CHAPTER 3

ACTIONS

Article 9. Classification of actions

The actions to be taken into consideration for the design of a structure or a structural component shall be those laid down by specific legislation in force, or, in the absence of this, by those indicated in this Code.

Actions may be classified according to their nature into direct actions (loads) and indirect actions (imposed strains).

Actions may be classified in accordance with their variation in time into Permanent Actions (G), Permanent Actions of a Non-Constant Value (G*), Variable Actions (Q) and Accidental Actions (A).

Article 10. Characteristic values of actions

10.1 General

The characteristic value of an action may be determined by an average value, a nominal value, or, in the cases laid down by means of statistical criteria, by a value corresponding to a determined probability of not being exceeded during a reference period, which takes account of the working life of the structure and the duration of action. The characteristic values of actions are those laid down in specific applicable legislation.

10.2 Characteristic values of permanent actions

For permanent actions in which significant dispersals are anticipated, or those which may have a certain variation during the period of service of the structure, the upper and lower characteristic values shall be taken. Otherwise, a single value may be adopted.

Generally speaking, for the weight of the structure itself, a single value determined from the nominal dimensions and the specific average weights shall be adopted as the characteristic action. For concrete elements the following densities shall be taken:

Plain concrete:	2300 kg/m^3	if $f_{ck} \leq 50$ N/mm^2
	2400 kg/m^3	if $f_{ck} > 50$ N/mm^2
Reinforced and prestressed concrete:	2500 kg/m^3	

10.3 Characteristic values of permanent actions of a non-constant value

For the determination of the rheological actions, values corresponding to the creep and shrinkage strains laid down in Article 39 shall be considered to be the characteristic values.

10.4 Characteristic values of prestressing action

10.4.1 General considerations

In general, actions due to prestressing in a structural element are determined from the prestressing forces of the tendons making up its active reinforcement. These actions vary along its path and over time.

In each tendon, by means of the jack or tensioning device used, a force, called the tensioning force, is applied, which at the outlet of the anchorage, at the side of the concrete, takes on a value of P_0, which shall be limited by the values laid down in 20.2.1.

In each section, the instantaneous losses of force ΔPi and the deferred losses of force ΔP_{dif} are calculated in accordance with 20.2.2 and 20.2.3. The characteristic value of the prestressing force P_k in each section and temporary phase is calculated from the values P_0, ΔP_i and ΔP_{dif} in accordance with 10.4.2.

10.4.2 Characteristic value of the prestressing force

The characteristic value of the prestressing force in a section and any phase is:

$$P_k = P_0 - \Delta P_i - \Delta P_{dif}$$

Article 11. Representative values of actions

The representative value of an action is the value thereof used for the checking of the Limit States.

A single action may have one or several representative values.

The representative value of an action is obtained by applying a factor Ψ_i to its characteristic value F_k.

$$\Psi_i F_k$$

The values indicated in specific applicable legislation shall be taken as the representative values of actions.

Article 12. Design values of actions

A design value of an action is defined as that obtained as the result of a partial safety factor multiplied by the representative value referred to in Article 11.

$$F_d = \gamma_f \Psi_i F_k$$

where:

F_d Design value of the action F.

y_f Partial safety factor for the considered action.

12.1 Ultimate Limit States

The values laid down in Table 12.1.a are adopted as partial safety factors for the actions for the Ultimate Limit State checks, provided that the corresponding specific legislation applicable to actions does not lay down other criteria.

In general, for permanent actions, the obtaining of the favourable or unfavourable effect thereof shall be determined weighing up all actions of the same origin with the same factor indicated in Table 12.1.a.

When the results of a check are very sensitive to variations in the magnitude of the permanent action, from one part to another in the structure, the favourable and unfavourable parts of this action shall be considered as individual actions. This shall apply in particular to the checking of the Equilibrium Limit State in which, for the favourable part, a factor γ_G = 0.9 shall

be adopted and for the unfavourable part a factor γ_G = 1.1 shall be adopted, for persistent situations, or γ_G = 0.95 for the favourable part and γ_G = 1.05 for the unfavourable part for temporary situations in the construction phase.

For the assessment of the local prestressing effects (anchorage areas, etc.) a force equivalent to the ultimate characteristic force thereof shall be applied to the tendons, obtained by multiplying the area of the tendon by the maximum unit load of the tendon without affecting the partial safety factor for the steel.

Table 12.1.a. Partial safety factors for actions, applicable for the assessment of the Ultimate Limit States

TYPE OF ACTION	Persistent or temporary situation		Accidental situation	
	Favourable effect	Unfavourable effect	Favourable effect	Unfavourable effect
Permanent	γ_G = 1,00	γ_G = 1,35	γ_G = 1,00	γ_G = 1,00
Prestressig	γ_P = 1,00	γ_P = 1,00	γ_P = 1,00	γ_P = 1,00
Permanent of a non-constant value	γ_{G^*} = 1,00	γ_{G^*} = 1,50	γ_{G^*} = 1,00	γ_{G^*} = 1,00
Variable	γ_Q = 0,00	γ_Q = 1,50	γ_Q = 0,00	γ_Q = 1,00
Accidental	-	-	γ_A = 1,00	γ_A = 1,00

12.2 Serviceability Limit States

The values in Table 12.2 shall be adopted as partial safety factors for actions for the Serviceability Limit State checks, provided that the corresponding specific legislation applicable to actions does not lay down other criteria.

Table 12.2. Partial safety factors for actions, applicable for the assessment of the Serviceability Limit States

TYPE OF ACTION		Favourable effect	Unfavourable effect
Permanent		γ_G = 1,00	γ_G = 1,00
Prestressed	Pre-tensioned reinforcement	γ_P = 0,95	γ_P = 1,05
	Post-tensioned reinforcement	γ_P = 0,90	γ_P = 1,10
Permanent of non-constant value		γ_{G^*} = 1,00	γ_{G^*} = 1,00
Variable		γ_Q = 0,00	γ_Q = 1,00

For temporary situations in structures with thorough inspection prestressed with pre-tensioned reinforcement, γ_P = 1.00 may be adopted as partial safety factor for the prestressing action, both if the action is favourable and unfavourable. For temporary

situations in structures with thorough inspection prestressed with post-tensioned reinforcement, γ_P = 0.95 may be adopted as partial safety factor for the prestressing action if the effect is favourable and γ_P = 1.05 if it is unfavourable. The same factors may be used for permanent situations in the case of elements with post-tensioned reinforcements with straight routing constructed in a precasting installation appertaining to the work or close thereto, with a thorough inspection, routing geometry and tensioning force, provided that the corresponding specific legislation applicable to actions does not lay down other criteria.

Article 13. Combination of actions

13.1 General principles

For each of the situations studied the possible combinations of actions shall be established. A combination of actions consists of a set of compatible actions which shall be considered as acting simultaneously for a specific check.

Generally speaking, each combination shall be formed from permanent actions, a decisive variable action and one or several concomitant variable actions. Any of the variable actions may be decisive.

13.2 Ultimate Limit States

For the various design situations, the combinations of actions shall be defined in accordance with the following criteria:

- Permanent or temporary situations:

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\gamma_{Q,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}$$

- Accidental situations:

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\gamma_A A_k+\gamma_{Q,1}\psi_{1,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{2,i}Q_{k,i}$$

- Seismic situations:

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\gamma_A A_{E,k}+\sum_{i\geq 1}\gamma_{Q,i}\psi_{2,i}Q_{k,i}$$

where:

$G_{k,j}$	Characteristic value of permanent actions.
$G^*_{k,j}$	Characteristic value of permanent actions with a non-constant value.
P_k	Characteristic value of the prestressing action.
$Q_{k,1}$	Characteristic value of the decisive variable action.
$\psi_{0,i}\,Q_{k,i}$	Representative combination value of concomitant variable actions.
$\psi_{1,1}\,Q_{k,1}$	Representative frequent value of decisive variable actions.
$\psi_{2,i}\,Q_{k,i}$	Representative quasi-permanent values of variable actions with decisive action or with accidental action.
A_k	Characteristic value of the accidental action.
$A_{E,k}$	Characteristic value of the seismic action.

In permanent or temporary situations, when the decisive action $Q_{k,1}$ is not obvious, different possibilities shall be assessed taking into account different variable actions as decisive.

The Fatigue Ultimate Limit State, in its current state of knowledge, requires special checks which depend on the type of material in question, metallic or concrete elements, which gives rise to the following specific criteria:

- Only the situation produced by the variable fatigue load shall be considered for the fatigue testing of anchorage devices and reinforcements, taking a weighting factor equal to one unit.
- For the fatigue testing of concrete, the stresses produced by the permanent loads and the variable fatigue load shall be taken into account, taking a weighting factor equal to one unit for both actions.

13.3 Serviceability Limit States

Only persistent and temporary design situations are considered for these Limit States. In these cases, the combinations of actions shall be defined in accordance with the following criteria:

- Unlikely or characteristic combination

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\gamma_{Q,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}$$

- Frequent combination

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\gamma_{Q,1}\psi_{1,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{2,i}Q_{k,i}$$

- Quasi-permanent combination

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\sum_{j\geq 1}\gamma_{G^*,j}G^*_{k,j}+\gamma_P P_k+\sum_{i>1}\gamma_{Q,i}\psi_{2,i}Q_{k,i}$$