EUROPEAN STANDARDISATION

The process of harmonisation of technical standards across Europe is steadily progressing in order to facilitate the Single Market.

CEN is the body responsible at European level for developing and producing standards for the construction sector.

Many European Standards (EN's) are already issued in the construction sector, while many others are reaching the final stages of agreement and ratification. Each National Standards body within CEN must publish all European Standards as national standards, following weighted majority approval at formal vote stage (these are referenced as "I.S. EN's").

Conflicting national standards must be withdrawn by a specified date, usually 6 to 12 months later. In some specific cases there is an extended period, particularly where a group of interrelated standards are involved.

Some of the European Standards are being produced by CEN under formal mandate from the EU Commission in accordance with the Construction Products Directive. These are known as harmonised standards and products produced to these standards will be CE marked.

The first harmonised standard published in the concrete materials sector was EN 197-1 'Common Cements' which was published as I.S. EN 197-1. I.S.1 'Portland Cement' and other cements "on the market" are required to be 'CE marked' with conformity certified to I.S. EN 197-2 'Conformity Criteria'.

In December 2003 I.S. 326 Part 2 "Guide to Specifying Concrete" was withdrawn and replaced by I.S. EN 206-1 Concrete - Part 1: Specification, Performance, Production and Conformity.

At present many standards for other concrete construction products and related test methods are also published with many others due to come forward over the next few years.

In this Technical Commentary, all of the European, Irish and British Standards listed, or referenced, are current at time of printing. However, this situation will change as more EN's are issued and withdrawal dates for national standards occur over the next few years. The NSAI should be consulted for the current status regarding Standards.

1. Cement and Additions

1.1 CEMENT

Cement is composed predominantly of compounds of calcium, silica, alumina and iron which hydrate upon the addition of water to form a strong and durable binder for aggregates in concrete or mortar.

The common cement used in traditional Irish construction has been predominantly Portland Cement Type CEM I. CEM I is a Portland cement (≥ 95% clinker), which can contain 0-5% of a permitted 'minor additional constituent'.

CEM II is defined as a Portland-composite cement, consisting of various sub-types depending on the type and quantity of secondary materials included – notably limestone, pulverised fuel ash or granulated blastfurnace slag. This cement can also contain 0 - 5 % of a permitted 'minor additional constituent.

1.1.2 Additions

Finely divided inorganic, pozzolanic or latent hydraulic material that may be added to concrete in order to improve certain properties or to achieve special properties.

Pulverised fuel ash
The use of coal for electricity production results in the generation of fly ash of different qualities, some of which have pozzolanic properties. The properties of fly ash suitable for use in concrete are specified in I.S. EN 450 and BS 3892 part 1.

Ground granulated blastfurnace slag
Granulated blastfurnace slag is made by the rapid cooling of a slag obtained by smelting iron ore in a blastfurnace. It contains at least two-thirds by mass of glassy slag and possesses hydraulic properties when suitably activated by a Portland cement. Properties of slag suitable for use in concrete are specified in BS 6699 : 1992.

1.1.3 Codes & Standards

I.S. EN 197-1: 2001	Composition, specification & conformity criteria for common cements.
BS 4027: 1996	Sulphate resisting Portland cement.
I.S. EN 450-1 : 2005	Fly ash for concrete.
BS 3892-1 : 1997	Pulverised fuel ash for use with Portland cement).
BS 6699 : 1992	Ground granulated blastfurnace slag for use with Portland cement *(to be withdrawn in 2006).*

1.1.4 Specification

The specification of cement used in concrete is given in I.S. EN 197-1. The concrete specification I.S. EN 206-1 (see section 2.1.2) gives advice on cements suitable for use in concrete in Ireland (see National Annex and Table F1 (IRL)).

1.2 AGGREGATES

1.2.1 General Description

An aggregate is a granular product obtained by processing natural materials. It may be a sand or gravel produced by natural disintegration of rock, or it may be manufactured by passing rock through a series of crushers.

Aggregate sizes are designated in terms of lower (d) and upper (D) sieve sizes expressed as d/D.

1.2.2 Codes & Standards

I.S. EN 12620: 2002	Aggregates for concrete.
S.R. 16: 2004	Guidance on the use of I.S. EN 12620: 2002 Aggregates for concrete.

1.2.3 Specification

The standard outlines the requirements for aggregates to be used in concrete production. The general requirement for aggregates is that they are clean, hard, durable and always derived from sources of proven quality and consistency. Concreting aggregates may be classified as coarse or fine as set out below.

A coarse aggregate is the designation given to the larger aggregate sizes with (D) greater than or equal to 4mm and (d) greater than or equal to 2mm.

Table A - Overall grading limits for coarse aggregate classified by I. S. EN 12620

Sieve Size (mm)	**Percentage by mass passing ISO 565 sieve for coarse aggregate size (d/D)**						
	Graded Aggregates			Single sized aggregates			
	4/40	4/20	4/14	20/40	10/20	6,3/14	4/10
80	100	-	-	100	-	-	-
63	98 to 100	-	-	98 to 100	-	-	-
40	90 to 99	100	-	85 to 99	100	-	-
31.5	-	98 to 100	100	-	98 to 100	100	-
20	25 to 70	90 to 99	98 to 100	0 to 20	85 to 99	98 to 100	100
16	-	-	-	-	-	-	-
14	-	-	90 to 99	-	-	85 to 99	98 to 100
10	-	25 to 70	-	0 to 5	0 to 20	-	85 to 99
8	-	-	25 to 70	-	-	-	-
6.3	-	-	-	-	-	0 to 20	-
4	0 to 15	0 to 15	0 to 15	-	0 to 5	-	0 to 20
2.8	-	-	-	-	-	0 to 5	-
2	0 to 5	0 to 5	0 to 5	-	-	-	0 to 5

Source: S.R.16: 2004 Annex C, Table C.1

A fine aggregate is the designation given to the smaller sized aggregates with (D) less than or equal to 4mm.

Table B: Overall grading limits for fine aggregate classified by I.S. EN 12620

	Percentage by mass passing ISO 565 sieve for fine aggregate size (d/D)				
Sieve Size (mm)	0/4 (CP)	0/4 (MP)	0/2(MP)	0/2(FP)	0/1 (FP)
8	100	100	-	-	-
6.3	95 to 100	95 to 100	-	-	-
4	85 to 99	85 to 99	100	100	-
2,8	-	-	95 to 100	95 to 100	-
2	-	-	85 to 99	85 to 99	100
1	-	-	-	-	85 to 99
0.5	5 to 45	30 to 70	30 to 70	55 to 100	55 to 100

Source: S.R.16: 2004 Annex D, Table D.1

Note: The producer should document and, on request, declare the typical grading to which set tolerances are applied. Also note that the C, M and F designations for coarse, medium and fine are replaced by CP, MP and FP to indicate coarse, medium and fine gradings as before and, that there are choices for the upper size (D) in MP and FP categories i.e. (0/4 or 0/2 and 0/2 or 0/1).

1.3 BUILDING LIME

1.3.1 General Description

Lime is available in the form of dry hydrated lime, or quicklime / lime putty. It is used with Portland cement to improve the workability and water retention of a mortar or render.

1.3.2 Codes & Standards

I.S. EN459-1 *Building Lime – Part 1: Definitions, Specifications and Conformity Criteria.*

The standards specify the requirements for limes used in mortars for masonry and rendering.

1.4 ADMIXTURES

1.4.1 General Description

Admixtures are chemicals which, except in special cases, are added to a concrete or mortar in quantities no larger than 5 percent by mass of cement in order to modify the normal properties of concrete or mortar.

1.4.2 Codes & Standards

I.S. EN 934-2:2001 Admixtures for Concrete and I.S. EN 934-3:2001 Admixtures for Masonry Mortar outline the performance, information, sampling and testing requirements for admixtures to be used with concrete and mortar.

1.4.3 Specification

The following table outlines the most commonly used admixtures in concrete:

Plasticisers	Increase the workability of fresh concrete
Water reducers	Increase the strength of hardened concrete
Superplasticisers	Produce 'flowing' concrete.
Air entraining agents	Improve resistance of hardened concrete to freezing / thawing
Accelerators	Increase early strength of concrete
Retarders	Extend the setting time of the concrete

A broader description is contained in Clause 3 of I.S. EN 934-2:2001.

1.5 WATER

1.5.1 Codes & Standards

I.S. EN 1008:2002 *Mixing water for concrete – Specification for sampling, test and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.*

1.5.2 Specification

Water deemed potable by national regulations is also deemed suitable for making concrete without any further testing.

Other water, such as that recovered from processes in the concrete industry, water from underground sources and natural surface water, may also be used but it must be tested to determine its suitability.

The tests required for these other waters include preliminary assessment, chloride content, sulphate content, alkali content and an assessment of how the chemical composition of the water will effect the setting time and / or the strength development of concrete. In the case of recovered water, there is also a restriction on the amount of solid material contained within it.

2.1 READY MIXED CONCRETE

2.1.1 General Description

Ready mixed concrete is typically a mixture of cement, natural aggregate and water. Most mixes also contain admixtures which are added to the fresh concrete to modify some properties of the fresh or hardened concrete. Other raw materials are occasionally used (e.g. additions such as GGBS, PFA, Silica Fume ; artificial aggregates such as light-weight, heavy-weight ; etc.).

The concrete is supplied in a moist or wet plastic state so that it is capable of being placed and moulded by the user into various shapes or forms prior to setting and hardening into a solid mass.

2.1.2 Codes & Standards

I.S. EN 206-1:2002 *Concrete – Part 1 : Specification, performance, production and conformity (consisting of I.S. EN 206-1:2000 and the Irish national annex).*

Other technical standards and documents should be consulted with respect to structural design, these include IS 326, BS 8110, IS EN 1990. Other European structural design codes are also under preparation at the moment (e.g. IS EN 1992 – Eurocode 2).

2.1.3 Specification

The concrete is required to meet various quality criteria.
These include the following:

- use of suitable raw materials ;
- proper mix design and resulting concrete compositions ;
- adequate strength for structural purposes (and / or as a guarantee that the min. cement and max w/c ratio required for durability purposes is being achieved) ;
- suitable consistence (workability) for the application and method of placement;
- suitable aggregate size for the application ;
- adequate durability to withstand the anticipated exposure conditions ;
- restriction on chloride content ;
- suitable air content where relevant ;
- suitable density where relevant ;
- min. temperature of concrete at delivery ;
- a formal system of production control which includes amongst other matters strict procedures for ensuring that the concrete is in conformity with the specification ;

I.S. EN 206-1 differs in a number of ways from the previous concrete standard specification IS 326.
The following are some of the main differences:

- Strength
- now described as a compressive strength class denoted by the letter C, followed by both the cylinder strength and the cube strength: example – 35N concrete now described as C28/35.
- table C below lists the compressive strength classes that can be specified for normal-weight concrete.
- although cubes will most likely remain as the sole system for making concrete samples in Ireland, both strengths must nevertheless be specified.

- Workability
- now described as a consistence class.
- four methods of specifying and measuring consistence – slump, vebe, compaction and flow denoted by the letter S (slump), V (vebe), C (compaction) or F (flow), followed by a number which indicates the range of consistence values covered by that class: example – where either a 50mm or 75mm nominal slump was previously specified, slump class S2 must now be specified.
- table D below lists the consistence classes that can be specified in the case of slump.
- it should be noted that a nominal slump is no longer specified – a range, as indicated by the consistence class, must be specified.

- Durability
- the conditions affecting durability to which the concrete will be exposed during its design life are now described as exposure classes denoted by the letter X, followed by another letter which indicates the general type of exposure in question.
- the exposure classes are as follows:
  XO - no risk of corrosion or attack
  XC - corrosion induced by carbonation
  XD - corrosion induced by chlorides other than from sea water
  XS - corrosion induced by chlorides from sea water
  XF - freeze / thaw attack with or without de-icing agents
  XA - chemical attack
- each of these exposure classes is then further subdivided by adding a number which generally indicates the severity of the exposure within each class.
- informative examples associating particular locations / situations with particular exposure classes are given in I.S. EN 206-1.
- further such examples (illustrated) are given in "The New Concrete Standards" published jointly by the Irish Concrete Federation and the Irish Concrete Society.

- Limiting Values of Composition

- in order to be durable when subjected to the various exposure conditions, the concrete must be of a certain quality, this is achieved by specifying limiting values for the concrete composition.
- this in effect means specifying the type of cement that must be used, the min. cement content and the max. w/c ratio.
- additionally, as an option, a min. strength class can be specified as assurance that the concrete does, in fact, contain the specified min. cement content and that its w/c ratio does not exceed the specified max w/c ratio.
- the limiting values applying to each exposure class are specified in table F.1. (IRL) in the Irish Annex to I.S. EN 206-1.
- table E below gives the limiting values required by Homebond for various house building applications (for unreinforced concrete only and in non-aggressive soil only).

- Conformity

- conformity with the specified requirements was previously substantially established by site testing by the Contractor / Specifier.
- the establishment of conformity is now the responsibility of the manufacturer.
- the manufacturer must now include a formal declaration of conformity to I.S. EN 206-1 on delivery documentation.
- this declaration can be made only if the manufacturer operates strict production/conformity control procedures as specified in I.S. EN 206-1.
- additionally, manufacturers may underpin their declaration of conformity by submitting their production/conformity control operations to scrutiny by approved independent third party inspection and certification bodies, although this is not obligatory.

TABLE C (from Table 7 (IRL) in Irish National Annex to I.S. EN 206 -1)

Compressive strength class	Min. Char. cylinder strength N/mm²	Min. Char. cube strength N/mm²	Compressive strength class	Min. Char. cylinder strength N/mm²	Min. Char. cube strength N/mm²
C8/10	8	10	C40/50	40	50
C12/15	12	15	C45/55	45	55
C16/20	16	20	C50/60	50	60
C20/25	20	25	C55/67	55	67
C25/30	25	30	C60/75	60	75
C28/35	28	35	C70/85	70	85
C30/37	30	37	C80/95	80	95
C32/40	32	40	C90/105	90	105
C35/45	35	45	C100/115	100	115

TABLE D (from Table 3 in I.S. EN 206-1)

Class	Slump mm
S1	10 to 40
S2	50 to 90
S3	100 to 150
S4	160 to 210
S5 *	≥ 220

* due to lack of sensitivity of the test method beyond certain values of consistence, it is recommended to use the slump test only for slumps ≥ 10mm and ≤ 210mm.

TABLE E (from Table 1 in "Right on the Site", Issue No. 35, Jan 2005 (Homebond))

APPLICATION	Exposure class	Minimum strength class N/mm² (Cylinder / Cube)	Minimum cement content Kg/m³ (see note 1)	Maximum water/ cement ratio	Recommended workability (see table 2)
Lean mix, pipe & kerb bedding, blinding & sub-floors	Not applicable	C 8/**10**	Not applicable	Not applicable	S1
Strip foundations (see note 2)	XO	C 12/**15**	200	0.85	S2 or S3
Ground supported floors	XO	C 16/**20**	200	0.85	S2 or S3
Paths around houses	XO	C 20/**25**	240	0.75	S2 or S3
Reinforced Concrete	Designed by an engineer in accordance with IS EN 206-1 (see note 3)				

Notes:

1. The minimum cement contents shown assume a maximum aggregate size of 20mm.
2. Where sulphates are present or where ground conditions might give rise to damage of concrete the foundations should be designed by an engineer.
3. The engineer appointed must be qualified by examination, be in private practice and possess professional indemnity insurance.
4. Heavily trafficked garages will require C 20/**25** concrete with minimum cement content of 240kg/m³ and water/cement ratio of 0.75 and workability of Slump class S2.
5. Where nominal steel is introduced it is recommended that it be placed at least 75 mm from the bottom and sides of the concrete.

2.2 READY MIXED MORTAR

2.2.1 General Description

Mortar is a mixture of sand, cement, water and lime or admixtures, used as a binder in masonry construction. A pigment may also be added as a specified optional material. Ready mixed mortar is an alternative to batching on site, offering greater reliability and consistency of mixes.

2.2.2 Codes & Standards

I.S. EN 998-2 :2003 *Specification for mortar for masonry – Part 2: masonry mortar.*
I.S. 325 : Part 1: 1986 *Code of practice for use of masonry*
Part 1 : Structural use of unreinforced masonry.
I.S. 325 : Part 2: 1996 *Code of practice for use of masonry*
Part 2 : Masonry construction.

The standards outline the specification, materials, mixing, performance and workmanship requirements of mortar. The design of masonry structures is also covered.

2.2.3 Specification

Mortar designations are set out by I.S.EN 998-2. The principles determining selection of the correct designation are covered in I.S.EN 325 : Part 1.

Table F Mixes suitable for mortar

Mortar Classes		Type of Mortar (Proportion by volume)		
* I.S. EN 998-2	I.S. 406	Designation cement: lime: sand	masonry cement: sand	cement: sand with plasticizer
M12	(i)	1:0 to 0.25:3	-	-
M6	(ii)	1:0.5:4 to 4.5	1:2.5 to 3.5	1:3 to 4
M4	(iii)	1:1:5 to 6	1:4 to 5	1:5 to 6
M2	(iv)	1:2:8 to 9	1:5.5 to 6.5	1:7 to 8

Note: e.g. M12 - M=Mortar, 12= equivalent strength
* these are the nearest equivalent designations under I.S. EN 998-2.

Table G Properties of mortar mixes

Mortar Classes		Compressive strength		Water Retention	Workability	
* I.S. EN 998-2	I.S. 406	7 Day	28 Day		BS 1881	BS 4551
		MPa	MPa	%	mm	%
M12	(i)	>7.3	>11.0	>88	<550	<135
M6	(ii)	>3.0	>4.5	>89	<550	<135
M4	(iii)	>1.7	>2.5	>90	<550	<135
M2	(iv)	>0.7	>1.0	>91	<540	<130

Note: e.g. M12 - M=Mortar, 12= equivalent strength
* these are the nearest equivalent designations under I.S. EN 998-2.

Table H Mortar Classes Table

Class	M1	M2,5	M5	M10	M15	M20	Md
Compressive strength N/mm^2	1	2,5	5	10	15	20	d
d is a compressive strength greater than 25 N/mm2 declared by the manufacturer.							

The classes given in Table H are those listed in I.S. EN 998-2. However, these classes are unlikely to be specified until the full introduction of I.S. EN 1996 (Eurocode 6).

For designed mortars the compressive strength of masonry mortar shall be declared by the manufacturer. The manufacturer may declare the compressive strength class in accordance with Table H, where the compressive strength is designated by an "M" followed by the compressive strength class in N/mm^2, which it exceeds.

When the masonry mortar is sampled from a consignment in accordance with EN 1015-2 and tested in accordance with EN 1015-11 the compressive strength shall no be less than the declared compressive strength or the declared compressive strength class. It shall be declared if the air-lime content calculated as calcium hydroxide $Ca(OH)^2$ is equal to or higher than 50% of the total amount of binder mass.

Ready mixed mortar may be supplied in a number of forms:

Sand / lime for mortar	A factory mixed combination of lime, sand and water with cement added on site as required.
Trowel ready mortar	A mortar which has been factory mixed and supplied ready for use.
Dry mortar	A factory mixed combination of sand, cement, lime or plasticiser with water added on site as required.

2.3 READY MIXED RENDER

2.3.1 General Description

Render is a mixture of sand, cement, water and lime or admixtures, used as a finish to masonry construction. A pigment may be added as a specified optional material. Ready mixed render is an alternative to batching on site offering greater reliability and consistency of mixes.

2.3.2 Codes & Standards

I.S. EN 998-1:2003	*Specification for mortar for masonry. Rendering and plastering mortar.*
I.S. EN 13914-1:2005	*Design, preparation and application of external rendering and internal plastering. External rendering.*
I.S. EN 13914-2:2005	*Design, preparation and application of external rendering and internal plastering. Design considerations and essential principles for internal plastering.*
BS 5262:1991	*Code of Practice for external renderings.*
BS 5492:1990	*Code of Practice for internal renderings.*

The standards outline the design, materials and workmanship requirements of cement based renders or plasters. The principles governing the design of render specifications are also covered.

2.3.3 Specification

The information given hereunder is taken from BS 5262:1991 and reflects current practice in Ireland.

The following tables outline render specification details for areas subject to various conditions of exposure. The standard should be consulted for other factors involved in the choice of rendering mix.

Smooth backgrounds or backgrounds providing inferior adhesion may be prepared with a scud coat of 2 : 1 Sand : Cement thrown to a thickness of 2 to 3 mm. An S.B.R. latex may be added to the mix to aid bonding.

Table 1 Mixes suitable for rendering

Render designation	Mix Proportions by volume based on damp sand			
	Cement:Lime:Sand	Cement:Sand (with plasticiser)	Ready Mixed Lime:Sand	Cement:Ready Mixed Material
(i)	1 : $^1/_4$: 3	-	1 : 12	1 : 3
(ii)	1 : $^1/_2$: 4 to 4$^1/_2$	1 : 3 to 4	1 : 9	1 : 4 to 4$^1/_2$
(iii)	1 : 1 : 5 to 6	1 : 5 to 6	1 : 6	1 : 5 to 6
(iv)	1 : 2 : 8 to 9	1 : 7 to 8	1 : 4$^1/_2$	1 : 8 to 9
(v)	1 : 3 : 10 to 12	-	1 : 4	1 : 10 to 12

Source: BS5262 : 1991. Code of practice for external renderings

Table J Recommended rendering specifications for moderate or sheltered exposure

Background	Undercoat		Final coat		
	Designation	Thickness mm	Finish	Type	Mix
Strong to moderate	(ii)	8 - 12	Thrown	Roughcast Buttercoat Tyrolean	1:1:3:2* (iii) (ii)
	(iii)	8 - 12	Trowel applied	Woodfloat Scraped Patterned Tooled	(iv) (iv) (iv) (iv)
Metal lathing	Two undercoats as for severe exposure		Thrown	Roughcast Buttercoat Tyrolean	1:1:3:2* (iii) (ii)
			Trowel applied	Woodfloat Scraped Patterned Tooled	(iv) (iv) (iv) (iv)
Moderate to weak	(iii)	8 - 12	Thrown	Roughcast Buttercoat Tyrolean	1:1:3:2* (iii) (ii)
	(iv)	8 - 12	Trowel applied	Woodfloat Scraped Patterned Tooled	(iv) (iv) (iv) (iv)
Weak (sheltered)	(iv) or (v)	8 - 12	Trowel applied	Woodfloat Patterned	(v) (v)

* Mix consists of Cement : Lime : Sand : Coarse aggregate.
Note 1: The nominal overall thickness is normally not less than 16mm

Source: BS5262 : 1991. Code of practice for external renderings

Table K Recommended rendering specifications for severe exposure

Background	First undercoat		Second undercoat		Final coat	
	Designation	Thickness mm	Designation	Thickness	Type	Mix
Strong to moderate	(ii)	8 - 12	(ii)	6 - 10	Roughcast Buttercoat Tyrolean	1:$^1/_2$:3:1$^1/_2$* (ii) (ii)
Metal lathing	(i)	3 - 6	(ii)	10 - 14	Roughcast Buttercoat Tyrolean	1:$^1/_2$:3:1$^1/_2$* (ii) (ii)
Moderate to weak	(iii)	8 - 12	(iii)	6 - 10	Roughcast Buttercoat Tyrolean	1:1:4:2* (iii) (ii)

* Mix consists of Cement : Lime : Sand : Coarse Aggregate
Note 1: The nominal overall thickness of the render is normally not less than 20mm
Note 2 : For severe exposure, it is preferred that the finish be thrown or rough textured

Source: BS5262 : 1991. Code of practice for external renderings

2.4 READY MIXED DASHING

2.4.1 General Description

Ready mixed dashing is a mixture of coarse aggregate, sand, cement, lime and water, applied as a final coat of render where a roughcast finish is required. The ratio of coarse aggregate to sand in a dashing may be adjusted in order to achieve various surface textures.

Ready mixed dashing is an alternative to batching a roughcast mix on site. Refer to Tables I and J of Section 2.3 (Ready Mixed Render) for specification of mixes.

2.5 INFORMATION ON USE OF READY MIXED MATERIALS

2.5.1 Workmanship and Performance

The long term performance of ready mixed materials will depend both on the quality of the supplied materials and also on the standards of workmanship during construction. Good methods of mixing, placing, compaction, finishing, curing etc. are therefore necessary for good long term strength and durability of a hardened concrete, render or mortar.

2.5.2 Health and Safety

Repeated skin contact with wet cement over a period may cause dermatitis. The abrasiveness of the other constituents in a concrete or mortar mix can aggravate the effect. Suitable protective clothing is therefore necessary when working with fresh cementitious materials. Any material coming into contact with skin should be washed off immediately with clean water. Reference should be made to the health and safety recommendations of the supplier before commencing work.