# Durability & Cover Requirements:

## a brief summary

according to EN1992-1-1 (EC2): §4

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# Environmental Conditions

**4.2 Environmental Conditions**

(2) Environmental conditions are classified according to Table 4.1

**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<br>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<br>Concrete permanently submerged in water |
| XC2 | Wet, rarely dry | Concrete surfaces subject to long-term water contact<br>Many foundations |
| XC3 | Moderate humidity | Concrete inside buildings with moderate or high air humidity<br>External concrete sheltered from rain |
| XC4 | Cyclic wet and dry | Concrete surfaces subject to water contact, not within exposure class XC2 |

# Environmental Conditions

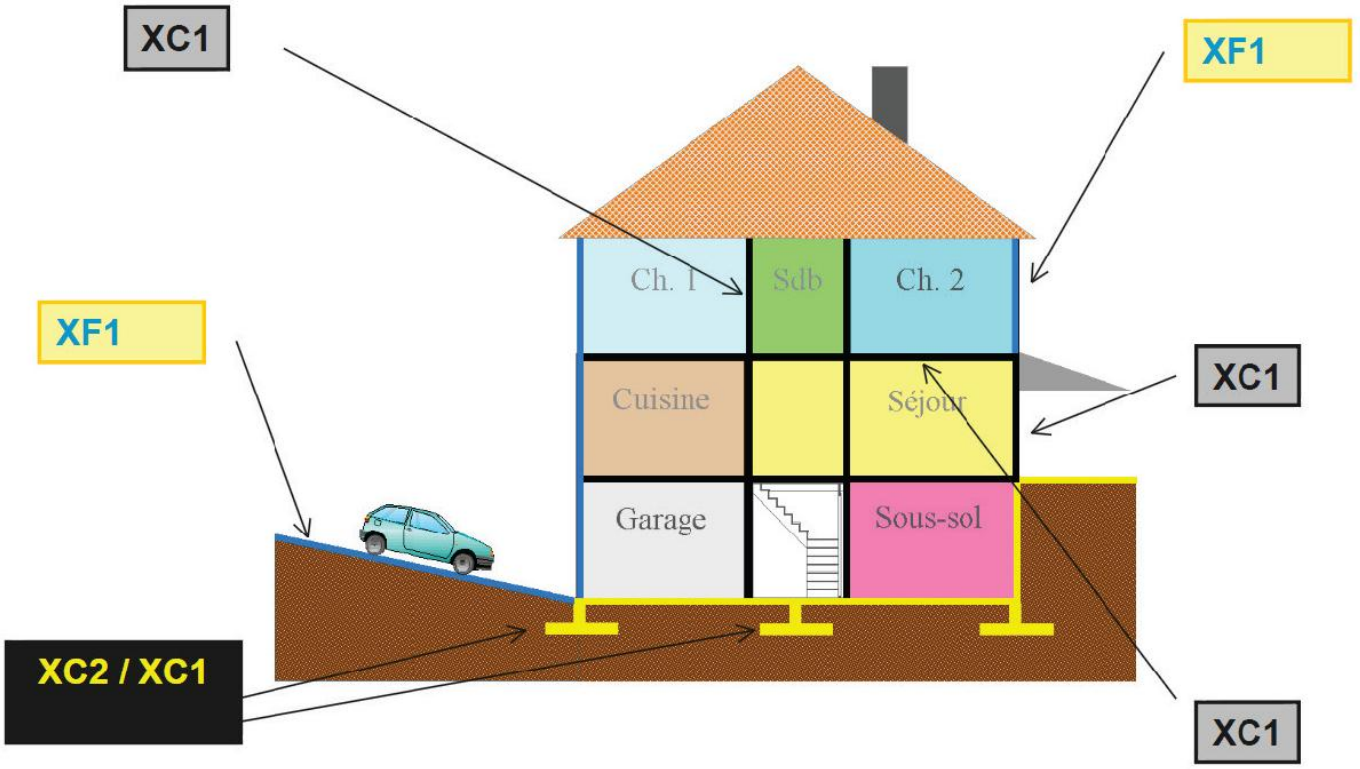
**Table 4.1: Exposure classes related to environmental conditions in accordance with EN 206-1**

| | | |
|---|---|---|
| **3 Corrosion induced by chlorides** | | |
| XD1 | Moderate humidity | Concrete surfaces exposed to airborne chlorides |
| XD2 | Wet, rarely dry | Swimming pools<br>Concrete components exposed to industrial waters containing chlorides |
| XD3 | Cyclic wet and dry | Parts of bridges exposed to spray containing chlorides<br>Pavements<br>Car park slabs |
| **4 Corrosion induced by chlorides from sea water** | | |
| XS1 | Exposed to airborne salt but not in direct contact with sea water | Structures near to or on the coast |
| XS2 | Permanently submerged | Parts of marine structures |
| XS3 | Tidal, splash and spray zones | Parts of marine structures |
| **5. Freeze/Thaw Attack** | | |
| XF1 | Moderate water saturation, without de-icing agent | Vertical concrete surfaces exposed to rain and freezing |
| XF2 | Moderate water saturation, with de-icing agent | Vertical concrete surfaces of road structures exposed to freezing and airborne de-icing agents |
| XF3 | High water saturation, without de-icing agents | Horizontal concrete surfaces exposed to rain and freezing |
| XF4 | High water saturation with de-icing agents or sea water | Road and bridge decks exposed to de-icing agents<br>Concrete surfaces exposed to direct spray containing de-icing agents and freezing<br>Splash zone of marine structures exposed to freezing |

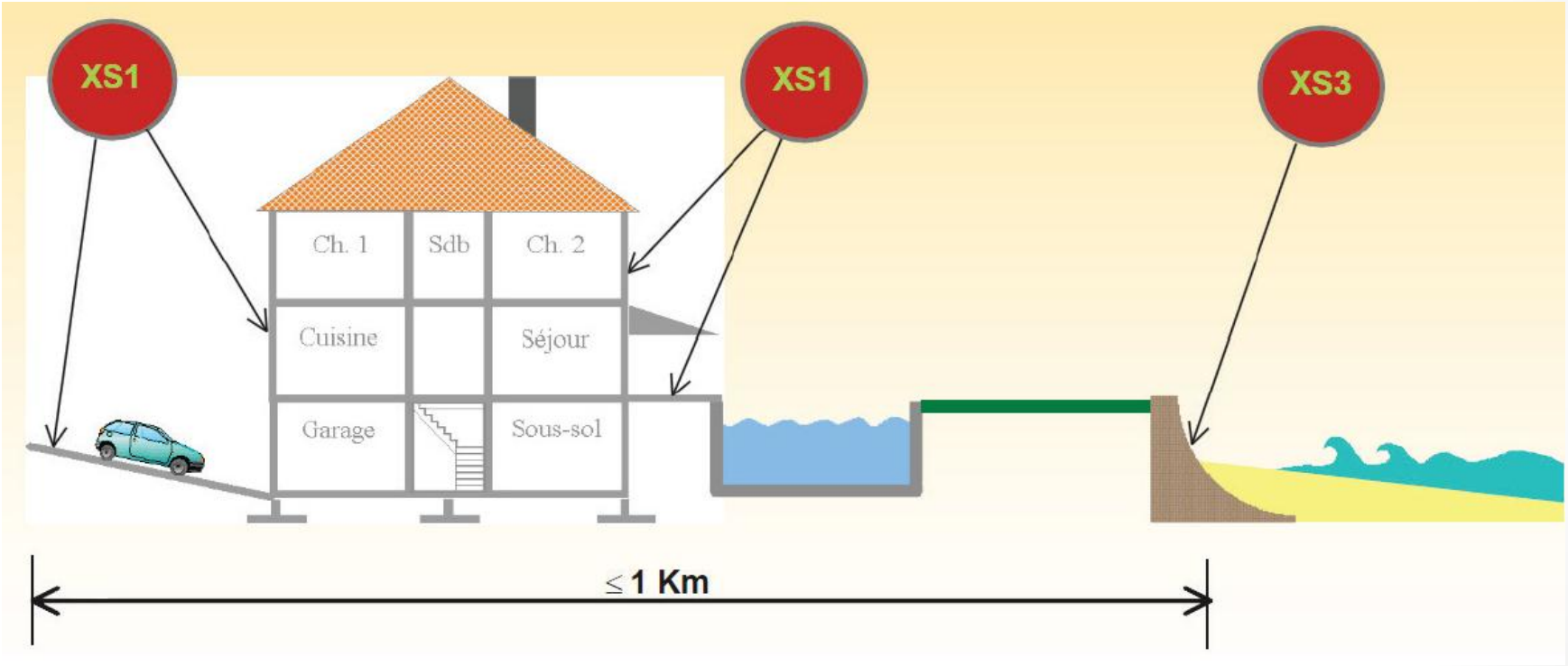
# Environmental Conditions

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

| | | |
|---|---|---|
| **6. Chemical attack** | | |
| XA1 | Slightly aggressive chemical environment according to EN 206-1, Table 2 | Natural soils and ground water |
| XA2 | Moderately aggressive chemical environment according to EN 206-1, Table 2 | Natural soils and ground water |
| XA3 | Highly aggressive chemical environment according to EN 206-1, Table 2 | Natural soils and ground water |



# Environmental Conditions



# Concrete Cover : EC2 §4.4.1

### 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).

(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, $\Delta c_{dev}$ (see 4.4.1.3):

$$\mathbf{c_{nom} = c_{min} + \Delta c_{dev}}$$

### 4.4.1.2 Minimum cover, $c_{min}$

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

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

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) |

# Concrete Cover : EC2 §4.4.1

(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 ($\phi_n$)(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).

# Concrete Cover : EC2 §4.4.1

**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 |

**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 |

# Concrete Cover : EC2 §4.4.1

**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 ($\Delta c_{dev}$). The required minimum cover shall be increased by the absolute value of the accepted negative deviation.

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

References:

1. Eurocodes | EN1992-1-1 : General Rules & Rules for Buildings §4

2. Graphical Representations of Exposure Classes Related to Environmental Conditions taken from seminar “Eurocodes & Basic Requirements” held on 03 & 10 of March 2012, Cyprus : Presentation by Dr. Loizos Papaloizou

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