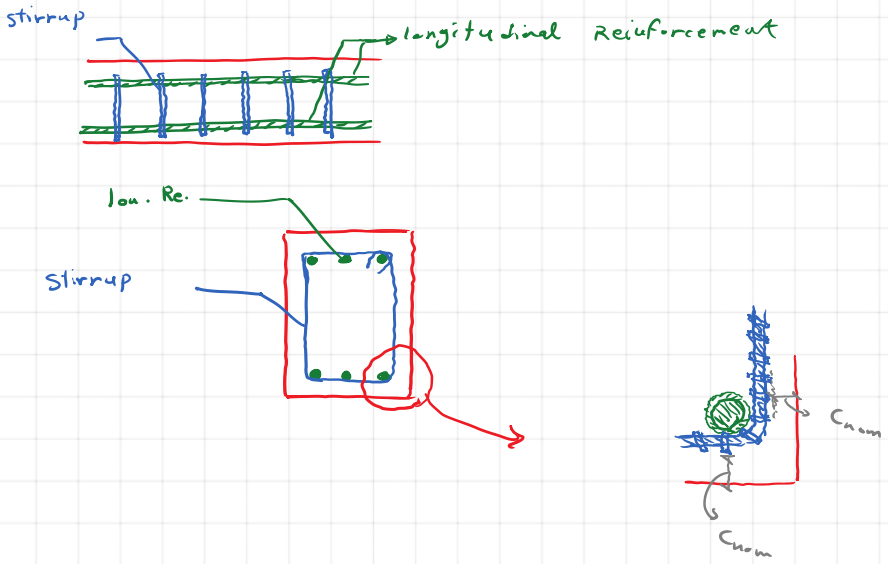
This video will teach us how to determine the nominal cover of the concrete element according to Eurocode 1992-1-1. Exposure class, Structural class in concrete structures will be discussed, as the required clauses and tables. Also, one example of the nominal cover calculation is provided.

The example of the video:

A beam reinforced by T25 as longitudinal reinforcement is supposed to be used in a swimming pool. The working life of the structure is agreed to be 100 years, and the concrete class is C40/50. If special quality control is ensured, what is the required nominal cover?



SECTION 4 DURABILITY AND COVER TO REINFORCEMENT

4.1 General

(1)P A durable structure shall meet the requirements of serviceability, strength and stability throughout its design working life, without significant loss of utility or excessive unforeseen maintenance (for general requirements see also EN 1990).

(2)P The required protection of the structure shall be established by considering its intended use, design working life (see EN 1990), maintenance programme and actions.

4.2 Environmental conditions

(1)P Exposure conditions are chemical and physical conditions to which the structure is exposed in addition to the mechanical actions.

(2) Environmental conditions are classified according to Table 4.1, based on EN 206-1.

Table 4.1: Exposure classes related to environmental conditions in accordance with EN 206-1

Class designation	Description of the environment	Informative examples where exposure classes may occur
1 No risk of corrosion or attack		
X0	For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack For concrete with reinforcement or embedded metal: very dry	Concrete inside buildings with very low air humidity
2 Corrosion induced by carbonation		
XC1	Dry or permanently wet	Concrete inside buildings with low air humidity Concrete permanently submerged in water
XC2	Wet, rarely dry	Concrete surfaces subject to long-term water contact Many foundations
XC3	Moderate humidity	Concrete inside buildings with moderate or high air humidity External concrete sheltered from rain
XC4	Cyclic wet and dry	Concrete surfaces subject to water contact, not within exposure class XC2
3 Corrosion induced by chlorides		
XD1	Moderate humidity	Concrete surfaces exposed to airborne chlorides
XD2	Wet, rarely dry	Swimming pools Concrete components exposed to industrial waters containing chlorides
XD3	Cyclic wet and dry	Parts of bridges exposed to spray containing chlorides Pavements Car park slabs

4.4 Methods of verification

4.4.1 Concrete cover

4.4.1.1 General

(1)P The concrete cover is the distance between the surface of the reinforcement closest to the nearest concrete surface (including links and stirrups and surface reinforcement where relevant) and the nearest concrete surface.

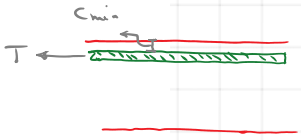
(2)P The nominal cover shall be specified on the drawings. It is defined as a minimum cover, c_{min} (see 4.4.1.2), plus an allowance in design for deviation, Δc_{dev} (see 4.4.1.3):

$$c_{nom} = c_{min} + \Delta c_{dev} \quad (4.1)$$

4.4.1.2 Minimum cover, c_{min}

(1)P Minimum concrete cover, c_{min}, shall be provided in order to ensure:

- the safe transmission of bond forces (see also Sections 7 and 8)
- the protection of the steel against corrosion (durability)
- an adequate fire resistance (see EN 1992-1-2)



(2)P The greater value for c_{min} satisfying the requirements for both bond and environmental conditions shall be used.

$$c_{min} = \max \{c_{min,b};\ c_{min,dur} + \Delta c_{dur,\gamma} - \Delta c_{dur,st} - \Delta c_{dur,add};\ 10\ mm\} \quad (4.2)$$

where:

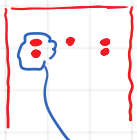
- $c_{min,b}$ minimum cover due to bond requirement, see 4.4.1.2 (3)
- $c_{min,dur}$ minimum cover due to environmental conditions, see 4.4.1.2 (5)
- $\Delta c_{dur,\gamma}$ additive safety element, see 4.4.1.2 (6)
- $\Delta c_{dur,st}$ reduction of minimum cover for use of stainless steel, see 4.4.1.2 (7)
- $\Delta c_{dur,add}$ reduction of minimum cover for use of additional protection, see 4.4.1.2 (8)

$C_{min} = \max\{C_{min,b}, C_{min,dur}, 10mm\}$

(3) In order to transmit bond forces safely and to ensure adequate compaction of the concrete, the minimum cover should not be less than $c_{min,b}$ given in table 4.2.

Table 4.2: Minimum cover, $c_{min,b}$, requirements with regard to bond

Bond Requirement	
Arrangement of bars	Minimum cover $c_{min,b}$*
Separated	Diameter of bar
Bundled	Equivalent diameter (ϕ_n)(see 8.9.1)
*: If the nominal maximum aggregate size is greater than 32 mm, $c_{min,b}$ should be increased by 5 mm.	



(5) The minimum cover values for reinforcement and prestressing tendons in normal weight concrete taking account of the exposure classes and the structural classes is given by $c_{min,dur}$.

Note: Structural classification and values of $c_{min,dur}$ for use in a Country may be found in its National Annex. The recommended Structural Class (design working life of 50 years) is S4 for the indicative concrete strengths given in Annex E and the recommended modifications to the structural class is given in Table 4.3N. The recommended minimum Structural Class is S1.

The recommended values of $c_{min,dur}$ are given in Table 4.4N (reinforcing steel) and Table 4.5N (prestressing steel).

Table 4.3N: Recommended structural classification

Structural Class							
Criterion	**Exposure Class according to Table 4.1**						
	X0	XC1	XC2 / XC3	XC4	XD1	XD2 / XS1	XD3 / XS2 / XS3
Design Working Life of 100 years	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2	increase class by 2
Strength Class [1) 2)]	≥ C30/37 reduce class by 1	≥ C30/37 reduce class by 1	≥ C35/45 reduce class by 1	≥ C40/50 reduce class by 1	≥ C40/50 reduce class by 1	≥ C40/50 reduce class by 1	≥ C45/55 reduce class by 1
Member with slab geometry (position of reinforcement not affected by construction process)	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1
Special Quality Control of the concrete production ensured	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1	reduce class by 1

Example: foundation, structure roof, C35/45, beam, No special Q.C.

↳ XC2, S4 → S6 → S5 → S5

Table 4.4N: Values of minimum cover, $c_{min,dur}$, requirements with regard to durability for reinforcement steel in accordance with EN 10080.

Environmental Requirement for $c_{min,dur}$ (mm)							
Structural Class	Exposure Class according to Table 4.1						
	X0	XC1	XC2 / XC3	XC4	XD1 / XS1	XD2 / XS2	XD3 / XS3
S1	10	10	10	15	20	25	30
S2	10	10	15	20	25	30	35
S3	10	10	20	25	30	35	40
S4	10	15	25	30	35	40	45
S5	15	20	30	35	40	45	50
S6	20	25	35	40	45	50	55

For our example : S5 , XC 2 $C_{min,dur} = 30$ mm

(11) For uneven surfaces (e.g. exposed aggregate) the minimum cover should be increased by at least 5 mm.

$C_{min} = max\{ C_{min,b} , C_{min,dur} , 10\,mm \}$

$C_{nom} = C_{min} + \Delta C_{dev}$

4.4.1.3 Allowance in design for deviation

(1)P To calculate the nominal cover, c_{nom}, an addition to the minimum cover shall be made in design to allow for the deviation (Δc_{dev}). The required minimum cover shall be increased by the absolute value of the accepted negative deviation.

Note: The value of Δc_{dev} for use in a Country may be found in its National Annex. The recommended value is 10 mm.

(4) For concrete cast against uneven surfaces, the minimum cover should generally be increased by allowing larger deviations in design. The increase should comply with the difference caused by the unevenness, but the minimum cover should be at least k_1 mm for concrete cast against prepared ground (including blinding) and k_2 mm for concrete cast directly against soil. The cover to the reinforcement for any surface feature, such as ribbed finishes or exposed aggregate, should also be increased to take account of the uneven surface (see 4.4.1.2 (11)).

Note: The values of k_1 and k_2 for use in a Country may be found in its National Annex. The recommended values are 40 mm and 75 mm.

Suppose a concrete beam is designed for a swimming pool with working life of 100 years. The concrete class is going to be C40/50 and special quality control is ensured. The available reinforcement is T25. What is the required nominal cover?

Beam, Swimming pool, 100 years, C40/50, Special Q.C, T25

Swimming pool → XD2 ← T4.1

$C_{min\,b} = d_b = 25\,mm$, ← T4.2

Structural class → S4 + 2 − 1 − 1 → (S4) ← T4.3 N

$C_{min,dur} = 35\,mm$ ← T4.4 N

$$C_{min} = \max\{C_{min,b}, C_{min,dur}, 10\,mm\} = \max\{25\,mm, 35\,mm, 10\,mm\} = 35\,mm$$

$$C_{nom} = C_{min} + \Delta C_{dev} = 35\,mm + 10\,mm = 45\,mm$$