Specifying Sustainable Concrete to BS 8500

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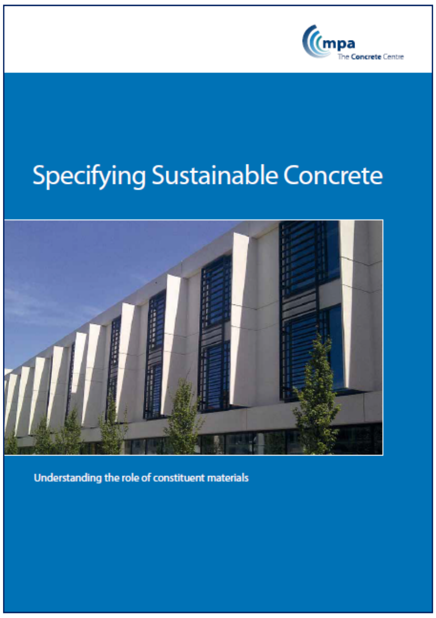


Guidance for concrete specification including:

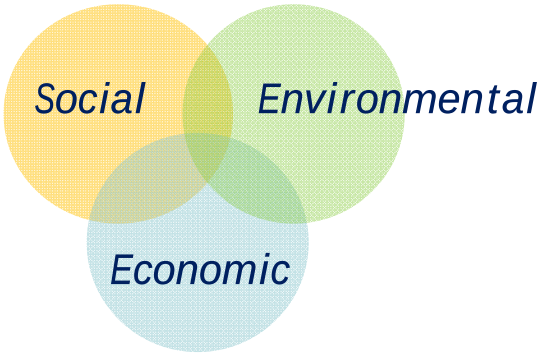
- Reduction of ECO_2
- Use of recycled content
- Responsible sourcing
- Material efficiency

www.concretecentre.com/publications

Sustainability

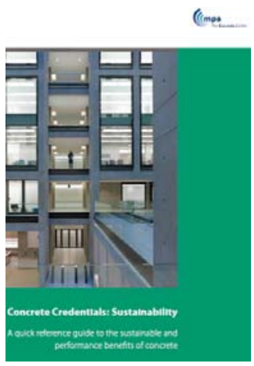
Sustainable development:

'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'



Performance benefits of concrete

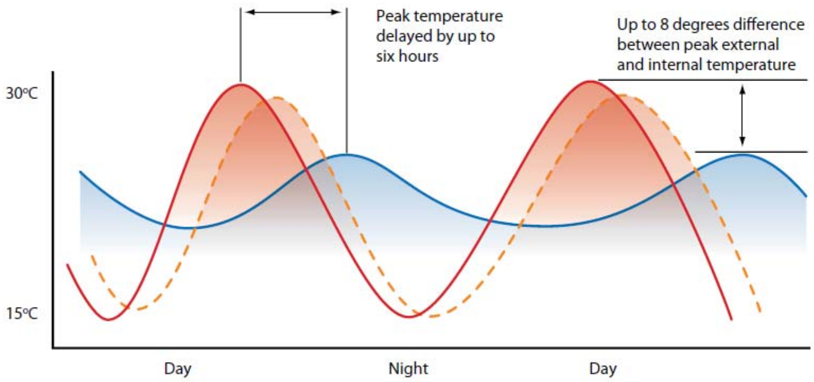
	Social	Economic	Environmental
Fire	✓	✓	✓
Acoustics	✓	✓	✓
Flooding	✓	✓	✓
Robustness	✓	✓	✓
Thermal Mass	✓	✓	✓
Durability	✓	✓	✓

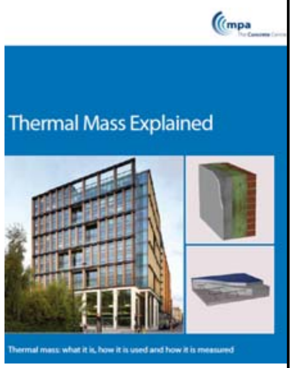


....structural performance taken as read

Thermal mass to reduce $OpCO_2$

- Concrete has very useful role in energy efficient design strategies
- Use of thermal mass and night-time cooling to reduce energy loads necessary for heating and cooling



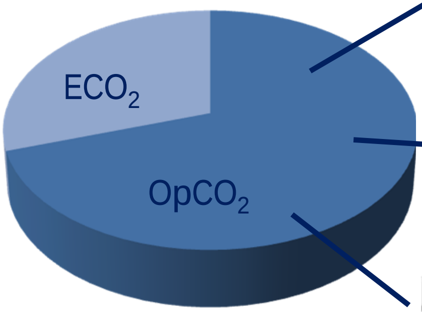


- Concrete on the inside
- Exposed soffit with night time ventilation to enhance passive cooling
- Exposed (or painted concrete) surface optimises thermal mass effect

Whole life CO_2

- Operational CO_2 + Embodied CO_2

(Ratio depends on building type and life span)



EU carbon reduction plan:

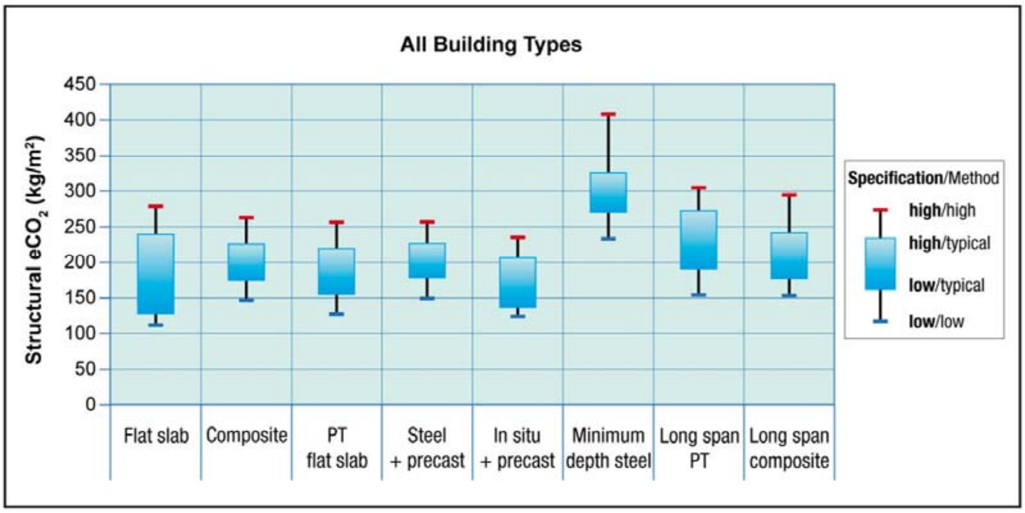
20% cut in emissions by 2020 compared to 1990

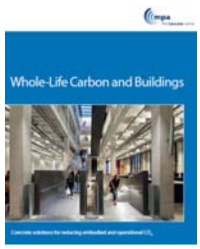
Energy Performance of Buildings Directive (EPBD)

By 2020 all new buildings are 'nearly zero-energy'

UK - Part L1A (2013) and SAP

Embodied CO_2





Research by Arup

Specifying concrete to BS8500

Exposure classification

XC: Corrosion induced by carbonation

XD: Corrosion induced by chlorides

XS: Corrosion induced by chlorides from sea

XF: Freeze-thaw attack

AC: Chemical attack

Exposure classification

XC: Corrosion induced by carbonation

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XF: Freeze-thaw attack

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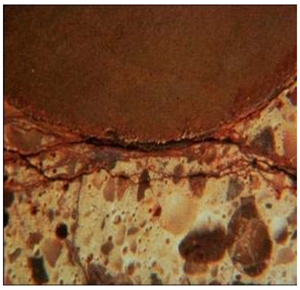


Exposure classification

XC: Corrosion induced by carbonation

- **XC1**: Dry or permanently wet
- **XC2**: Wet, rarely dry
- **XC3**: Moderate humidity
- **XC4**: Cyclic wet and dry

XD: Corrosion induced by chlorides

XS: Corrosion induced by chlorides from sea

XF: Freeze-thaw attack

AC: Chemical attack

Exposure classification

XC: Corrosion induced by carbonation

XD: Corrosion induced by chlorides

- **XD1: Moderate humidity**
- **XD2: Wet, rarely dry**
- **XD3: Cyclic wet and dry**

XS: Corrosion induced by chlorides from sea

XF: Freeze-thaw attack

AC: Chemical attack

Exposure classification

XC: Corrosion induced by carbonation

XD: Corrosion induced by chlorides

XS: Corrosion induced by chlorides from sea

- **XS1: Exposed to airborne salt**
- **XS2: Permanently submerged**
- **XS3: Tidal, splash and spray zones**

XF: Freeze-thaw attack

AC: Chemical attack

Exposure classification

XC: Corrosion induced by carbonation

XD: Corrosion induced by chlorides

XS: Corrosion induced by chlorides from sea

XF: Freeze-thaw attack ➡

AC: Chemical attack

XF1: Moderate water saturation
(no de-icing agent)
XF2: Moderate water saturation
(de-icing agent)
XF3: High water saturation,
(no de-icing agent)
XF4: High water saturation
(de-icing agent)

Exposure classification

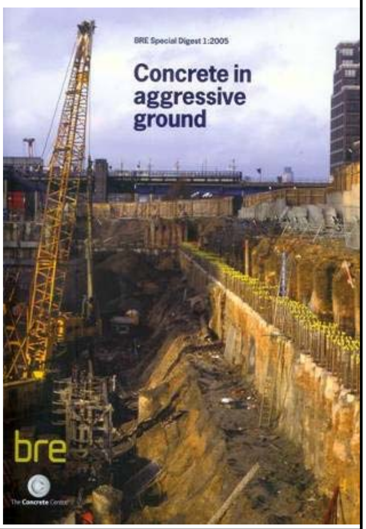
XC: Corrosion induced by carbonation

XD: Corrosion induced by chlorides

XS: Corrosion induced by chlorides from sea

XF: Freeze-thaw attack

AC: Chemical attack ➡



Methods of Specifying Concrete
BS 8500-1: 2015

a) **Designated concrete**

b) **Designed concrete**

c) **Prescribed concrete**

d) **Standardized prescribed concrete**

e) **Proprietary concrete**

Designated Concretes

Simple and reliable form of specification, widely used.

Specified by giving the designated name:

- FND
- GEN
- RC
- PAV

Designated Concretes

Basic specification requirements

- Concrete designation
- Max. aggregate size
- Consistence class

Designated Concretes

Basic specification requirements

- Concrete designation
- Max. aggregate size
- Consistence class

Other?

- Restriction / relaxation of cement type
- Special aggregate requirements

Designated Concrete

BS 8500-2: 2015 (Table 5)

Concrete designation	Min. strength class	Slump class A)	Max. w/c ratio	Min. cement or combination content (kg/m^3) for max. aggregate size (mm)				Cement and combination types
				≥40	20	14	10	
GEN0	C6/8	S3	—	120	120	120	120	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN1	C8/10	S3	—	180	180	180	180	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN2	C12/15	S3	—	200	200	200	200	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
GEN3	C16/20	S3	—	220	220	220	220	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
RC20/25	C20/25	S3	0.70	240	240	260	280	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V
RC25/30	C25/30	S3	0.65	240	260	280	300	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)
RC28/35	C28/35	S3	0.60	260	280	300	320	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)
RC30/37	C30/37	S3	0.55	280	300	320	340	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)
RC32/40	C32/40	S3	0.55	280	300	320	340	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)
RC35/45	C35/45	S3	0.50	300	320	340	360	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)
RC40/50	C40/50	S3	0.45	320	340	360	360	CEM I, IIA, IIB-S, IIB-V, IIIA, IVB-V B)

Designed Concretes

- Permits flexibility
- Suitable for most applications
- Strength, allowable cement types; water/cement ratios; use of recycled or secondary aggregates are specified

Designed Concrete

Basic Specification Requirements

- Strength class
- Max. W/C ratio
- Cement type and min. content
- Max. aggregate size
- Consistence class
- Chloride class
- Density class

Designed Concrete

Additional Specification Options

- Aggregate type, including use of recycled aggregate
- Fibres if used
- Air entrainment
- Temperature of the fresh concrete
- Heat development during hydration

Concrete constituents

Reinforcement

Admixture

Approx. proportions of A typical concrete mix

Specifying concrete - tips

1. Specify low carbon cements

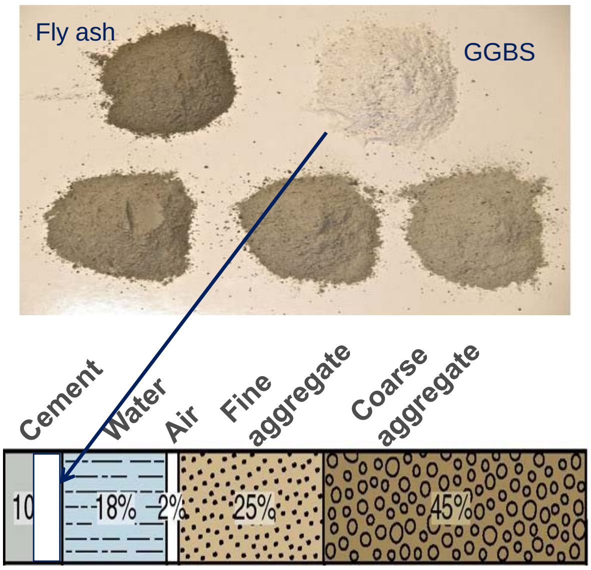
- Portland cement contributes the majority of ECO_2 to concrete
- Carbon footprint of cement production has reduced by 55% since 1990.
- Use of cement replacements can reduce ECO_2 further eg: GGBS, fly ash

Concrete mix - ECO_2 of constituents

Material		Embodied CO_2 (kg / tonne)
Portland cement, CEM I		913
Addition or cement constituent	Ground granulated blastfurnace slag (ggbs)	67
	Fly ash	4
	Limestone	75
Aggregate		5
Reinforcement		427

Ref: Table 5: Embodied CO_2 for main constituents of reinforced concrete
Specifying Sustainable Concrete, The Concrete Centre, 2017

Define cements and combinations



Approx. gen mix by volume

CEM	Addition	Portland cement replacement, %
I	~	0 - 5
IIA	Silica fume	6 - 10
	Fly ash	6 - 20
IIB-V	Fly ash	21 - 35
IVB-V		36 - 55
IIB-S	GGBS	21 - 35
IIIA		36 - 65
IIIB		66 - 80

Based on BS 8500-1

Embodied CO_2 of concrete

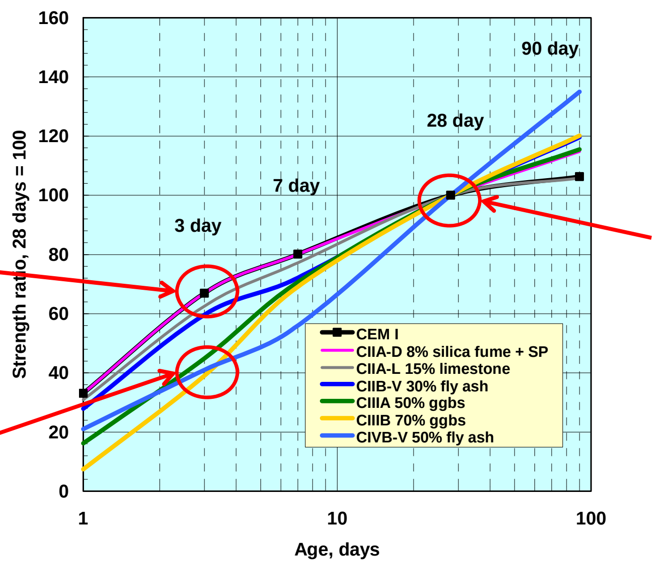
Cement type	Strength class	CO_2 (kg/T)
CEM I	C32/40	153
CEM IIB-V (30% fly ash)		130
CEM IIIA (50% GGBS)		97

40% less CO_2 than CEM I

Strength Development

CEM I at 3 days

70% GGBS and 30% FA at 3 days



Same strength at 28 days

Sustainability specification tips for cement in concrete

1. Generally <40% GGBS for concrete soffits (unless programme can accommodate)

2. Maximise cementitious additions in footings or other locations where striking times are less critical. (e.g. ICF construction)

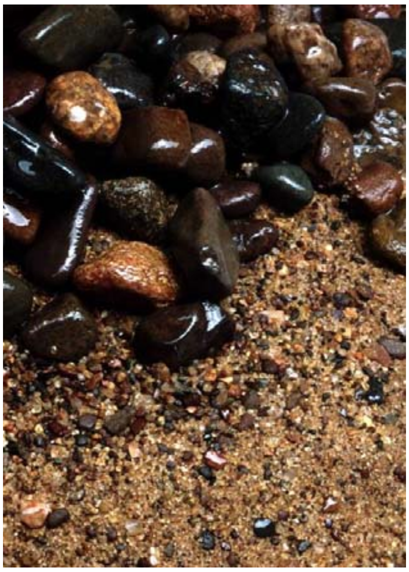
3. Allow some flexibility of % content for contractor to tailor mix to suit site conditions

Specifying Concrete - tips

2. Consider recycled or secondary aggregates

(if available locally or using low carbon transport)

Low carbon natural aggregates



- Inherently low carbon
- Mostly naturally occurring, local resource
- Potential self-sufficiency in UK aggregates for many thousands of years
- Recycled aggregates transported more than 15km by road are likely to have higher ECO_2 content than local primary aggregates

Use of recycled aggregates

- Recycled aggregates (RA) are already efficiently used e.g. as hardcore or in landscaping
- Very little (effectively none) goes into landfill
- Approx. a third of all aggregate in UK is recycled or secondary aggregate (three times more than the European average)
- Consistency of supply and source material are necessary for use in concrete
- Testing regimes for quality control is more rigorous than for natural/primary aggregates

as brown roofs

in gabions

to create landscape

Coarse crushed concrete aggregate (CCA)

Crushed concrete used as aggregate: a form of RA with maximum 5% masonry content

An in-situ crusher producing CCA
(From NF45 The use of recycled materials in residential NHBC Foundation)

- Fewer restrictions on use in concrete than RA
- Up to 20% is permitted to be supplied in 'Designated' reinforced concrete
- 100% coarse CCA possible in:
  - Lower grade concretes (GEN0, GEN1, GEN2, GEN3)
  - Strength classes up to C40/50 in exposure classes X0, XC1, XC2, XC3,XC4, XF1 & DC-1 (but are rarely supplied)

All RA tend to require more cement, change the mix relationships and add an element of risk

Secondary aggregates

Derived from by-products of other quarrying operations or industrial processes

- Recognised secondary aggregates available for concrete include:
  - China clay waste (known as stent aggregate, or granite aggregate and sands)
  - Fly ash (lightweight aggregate)
  - Air cooled blast-furnace slag aggregate
- Typically greater % in concrete possible than RA. Use depends upon properties of the aggregate.

Sustainable concrete specification tips for aggregates

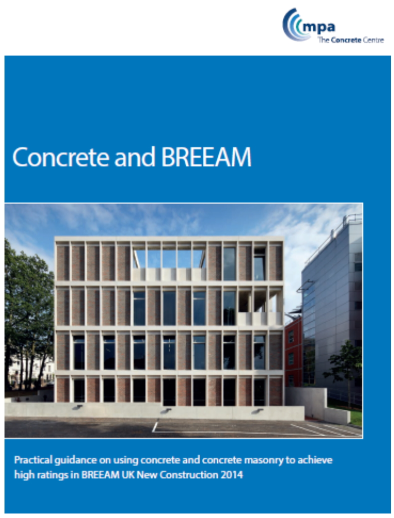
1. Consider recycled or secondary aggregates, depending on:
    - Availability
    - Type of aggregate
    - Use of concrete
    - Local supply or low carbon transportation
    - Don't rule out primary (virgin aggregates)

Specifying Concrete - tips

3. Specify responsible sourced concrete (BES 6001)

BES 6001
Responsible Sourcing
www.greenbooklive.com

- Concrete is the leading construction material for responsible sourcing
- Around 90% all concrete production is BES 6001 accredited



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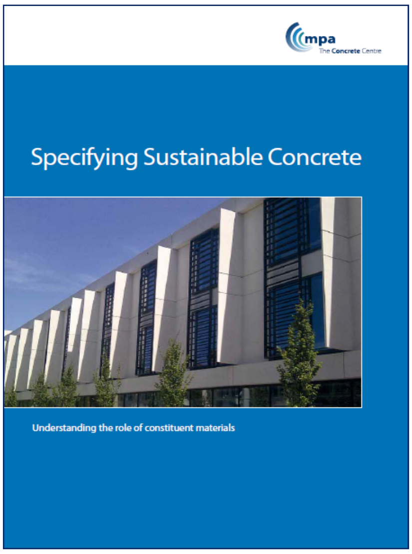

2015 Publications

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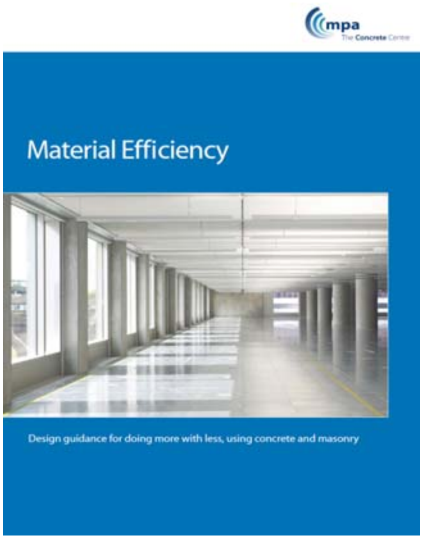

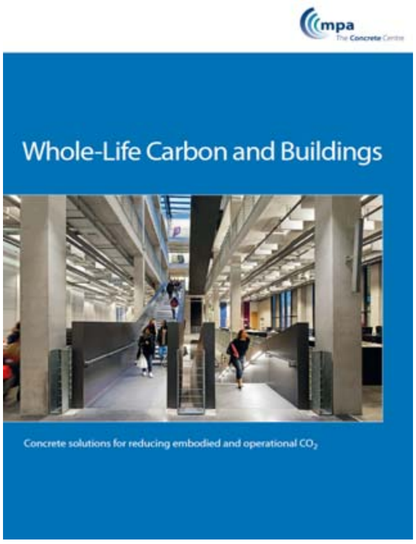

2016 Publications

Concrete is a local material

- Local manufacture and locally sourced raw materials
- Average delivery distance of ready-mixed concrete is less than 12km

Many quarries have on-site rail terminals enabling direct access to the rail network.

Sustainable concrete summary specification tips

When using BS 8500:

1. Specify low carbon cements
2. Consider recycled or secondary aggregates (if available locally or using low carbon transport)
3. Specify responsible sourced concrete (BES 6001)

Thank you

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