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TECHNICAL NOTE 1022
Guidance on the use of MixSim for the design of concrete mixtures when EN 206 is the basis of concrete specification, production and conformity.

From 1 December 2003, the CEN standard EN 206 becomes the basis of concrete specification, production and conformity for CEN members throughout Europe. By the same date, the existing corresponding national standards of CEN members are required to be withdrawn.

EN 206 contains a number of important aspects permitted to be referred to provisions in national standards (which can be expected to differ between countries), e.g. limiting values for durability parameters.

In the UK, for example, the BSI has published BS EN 206-1:2000, being EN 206 in the English language, together with BS 8500-1:2002 and BS 8500-2:2002, being complementary British standards detailing the UK provisions. The current British Standard BS 5328 will be withdrawn.

The design of concrete mixtures is a key part of concrete production and, while EN 206 exerts relatively little influence directly on the design process, it does of course have considerable indirect effect through the requirements for specification and conformity in EN 206 together with the permitted national variations.

Fortunately, the use of MixSim for design is not greatly affected by the adoption of EN206 because most of the various options covered by EN 206 had been incorporated already into MixSim to cater for the very wide range of options needed up to now for specifications worldwide.

Generally.

It has been traditional in different countries for the specified values of some parameters to be absolute minima or maxima, characteristic values, target mean values, tolerances or ranges. EN 206 similarly adopts different approaches for different parameters and in some cases allows alternative approaches for the same parameter to be used for specification purposes.

MixSim adopts the characteristic value approach for strength, the target mean for slump and for air, minimum target mean for cement content and maximum target mean for water/cement ratio. The user of MixSim needs to decide whether to allow additionally for variation taking account of the way in which each parameter has been specified and the consequences of failing to conform.

With regard to the properties of materials, it is always necessary for users of MixSim to ensure that materials selected to be included in designs are permitted by the specifications and that any restrictions on properties of the materials or on concrete made with them are taken into account.

For the use together of EN206 and MixSim there are just a few aspects requiring more specific guidance.

Aggregates

The new series of standard sieve sizes for aggregates for concrete are shown in Table 1

Table 1 Sieve series for coarse and fine aggregates for concrete

Coarse aggregate sieve series (mm)	Fine aggregate sieve series (mm)
80	4
63	2.8
40	2
31.5	1
20	0.5
16	0.25
14	0.125
10	0.063
8	
6.3	
4	

The significance for MixSim relates only to the sieve sets used to calculate the mean sizes of the materials. To modify any of the sets it is necessary only to select the Sieve Sets button on the Materials Database screen and then edit the sieve sizes as necessary. It is recommended to include some sieves outside the nominal limits to allow for undersize and oversize material.

The present MixSim sieve sets (assuming the user has not already made changes) and recommended sets for future use are shown in **Figure 1**

NOTE. Changing the sieve sets for future use will not affect the sieve sets adopted previously for existing materials in the database.

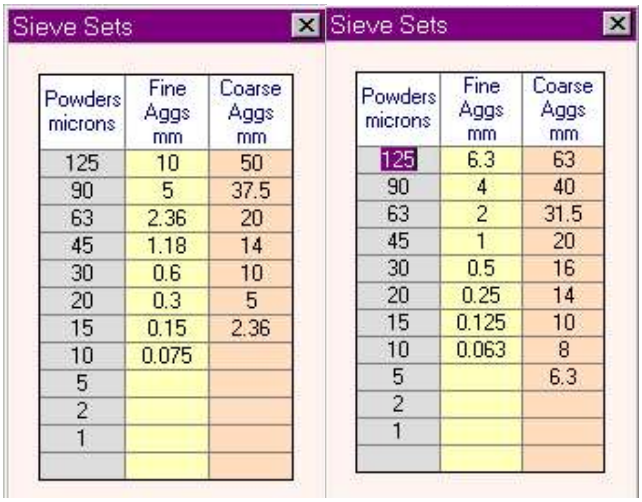

Figure 1 The dropdown screen for the sieve sets used for calculating mean sizes of materials, before and after modification to the right-hand pair of columns to allow for European standardisation of aggregate test sieves

The designations for aggregates have also changed, thus for the UK some examples are shown in .

Table 2 Some examples of aggregate designations by size

Existing designations	New designations
20 mm single size	10/20
10 mm single size	4/10
20-5 graded	4/20
M (medium) sand	0/4 or 0/2

The new designations are established from the nominal lower and upper sieve sizes for the particular aggregates, the lower size being stated first. The effect for MixSim relates only to the descriptions of the aggregates in the Materials Database.

Additions

EN 206 caters for the use of Type 1 (nearly inert) additions and Type 2 (pozzolanic or latent hydraulic) additions.

MixSim allows already for their use taking account of their effects on water demand and strength and on certain restrictions placed upon their use in specifications such as EN 206 for durability, e.g. the proportion (k) of addition in the combination with cement permitted to count towards satisfying specified limits for minimum cement content and maximum water/cement ratio.

EN 206 allows certain additions to be used with corresponding stated maximum k values for durability and also allows national rules to be applied to these and other additions. For example, in the UK, some additions may count fully towards durability provided special tests of the combinations have been made.

MixSim also allows for use of the efficiency (strength factor or k value) of the addition relative to the cement with respect to strength.

Specified values relating to durability are usually safe absolute maxima whereas the k values for strength design should be target mean values determined for specific combinations of additions and cements.

For MixSim, the specified maximum values for durability, expressed as percentages, should be entered in the “percentages permitted to count as cement” whereas for strength the target mean values should be entered in the conditions section, in decimal format, against “strength factors” for additions.

> NOTE. It should also be noted that for strength, factors usually vary with age at test. At present MixSim permits only a single value of strength factor to be entered for each material.
>
> MixSim does not yet include a calculator enabling strength factor for an addition to be calculated from concrete trial data. However, such a calculator, in MS Excel spreadsheet format, may be obtainable from the supplier of MixSim.

Design for workability of fresh concrete

MixSim design is based on selection of a target slump. EN 206 permits specification of target slump but also permits specification by slump class and by other test methods than slump.

The EN 206 slump classes are shown in Table 3 together with recommendations for corresponding design slumps for use in MixSim.

> NOTE. The suggested design slump in the final column is lower than the arithmetic mean value of the range in the middle column to allow for the non-linear relation between slump and water content.

Table 3 EN 206 slump classes

EN206 slump class	EN 206 slump mm	Suggested target slump mm
S1	10-40	20
S2	50-90	65
S3	100-150	120
S4	160-210	180

Where another workability method than slump is specified it is recommended that a relationship between the methods is established so that the corresponding slump may be used in MixSim.

Where the corresponding slump is expected to be outside the normal working range for slump, e.g. below zero slump or above 200 mm slump, it is recommended to make a trial concrete batch, measure the water content at a reference slump, (within the normal working range for slump), and the water content for the chosen workability by the specified method (or to suit the method of compaction) and to calculate the water factor and corresponding design slump using the following formulae.

Water factor $$WF = \frac{Water\ for\ spec\ work'y}{Water\ for\ reference\ slump}$$

Correponding design slump $$Design\ slump = ref\ slump \times \frac{6WF - 5}{7 - 6WF}$$

Example

Reference slump			50 mm
Water for specified or target workability			140 kg/m^3
Water for 50mm slump			180 kg/m^3
Water factor	WF	=	140/180 = 0.78
Design slump	DS	=	50 x (6 x 0.78 – 5)/ (7 – 6x 0.78)
		=	50x (–0.32)/ (2.32)
		=	–7 mm

NOTE. In this case the design slump is negative but can be used successfully within MixSim to design concrete having a lower workability than zero slump, by ensuring the negative sign is included.

Design for air content of fresh concrete.

For non-air entrained concrete, air content is not normally specified but entrapped air always needs to be allowed for in design. MixSim allows the user to input target values for total and entrapped air and this should still be done for EN 206 concrete.

For air entrained concrete, EN 206 specifies minimum total air content and a maximum total air content 4% higher than the specified minimum. Thus, a target mean value of specified minimum plus 2% is implied.

MixSim currently requires input of the target mean value for air, so that for EN 206 the specified minimum air content plus 2% should be entered against total air. The expected mean content of entrapped air (say 0.5 or 1%) included within this total air content should still be entered because the two types of air (entrained and entrapped) in air entrained concrete

affect strength differently. The difference between the two entered values is the entrained air content which is not specified directly in EN 206 but is shown for information in the MixSim entries.

Design for minimum cement content and maximum water/cement ratio.

EN206 requires specification of minimum cement content and maximum water/cement ratio. For conformity, the producer is required to demonstrate from batch records achievement of at least the specified minimum cement content less 10 kg and not more than the specified maximum water/cement ratio plus 0.02.

MixSim currently allows for input of both the specified minimum cement content and the maximum water/cement ratio as limiting target mean values. Thus, the user needs to consider whether, on the basis of past data, it is necessary to include design margins in the input values to take account of the conformity requirements of EN 206.

Design for compressive strength.

EN 206 classifies strength in terms of 28 day characteristic strengths on the basis of cylinders and cubes, e.g. C25/30, where the first number is the strength of a 150 mm dia, 300 mm high cylinder and the second number is the 150 mm cube strength.

> NOTE. The EN206 dual numbering system may be confused with some well established systems which combined the strength with some other feature of the specification, e.g maximum aggregate size. Also , it should not be assumed that by giving both cube and cylinder strength a particular relationship is being assumed for purposes of conversion for mixture design or control. The user will need to establish relationships for different materials and strength levels if it becomes necessary to work with both systems.

MixSim enables the user to adopt either cubes or cylinders as the basis for strength using the option located under the utilities menu. Once adopted, the selection must not be changed and the corresponding strength basis must be maintained for all input data for specified strength, standard deviation and concrete trial strength results.

> NOTE. The strength factors calculator Method 2 operates currently on mortar prisms for cement strength and cubes not cylinders for concrete strength. Method 1 operates on cube strengths. This may be the subject of review for a later version of MixSim.
>
> When the user adopts the utilities option for cylinders, the formulae generated for strength v w/c are adjusted automatically but approximately to allow for the lower strengths compared with concrete cubes.
>
> If the user has data available on cylinder strength v w/c enabling use of method 1 in the strength factors calculator, then the factors displayed for cement strength and for aggregate will also include a factor for cube to cylinder strength conversion. It will then not be necessary to use the utilities option for cylinders and, provided the specified strength, standard deviation and trials data are all entered as cylinder strengths, MixSim will provide designs and data in terms of cylinder strength.

MixSim allows the user to select a strength margin factor and the standard deviation for calculation of the target mean to suit the strength specified and the degree of safety required to take account of the conformity rules for strength and for production control in EN 206. Whether these rules enable a relaxation or a tightening of the margins for use in MixSim will depend on detailed examination of EN206 by the user taking into account current company and national practices, and the rules of quality certification schemes.

> NOTE. The appropriate margin factor and standard deviation for cylinders may well differ from those for cubes.

Design for tensile strength

MixSim provides no direct method for design for tensile strength but MixSim can be used on the basis of compressive strength by first determining the relation between tensile and compressive strength from concrete trials . The relation can be expected to be material sensitive.

References and further reading

BSI	BS EN 206-1:2000	Concrete- Part 1: Specification, performance, production and conformity.
	BS 8500	Concrete- Complementary British Standard to BS EN 206- 1 Part 1: 2002 Method of specifying and guidance for the specifier. Part 2: 2002 Specification for constituent materials and concrete.
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Fig 1 amended, Draft **Rev1** 12 October 2004