



# SPECIFYING 60 YEARS DESIGN LIFE

## FOR PRECAST CONCRETE WALLING AND CLADDING SYSTEMS

The current 'Eurocode 0' offers indicative design working lives for structures. For permanent building structures, there are two main categories relevant to precast concrete wall and cladding systems.

These are:

- Category 4 'Building structures and other common structures': 50 years
- Category 5 'Monumental building structures, bridges and other civil engineering structures': 100 years.

The British Standard for Concrete, BS 8500, Part 1 Annex A provides guidance for the specifier for the nominal cover to reinforcement, concrete compressive strength class, maximum w/c ratio and minimum cement content for intended working lives of at least 50 years and at least 100 years. This guidance may be applied to precast walling and cladding elements. Many building projects in the UK still prefer to specify a design life of 60 years in line with previous versions of BS 7543, *Guide to durability of buildings and building elements, products and components*.

The slight disparity between the standard 50 years design life and a 60-year design life for walling, or precast cladding, elements may be dealt with by one of the following options. The options consider XC3 exposure, but the principles can be applied to any exposure. XC3 was chosen in the worked examples as most relevant to architectural and structural elements used in buildings in 'normal' conditions. Where exposure conditions vary greater cover depths may be required.

**Option I: Use 50 years (based on Table A.4 of BS 8500-1)**

A precast walling or cladding element's reinforcement cover depth can be determined by using BS 8500-1: 2015 + A1: 2016 Annex A, Table A.4 "Durability recommendations for reinforced or prestressed elements with an intended working life of at least 50 years". Based on Table A.4, for XC3 exposure a **minimum 20mm** cover to reinforcement is recommended using a CEM I concrete to achieve an intended working life of at least 50

years. It should be acknowledged that the BS 8500-1 guidance tables are largely empirically based and as there are inherent variations in actual exposure and construction processes then the difference between the cover required for 50 and 60 years intended working life may not be significant in practical terms.

**Option II: Use 100 years (based on Table A.5 of BS 8500-1)**

A designer may opt for the conservative option by designing the reinforcement cover to a 100 years durability requirement using BS 8500-1: 2015+A1:2016 Annex A, Table A.5 "Durability recommendations for reinforced or prestressed elements with an intended working life of at least 100 years". Based on Table A.4, concrete produced to XC3 exposure, with CEM I cement, needs a minimum reinforcement cover of **30mm** to achieve a 100 years' intended working life.

As noted above, this would be a conservative option and can be considered too onerous for quality concrete products manufactured, and cured, under controlled factory conditions.

Nominal cover mm	Compressive strength class, maximum w/c ratio and minimum cement or combination content for normal-weight concrete with 20mm maximum aggregate size											Cement/combination types
	15 + Δc	20 + Δc	25 + Δc	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	60 + Δc	70 + Δc	80 + Δc	
Corrosion induced by carbonation (XC exposure classes)												
XC1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All in Table A.6
XC2	-	-	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6
XC3/4	-	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6 except IVB-V
	-	-	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB-V
Corrosion induced by chlorides other than sea water (XD exposure classes) adequate for any associated carbonation induced corrosion (XC)												
XD1	-	-	C40/50 0.45 360	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All in Table A.6
XD2	-	-	-	C40/50 0.40 380	C32/40 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB-S CEM I-SR0, CEM I-SR3
	-	-	-	C35/45 0.40 380	C28/35 0.55 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA
	-	-	-	C32/40 0.40 380	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIIB, IVB-V
XD3	-	-	-	-	-	C45/55 0.35 380	C45/55 0.40 380	C45/55 0.45 380	C45/55 0.45 380	C45/55 0.45 380	C45/55 0.45 380	CEM I, IIA, IIB-S CEM I-SR0, CEM I-SR3
	-	-	-	-	-	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C28/35 0.50 340	C28/35 0.50 340	C28/35 0.50 340	IIB-V, IIIA
	-	-	-	-	-	C32/40 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	IIIB, IVB-V

Figure 1. Minimum cover for a concrete product with 50 years' service life (BS 8500-1, Table A.4).

Nominal cover mm	Compressive strength class, maximum w/c ratio and minimum cement or combination content for normal-weight concrete with 20mm maximum aggregate size											Cement/combination types		
	15 + Δc	20 + Δc	25 + Δc	30 + Δc	35 + Δc	40 + Δc	45 + Δc	50 + Δc	55 + Δc	60 + Δc	70 + Δc		80 + Δc	
Corrosion induced by carbonation (XC exposure classes)														
XC1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All in Table A.6		
XC2	-	-	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6		
XC3/4	-	-	-	C40/50 0.45 340	C35/45 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All in Table A.6 except IVB-V		
	-	-	-	-	C40/50 0.45 340	C35/45 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB-V		
Corrosion induced by chlorides other than sea water (XD exposure classes) adequate for any associated carbonation induced corrosion (XC)														
XD1	-	-	-	C45/55 0.40 380	C40/50 0.45 360	C35/35 0.50 340	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All in Table A.6		
XD2	-	-	-	-	-	C35/45 <sup>f)</sup> 0.45 360	C32/40 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB-S CEM I-SR0, CEM I-SR3		
	-	-	-	-	-	C32/40 <sup>f)</sup> 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB-V, IIIA		
	-	-	-	-	-	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIIB, IVB-V		
XD3	-	-	-	-	-	-	-	-	-	C45/55 <sup>f)</sup> 0.35 <sup>g)</sup> 380	C40/50 <sup>f)</sup> 0.40 380	C35/45 <sup>f)</sup> 0.45 360	C35/45 <sup>f)</sup> 0.45 360	CEM I, IIA, IIB-S CEM I-SR0, CEM I-SR3
	-	-	-	-	-	-	-	-	-	C40/50 <sup>f)</sup> 0.35 380	C35/45 <sup>f)</sup> 0.40 380	C28/35 0.45 360	C28/35 0.50 340	IIB-V, IIIA
	-	-	-	-	-	-	-	-	-	C32/40 <sup>f)</sup> 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.55 320	IIIB, IVB-V

Figure 2. Minimum cover for a concrete product with 100 years' service life (BS 8500-1, Table A.5).

### Option III: Extrapolate to 60 years (Using a square root relationship & Table A.4, BS 8500-1)

This option utilises the square root relationship which the ingress of carbonation and chloride may be approximated to, expressed thus:

$$D = k \times t^{0.5}$$

D	The depth of carbonation or chloride ingress – where this may be assumed to equal the minimum cover
k	Coefficient
t	Time

Table A.4 of BS 8500-1 could be assumed to apply for 50 years, and from this the depth required for 60 years is calculated:

$$20 \text{ mm} = k \times 50^{0.5}$$

$$K = 2.8 \text{ mm/year}^{0.5}$$

So, for 60 years using the same concrete, the minimum cover will need to be:

$$D = 2.8 \times 60^{0.5} = \mathbf{22 \text{ mm}}$$

As concrete cover spacers are normally manufactured in 5mm steps the practical implication of Option III is that the minimum cover is increased by 5mm from that in Option I. It can be demonstrated through the methodology in Option III that adding 5mm to the minimum cover required by BS8500 for a design life of 50 years will be conservative for a design life of 60 years, when the minimum cover for 50 years is 50mm or less.

## Conclusions

Any of the three options for reinforcement cover determination may be used but the selection should be confirmed by the designer. Option III is a safe technical justification. Option III permits leaner, lighter and potentially less expensive cladding units compared to the more conservative Option II.

It is important to remember that cover depth for exposure classes other than XC3 will differ.

The choice should be agreed on a project-by-project basis. All implications associated with units' depth, geometry, weight and cost will need to be accounted for fully.

## References

- BSI (2019) **BS 8500-1:2015+A2:2019**, Concrete – Complementary British Standard to BS EN 206, Methods of specifying and guidance for the specifier. BSI, 2016.