by use of the aggregate correction factor determined as part of the test method.

This subclause of ENV 206 relates to concrete in test specimens and not directly to concrete in the structure. A well designed concrete with 20 mm nominal maximum size aggregate can be expected to have an entrapped air content of approximately 1.5 %. Some superplasticizers and some water-reducing admixtures entrain approximately 1 % air.

It is recommended that the requirement for air content forms part of the mix approval procedure and not part of the routine testing.

Footnote 7 of ENV 206 refers to ISO 2736-2 which describes a method of compaction of test specimens by use of a vibrating table with a recommended minimum frequency of 40 Hz, by use of an internal vibrator with a recommended minimum frequency of 120 Hz, and by hand tamping. The suitability of each method as stated in ISO 2736-2 for the various consistence classes of the concrete is given in table III of this guide.

Table III. Method of compaction of test specimens

Consistence class of concrete		Method of compaction		
		Vibrating table	Internal vibrator ¹⁾	Hand tamping
Slump	S1	Yes	No	No
	S2	Yes	Yes	No
	S3	No	No	Yes
	S4	No	No	Yes
Vebe	V0	Yes	No	No
	V1	Yes	No	No
	V2	Yes	Yes	No
	V3	No	No	Yes
	V4	No	No	Yes
Compaction	C0	Yes	No	No
	C1	Yes	No	No
	C2	Yes	Yes	No
	C3	No	No	Yes
Flow ²⁾	F1	Yes	No	No
	F2	Yes	Yes	No
	F3	No	No	Yes
	F4	No	No	Yes

¹⁾ There is little experience in the UK with compaction of test specimens using internal vibrators. Indeed, internal vibration may not be suitable for small specimens such as 100 mm cubes.

²⁾ ISO 2736-2 does not contain recommendations for compaction of test specimens according to flow class. The information in this table is based on relationships between compaction and flow classes derived from the German standard DIN 1045[4].

5.3 Types of cement, cement content and water/cement ratio

Under certain conditions, 4.1 of this guide enables combinations of cement and ggbs or pfa to be classified as cements; they are therefore permitted by 5.3 of ENV 206 to be taken into account for minimum cement content and maximum water/cement ratio. The conditions are as follows.

a) The proportions and properties of the combinations of ggbs or pfa with CE I cement (see table A.1 of this guide) have to conform to EN(V) 197 for CE II, CE III, or CE IV cement. The proportions and properties of the combinations of ggbs or pfa with cement conforming to BS 12 have to conform to clauses 2 to 8 of:

- BS 146 (except 5.3);
- BS 4246 (except 5.2);
- BS 6588 (except 5.3); or
- BS 6610 (except 5.2).

b) The total quantity of CE I cement or cement conforming to BS 12 and ggbs or pfa has to be not less than the minimum cement content specified in table 3 of ENV 206 for a cement conforming to EN(V) 197.

c) The ratio of water to cement plus ggbs or pfa has to be not greater than the value specified in table 3 of ENV 206 for a cement conforming to EN(V) 197.

The permitted or required type of cement or combination should be specified as should the minimum cement content and the maximum water/cement ratio. Types of cement that are known to perform well in the local environment should be specified. These may be selected from those specified in British Standards. If a supplier wishes to use a different cement, he should provide satisfactory data to the purchaser on the properties of the concrete made with that cement.

The values of minimum cement content given in table 3 of ENV 206 are applicable to aggregates of all nominal maximum sizes of 32 mm and below (e.g. 20 mm, 14 mm and 10 mm). No increase in minimum cement content is required for aggregates of 14 mm and 10 mm nominal maximum size. Nevertheless, specifiers should consider increasing the values in table 3 of ENV 206 by 20 kg/m³ for 14 mm and by 40 kg/m³ for 10 mm aggregates in accordance with the recommendations in BS 8110 : Part 1 : 1985. The minimum cement content values in table 3 of ENV 206 should not be reduced for aggregates of 40 mm nominal maximum size.

Where there are special requirements for concrete properties, which cannot be expressed in performance terms, the cement content should be specified.

5.4 Particle size of aggregates

The maximum aggregate size should be specified in accordance with BS 882 : 1983, BS 1047 : 1983 or BS 3797 : 1990 as appropriate.

Advice on the positioning of the reinforcing bars is included in ENV 206 for the information of the designer and is not relevant to the manufacture and supply of concrete.

The smallest dimension should be taken as the smallest major or overall dimension.

The use of aggregates of nominal maximum size greater than the distance between the reinforcing bars or the thickness of the concrete cover is permitted on the basis that few of the actual aggregate particles have a minimum dimension greater than the spacing of the bars or the thickness of the actual concrete cover and are thus unable to pass between the bars. Nonetheless, the UK practice of not using a nominal maximum aggregate size greater than the specified cover should continue.

Guidance on relating the aggregate size to the nominal minimum cover to achieve a good bond and transmit bond forces safely is given in 4.1.3.3 of DD ENV 1992-1-1 : 1992.

5.5 Chloride content of concrete

Recommendations for chloride ion content are given in 4.2.2 of BS 5328 : Part 1 : 1991 and 6.2.5.2 of BS 8110 : Part 1 : 1985. These should be used instead of the values in table 1 of ENV 206. The limit for prestressed concrete in BS 5328 : Part 1 is more onerous than that in ENV 206.

In 6.2.5.2 of BS 8110 : Part 1 : 1985 it is stated that calcium chloride and chloride-based admixtures should never be used in reinforced concrete, prestressed concrete and concrete containing embedded metal.

5.6 Consistence during casting

The purchaser of the fresh concrete is responsible for specifying its consistence class.

No information is available to indicate which Vebe or compaction classes correspond to the recommended slump class S3 or flow class F3.

Concrete of slump class S3 (100 mm to 150 mm) has a consistence that is higher than is generally in current use for vibrated concrete in the UK. Care should be taken that this degree of workability is achieved by mix design in accordance with table 3 of ENV 206, especially with regard to maximum water/cement ratio. Increased workability at a given water/cement ratio or strength grade generally requires the use of higher cement contents or plasticizing admixtures. Significant increases in workability may result in increased formwork pressures but will probably reduce the amount of effort required to achieve compaction. The purchaser should consider the need for additional precautions to minimize bleeding and segregation.

Other measures to be taken when using concrete of consistence less than S3 or F3 include the use of suitable equipment to compact concretes of lower levels of workability.

5.7 Resistance to alkali-silica reaction

General guidance on alkali-silica reaction is given in 4.2.4 of BS 5328 : Part 1 : 1991 and 6.2.5.4 of BS 8110 : Part 1 : 1985. More detailed advice applicable to UK materials is contained in BRE Digest 330 [5] and Concrete Society Technical Report No. 30[6].

5.8 Admixtures

For liquid admixtures in quantities exceeding 3 l/m³ the total amount of admixture should be added to the water content for the calculation of the water/cement ratio.

Admixtures which conform to 4.4 of ENV 206 are permitted in all concretes. Any purchaser wishing to limit the use of admixtures should specify any restrictions to the producer.

5.9 Additions

For the use of pfa conforming to BS 3892 : Part 1 : 1982 and Part 2 : 1984 or ggbs conforming to BS 6699 : 1984 in concrete, see 5.3 of ENV 206, 5.3 of this guide, appendix H of BS 3892 : Part 1 : 1982, appendix B of BS 3892 : Part 2 : 1984, 3.6 and 4.4.3 of BS 5328 : Part 1 : 1991 and 6.1.2 of BS 8110 : Part 1 : 1985. See also 4.5 of this guide.

Examples of the classification of materials currently in use in the UK are given in 3.15 of this guide. Other materials may be used as type I additions provided there are satisfactory data on the properties of concrete made with them.

5.10 Concrete temperature

Temperatures below 5 °C, but above the point where the mix water turns to ice, are not in themselves detrimental to the long-term properties of concrete. Nevertheless, they significantly increase finishing times and formwork pressures, reduce the rate of early strength development and extend the time before formwork can safely be removed. On the other hand, low concrete temperatures reduce the risk of early-age thermal cracking and may increase long-term strength.

Temperatures above 30 °C have the opposite effects. If cubes taken for control purposes are stored for the first day at temperatures above those permitted in ENV 206, the 28 day strength is likely to be reduced.

Temperatures in the permitted range allow a generally adequate period for placing, compacting and finishing the concrete.

6 Requirements for durability

6.1 General

The approach in ENV 206 is different from that in BS 5328 in that the purchaser specifies the exposure class and the producer then complies with the appropriate requirements of ENV 206. Further information is required by ENV 206, however, and information on this is given in clause 8 of ENV 206 and clause 8 of this guide.

It is the responsibility of the purchaser to specify requirements for durability.

6.2 Resistance to environmental actions

6.2.1 Classes of exposure related to environmental conditions

Exposure class is identified in ENV 206 by three elements: the classification (e.g. 2b); the description (e.g. humid environment with frost); and examples (e.g. exterior components exposed to frost). Identification of the appropriate exposure class should be made by reference to the description; the examples should then be checked to ensure that the conditions are not satisfied by a different exposure class.

The exposure classes 1 to 4b in table 2 of ENV 206 cannot be directly related to the exposure classes mild to very severe in table 3.2 of BS 8110 : Part 1 : 1985 although there are obvious similarities.

Guidance on table 2 of ENV 206

Where an aggressive chemical environment occurs in combination with one of the general exposure classes 1 to 4b, the appropriate limitations on mix proportions, and other required properties, should first be determined from table 3 of ENV 206 for the general exposure class. The chemical aggressiveness classification should then be determined, from ISO/DP 9690 and footnote 2 of table 2 of ENV 206, in terms of classes 5a to 5c. The maximum water/cement ratio and minimum cement content for the chemical aggressiveness exposure class should then be determined from table 3 of ENV 206 and compared with that for the general exposure. The lowest maximum water/cement ratio and the highest minimum cement content values should be used. Any additional requirements for minimum air content, frost resistant aggregates or impermeable concrete appropriate to either of the exposure classes should also be complied with.

ENV 206 does not allow for the use of national rules for classification of aggressive environments such as sulfate-bearing soils or water. Nevertheless, it has not been possible to translate the requirements of ISO/DP 9690 into a usable form in the UK as there is insufficient information available on the classification of sulfate-resisting cements. The recommendations

given in 6.2.2 of this guide on table 3 of ENV 206 regarding types of cement for plain and reinforced concrete according to EN(V) 197 should therefore be followed.

ISO/DP 9690 is reproduced as annex C of this guide and is summarized in the following paragraphs. A more detailed consideration of the classification of sulfate-bearing soils and ground waters is given in annex D.

NOTE. To avoid confusion between the clauses, tables, figures and footnotes in the annexes and those in this guide and in ENV 206, the clauses tables, figures and footnotes in the annexes have been renumbered, i.e. clause 1 of ISO/DP 9690 appears as C.1 and annex A of ISO/DP 9690 appears as annex CA.

The definitions of aggressive chemical environments given in ISO/DP 9690 are based on five levels of severity, A1 to A5, and three states, gas, liquid and solid (G, L and S). The classification in table 2 of ENV 206 only uses the levels A1 to A3 (see footnote 2 to table 2). ISO/DP 9690 remains to be finalized and simpler rules for classification of aggressive environments are under consideration for inclusion in EN 206.

ISO/DP 9690 considers exposure conditions in terms of the general description of environment, chemical aggressiveness and climatic actions. The effect of each of these on concrete and on reinforcement is considered. When using ENV 206, only the chemical aggressiveness classifications reproduced in annex CA need be considered.

The classifications are applicable to the following types of aggressiveness.

a) Gaseous:

- carbon dioxide (G CO₂);
- sulfur dioxide (G SO₂);
- hydrogen chloride (G HCl);
- hydrogen sulfide (G H₂S);
- chlorine (G Cl).

b) Liquid (aqueous solution):

- bicarbonate alkalinity, hardness (L HCO₃);
- acids (L pH);
- carbon dioxide, aggressive (L CO₂);
- sulfates (L SO₄);
- magnesium (L Mg);
- ammonium (L NH₄);
- total content of salts in case of an evaporating surface¹⁾ (L S)²⁾;
- chlorides (L Cl).

c) Solid:

- sulfates (S SO₄);
- chlorides (S Cl).

¹⁾ An evaporating surface is one that is open to the air and not further than 1 m from the liquid.

²⁾ The symbol S here denotes total content of salts; care should be taken to avoid confusion as the same symbol is also used to denote sulfur and solid.