

## Lightweight concrete

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### INTRODUCTION

This publication gives guidance on the specification of lightweight aggregate concrete. It should be read in conjunction with the complementary publications in this series, *Concrete for normal uses* and, if relevant, *Concrete resistant to chemical attack*.

BS EN 206–1, *Concrete. Part 1: Specification, performance, production and conformity* is a framework standard. This is a standard where some of the detailed requirements are given in national provisions, i.e. the details of what to specify and certain rules of application are given in a complementary British Standard, BS 8500, *Complementary British Standard to BS EN 206–1*. To help specifiers, producers and users, a derived publication, *Standards for fresh concrete*, has been produced that contains the text of both standards woven together, plus guidance on its use.

Concrete may be specified as either designed concrete or prescribed concrete, each with their respective sub-sets of designated and standardized prescribed concrete. Designed concrete contains a performance requirement for strength. Prescribed concrete only requires the producer to batch the specified quantities of constituent materials and the specifier remains responsible for these proportions achieving any intended performance. The use of prescribed and standardized prescribed concrete for structural applications is not usual, and consequently this publication covers designed concrete only.

For designed concrete, specify that the concrete shall be produced in accordance with the relevant clauses of BS EN 206–1/BS 8500 and also specify the following:

- compressive strength class;
- density class;
- exposure class, concrete designation or limiting values for concrete composition and properties related to exposure class;
- maximum nominal upper aggregate size;
- chloride content class;
- consistence class.

One of a series of publications produced in conjunction with the following organizations, and part-funded by DETR:

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  
Concrete Industry Alliance  
Concrete Society  
Glanville Consultants  
Institute of Concrete Technology  
Ove Arup & Partners  
Quarry Products Association  
Ready-mixed Concrete Bureau  
RMC Readymix Ltd  
L M Scofield Ltd  
United Kingdom Quality Ash Association

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

If there is a requirement to specify properties in addition to those above, consult *Standards for fresh concrete* or 6.2.3 of BS EN 206–1.

Lightweight concrete is not within the scope of designated concretes.

### COMPRESSIVE STRENGTH CLASS

Specify the compressive strength class from Table 1, for example LC30/33. The compressive strength for lightweight concrete is a dual classification comprising the required characteristic cylinder strength followed by the required characteristic strength of 150 mm cubes. The relationship between these values is different from that for normal-weight concrete and to signify that lightweight concrete is being specified, the compressive strength class is preceded by L to distinguish it from normal-weight concrete

When all types of lightweight aggregates are considered, there is a wide variation in the relationship between the strengths of concrete cylinders and cubes. Table 1 gives a safe relationship between the reference cylinder strength and the cube strength. Different values of cube strength may be used if they are established with sufficient accuracy, and are documented (see Table 8 of BS EN 206–1).

**Table 1:** Compressive strength classes for lightweight concretes

Compressive strength class	$f_{ck, cv1}$ N/mm <sup>2</sup>	$f_{ck, cube}$ N/mm <sup>2</sup>
LC 8/9	8	9
LC 12/13	12	13
LC 16/18	16	18
LC 20/22	20	22
LC 25/28	25	28
LC 30/33	30	33
LC 35/38	35	38
LC 40/44	40	44
LC 45/50	45	50

NOTE  
See BS EN 206–1 for higher strength classes and for different values for  $f_{ck, cube}$ .

### DURABILITY

The recommendations in BS 8500 do not differentiate between durability provisions for lightweight concrete and normal-weight concrete.

The minimum compressive strength requirements are given in Table 2.

**Table 2:** Minimum compressive strength class recommendation for different exposure classes

Exposure class <sup>1)</sup>	Minimum compressive strength class
X 0 <sup>2)</sup>	LC 8/9
XC 1 <sup>2)</sup>	LC 20/22
XC 2 <sup>2)</sup>	LC 25/28
XC 3 or 4 <sup>2)</sup>	LC 30/33
XF 1	LC 30/33
XF 2	LC 25/28 <sup>3)</sup>
XF 3	LC 25/28 <sup>3)</sup>
XF 4	LC 30/33 <sup>3)</sup>

NOTES  
1) See BS 8500 for other exposure classes.  
2) See BS 8500–1 for associated minimum covers to reinforcement.  
3) These concretes require entrained air, see BS 8500–2

For the selected exposure class(es), determine from Table 2 the minimum compressive strength class that is required for durability. Try to use this in the structural design as it may give a more cost-effective solution. Alternatively, select a higher compressive strength class based on the structural considerations.

### DENSITY CLASS

The density class is based on oven-dry density to BS EN 12390–7, *Testing hardened concrete. Part 7: Density of hardened concrete*. Alternatively the density may be specified as a target value with a defined method of testing, e.g. saturated to BS EN 12390–7.

Specify a density class of concrete from Table 3 or specify a target value and an appropriate method of testing.

**Table 3:** Lightweight concrete density classes

Density class	Range of oven-dry densities, kg/m <sup>3</sup>
LC 1.0	$\geq 800$ and $\leq 1000$
LC 1.2	$> 1000$ and $\leq 1200$
LC 1.4	$> 1200$ and $\leq 1400$
LC 1.6	$> 1400$ and $\leq 1600$
LC 1.8	$> 1600$ and $\leq 1800$
LC 2.0	$> 1800$ and $\leq 2000$

The density used for the calculation of self-weight in design should be higher than that obtained in the oven-dry test. Guidance on densities for both internal and external design purposes should be sought from the aggregate manufacturer. Values range from 1050 to 2050 kg/m<sup>3</sup> and, where reinforcing or prestressing steel is used, an additional 100 kg/m<sup>3</sup> should be added to the values given for plain concrete.

For production control purposes the density classes should be related to a range of fresh wet densities. The producer will need to determine the relationship between these values. Generally this will be around the target oven-dry density plus, say, 200 kg/m<sup>3</sup>.

There is no general relationship between density and strength classes for different types of lightweight aggregates.

### EXPOSURE CLASSIFICATION

See the complementary publications in this series, *Concrete for normal uses* and, if relevant, *Concrete resistant to chemical attack*.

### NOMINAL UPPER AGGREGATE SIZE

Lightweight aggregates widely available in the UK have a nominal upper aggregate size of 14 mm.

### MAXIMUM CHLORIDE CONTENT

Follow guidance given in *Concrete for normal uses* in this series.

### CONSISTENCE CLASS

Specify the consistence class based on the intended method of placing. Coarse lightweight aggregate used in concrete will absorb water. To avoid problems

associated with significant loss of consistence caused by water absorption between mixing and placing, the consistency at the point of batching may be greater than that specified. For the calculation of the effective water content and the water/cement ratio, the correct method for determining the water absorption of the coarse aggregate is given in 5.4.2 of BS EN 206-1

When lightweight concrete is placed under pressure during handling, e.g. whilst pumping, loss of consistence can occur due to further water absorption by the coarse aggregate. Guidance should be sought from manufacturers of lightweight aggregates regarding the use of admixtures to assist pumping, or on methods of pre-treating aggregate before placing.

The concrete producer shall be informed of the intended method of placing in order that this is taken into account when designing the concrete for consistence.

For lightweight concrete to be placed with a pump, consistence class F5 is normally appropriate.

### SUPPLY

The specification is interpreted by the concrete producer using BS EN 206-1/ BS 8500 to obtain a concrete that satisfies **all** the specified requirements.

To provide a concrete with the specified consistence, strength, density and, where relevant, air content, the producer will select materials available to him that have been identified in BS EN 206-1/BS 8500 as being suitable for the specified concrete designation and that will perform within the specified mix limitations.

The producer will calculate batch quantities that provide the correct yield.

### CONFORMITY AND ACCEPTANCE

General guidance is given in *Concrete for normal uses*. Additionally the producer is required to test the density of lightweight concrete for conformity as frequently as tests for compressive strength.

BS EN 12390-7, recognizes as received, water-saturated and oven-dried concrete states and allows testing for density in each. However, concrete for compressive strength testing must be moist/wet cured to conform to BS EN 12390-2,

*Testing concrete. Part 2: Making and curing specimens for strength tests.* Therefore, concrete producers may elect to measure the wet density as the specimen can then be used for testing compressive strength. For conformity assessment, which in BS EN 206–1 is based on oven-dry density, the producer will have to either convert the wet density to oven-dry density or convert the conformity criteria to equivalent wet density criteria. If the concrete producer is not subject to third-party assessment, the specifier should ask for a copy of the correlation.

NOTE: The two most accurate density measurements are the fresh wet (plastic) density and oven-dry density. Fresh wet density can also be used to check yield, and may be useful to indicate density conformity at an early stage using the correlation between fresh wet density and oven-dry density.

Any identity testing procedures should be agreed prior to supply.

## FURTHER READING

The other publications from this series will be helpful. Visit [www.cementindustry.co.uk](http://www.cementindustry.co.uk) and click ‘information’/‘library’/‘BCA publications’ to check availability and for free download.

*Standards for fresh concrete – a composite of BS EN 206-1 and BS 8500*

*Specifying concrete to BS EN 206–1/BS 8500:*

*Concrete for normal uses*

*Concrete resistant to chemical attack*

*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*

*Guidance on additional requirements for designed concrete*

*Lightweight concrete*

*Visual concrete*

*Coloured concrete*

*Concrete for industrial floors*

*Specifying constituent materials for concrete to BS EN 206-1/BS 8500:*

*Cements*

*Additions*

*Admixtures*

*European replacements for British Standards: Concrete and its constituent materials*

### **Specifying concrete to BS EN 206–1/BS 8500:**

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