In this video, a comprehensive explanation of load combinations and the impact of favorable and unfavorable actions on structures is provided. The video covers the various types of loads that can act on a structure, such as dead loads, live loads, wind loads, and snow loads. Considering both favorable and unfavorable loads, which can affect internal forces, is emphasized.

6.4.3.2 Combinations of actions for persistent or transient design situations (fundamental combinations)

(3) The combination of actions in brackets { }, in (6.9b) may either be expressed as:

$$\sum_{j \geq 1} \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \gamma_{Q,1} Q_{k,1} \text{ "+" } \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \qquad (6.10)$$

or, alternatively for STR and GEO limit states, the less favourable of the two following expressions:

$$\sum_{j \geq 1} \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \gamma_{Q,1} \psi_{0,1} Q_{k,1} \text{ "+" } \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \qquad (6.10a)$$

$$\sum_{j \geq 1} \xi_j \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_P P \text{ "+" } \gamma_{Q,1} Q_{k,1} \text{ "+" } \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i} \qquad (6.10b)$$

Where:

"+ " implies "to be combined with"

Σ implies "the combined effect of"

ξ is a reduction factor for unfavourable permanent actions *G*

NOTE: Further information for this choice is given in Annex A.

EN 1990

G → Self weight & Dead load

$Q_{k,1}$ → variable action leading

$Q_{k,i}$ $i>1$ → variable action accompanying action

A2.3 Ultimate limit states

NOTE: Verification for fatigue excluded.

A2.3.1 Design values of actions in persistent and transient design situations

(1) The design values of actions for ultimate limit states in the persistent and transient design situations (expressions 6.9a to 6.10b) should be in accordance with Tables A2.4(A) to (C).

NOTE: The values in Tables A2.4(A) to (C) may be changed in the National Annex (e.g. for different reliability levels see Section 2 and Annex B).

(2) In applying Tables A2.4(A) to A2.4(C) in cases when the limit state is very sensitive to variations in the magnitude of permanent actions, the upper and lower characteristic values of these actions should be taken according to 4.1.2(2)P.

(3) Static equilibrium (EQU, see 6.4.1 and 6.4.2(2)) for bridges should be verified using the design values of actions in Table A2.4(A).

(4) Design of structural members (STR, see 6.4.1) not involving geotechnical actions should be verified using the design values of actions in Table A2.4(B).

(5) Design of structural members (footings, piles, piers, side walls, wing walls, flank walls and front walls of abutments, ballast retention walls, etc.) (STR) involving geotechnical actions and the resistance of the ground (GEO, see 6.4.1) should be verified using one only of the following three approaches supplemented, for geotechnical actions and resistances, by EN 1997:

4.1.2 Characteristic values of actions

(2)P The characteristic value of a permanent action shall be assessed as follows:

— if the variability of G can be considered as small, one single value G_k may be used;

— if the variability of G cannot be considered as small, two values shall be used: an upper value $G_{k,sup}$ and a lower value $G_{k,inf}$.

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Table A1.2(A) Design values of actions (EQU) (Set A)

Persistent and transient design situations	Permanent actions		Leading variable action (*)	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10)	$\gamma_{G,j,sup} G_{k,j,sup}$	$\gamma_{G,j,inf} G_{k,j,inf}$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$

(*) Variable actions are those considered in Table A1.1

NOTE 1 The γ values may be set by the National annex. The recommended set of values for γ are:

$\gamma_{G,j,sup} = 1,10$
$\gamma_{G,j,inf} = 0,90$
$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

NOTE 2 In cases where the verification of static equilibrium also involves the resistance of structural members, as an alternative to two separate verifications based on Tables A1.2(A) and A1.2(B), a combined verification, based on Table A1.2(A), may be adopted, if allowed by the National annex, with the following set of recommended values. The recommended values may be altered by the National annex.

$\gamma_{G,j,sup} = 1,35$
$\gamma_{G,j,inf} = 1,15$
$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

provided that applying $\gamma_{G,j,inf} = 1,00$ both to the favourable part and to the unfavourable part of permanent actions does not give a more unfavourable effect.

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Table A1.2(B) Design values of actions (STR/GEO) (Set B)

Persistent and transient design situations	Permanent actions		Leading variable action	Accompanying variable actions (*)	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10)	$\gamma_{G,j,sup}G_{k,j,sup}$	$\gamma_{G,j,inf}G_{k,j,inf}$	$\gamma_{Q,1}Q_{k,1}$		$\gamma_{Q,i}\psi_{0,i}Q_{k,i}$

Persistent and transient design situations	Permanent actions		Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable	Action	Main	Others
(Eq. 6.10a)	$\gamma_{G,j,sup}G_{k,j,sup}$	$\gamma_{G,j,inf}G_{k,j,inf}$		$\gamma_{Q,1}\psi_{0,1}Q_{k,1}$	$\gamma_{Q,i}\psi_{0,i}Q_{k,i}$
(Eq. 6.10b)	$\xi\gamma_{G,j,sup}G_{k,j,sup}$	$\gamma_{G,j,inf}G_{k,j,inf}$	$\gamma_{Q,1}Q_{k,1}$		$\gamma_{Q,i}\psi_{0,i}Q_{k,i}$

(*) Variable actions are those considered in Table A1.1

NOTE 1 The choice between 6.10, or 6.10a and 6.10b will be in the National annex. In case of 6.10a and 6.10b, the National annex may in addition modify 6.10a to include permanent actions only.

NOTE 2 The γ and ξ values may be set by the National annex. The following values for γ and ξ are recommended when using expressions 6.10, or 6.10a and 6.10b.
$\gamma_{G,j,sup} = 1,35$
$\gamma_{G,j,inf} = 1,00$
$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)
$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)
$\xi = 0,85$ (so that $\xi\gamma_{Q,j,sup} = 0,85 \times 1,35 \cong 1,15$).

See also EN 1991 to EN 1999 for γ values to be used for imposed deformations.

NOTE 3 The characteristic values of all permanent actions from one source are multiplied by $\gamma_{G,sup}$ if the total resulting action effect is unfavourable and $\gamma_{G,inf}$ if the total resulting action effect is favourable. For example, all actions originating from the self weight of the structure may be considered as coming from one source; this also applies if different materials are involved.

NOTE 4 For particular verifications, the values for γ_G and γ_Q may be subdivided into γ_g and γ_q and the model uncertainty factor γ_{Sd}. A value of γ_{Sd} in the range 1,05 to 1,15 can be used in most common cases and can be modified in the National annex.

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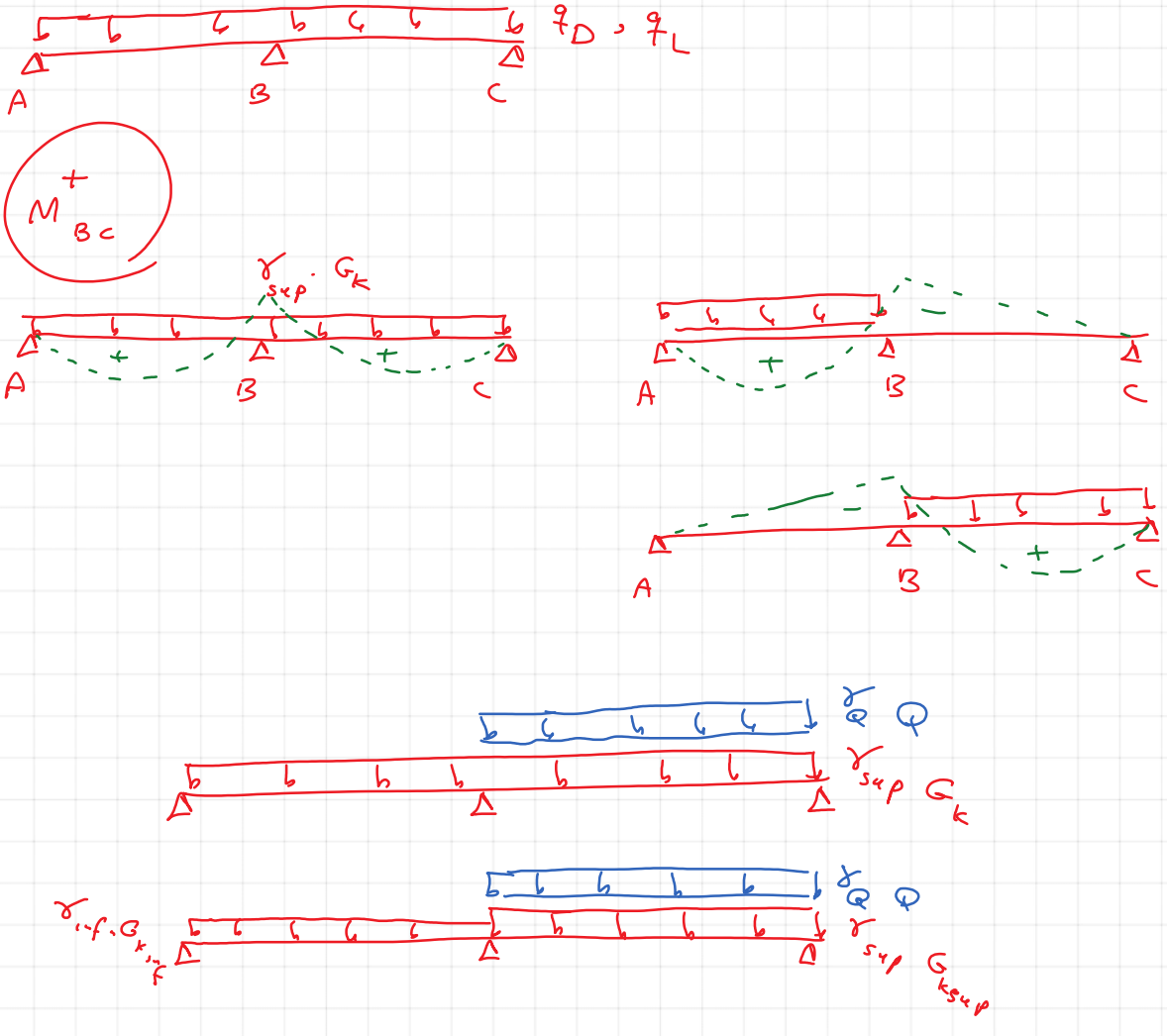

LC1 → Dead load

LC2 → Live load (category A) → CC 2 ($k_{FI} = 1$)

LC3 → Snow load

LC4 → Wind +X

LC5 → Wind −X

LC6 → Wind +Y

LC7 → Wind −Y

Table 3. Design values of the actions (durability of the structural members and geotechnical load-bearing capability)
(Set B)

Persistent and transient design situations	Permanent actions		Leading variable action (*)	Accompanying variable actions (*)
	Unfavourable	Favourable		
(Eq. 6.10a)	1.35 K_{FI} $Q_{kj,sup}$	0.9 $G_{kj,inf}$		
(Eq. 6.10b)	1.15 K_{FI} $Q_{kj,sup}$	0.9 $G_{kj,inf}$	1.5 K_{FI} $Q_{k,1}$	1.5 K_{FI} $\psi_{0,i} Q_{k,i}$
(*) Variable actions are those considered in Table A.1.1.				

CC 1 → 0.9 = k_{FI}

CC 2 → 1 = k_{FI}

CC 3 → 1.1 = k_{FI}

Note 1. This can be expressed as a design formula in such a way that the most unfavourable of the two following expressions is used as a combination of loads when it should be noted that the latter expression only contains permanent loads:

$$\begin{cases} 1,15\,K_{FI}\,G_{kj,sup} + 0,9\,G_{kj,inf} + 1,5\,K_{FI}\,Q_{k,1} + 1,5\,K_{FI}\sum_{i>1}\psi_{0,i}\,Q_{k,i} \\ 1,35\,K_{FI}\,G_{kj,sup} + 0,9\,G_{kj,inf} \end{cases}$$

Table 1. Values of coefficients ψ for buildings

Load	ψ_0	ψ_1	ψ_2
Imposed loads in buildings, category (SFS-EN 1991-1-1)			
Category A: areas in domestic and residential buildings	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.3
Category D: shopping areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic areas, vehicle weight ≤ 30 kN	0.7	0.7	0.6**)
Category F: traffic areas, vehicle weight 30 kN < vehicle weight ≤ 160 kN	0.7	0.5	0.3**)
Category H: roofs	0	0	0
Snow load (see EN 1991-1-3)*), when			
s_k < 2.75 kN/m²	0.7	0.4	0.2
s_k ≥ 2.75 kN/m²	0.7	0.5	0.2
Ice load ***)	0.7	0.3	0
Wind loads on buildings (SFS-EN 1991-1-4)	0.6	0.2	0
Temperature (non-fire) in buildings (SFS-EN 1991-1-5)	0.6	0.5	0

*) Outdoor terraces and balconies $\psi_0 = 0$ combined with categories A, B, F and G.
Note: In case there are different categories of loads in one building that cannot clearly be separated into different sections, values for ψ giving the most unfavourable effect should be used.
**) On access ways $\psi_2 = 0$
***) Applies to ice loads caused by frosting, freezing rain and sleet

For structures other than buildings, the values for coefficients ψ are provided in connection with the Eurocodes concerning the structures in question.

Characteristic values of ice loads are given in ISO 12494:2001, among others.

$\psi_{0,L} = 0.7$
$\psi_{0,S} = 0.7$
$\psi_{0,W} = 0.6$
$(k_{FI} = 1)$

$1.35 G_{k,sup} + 0.9 G_{k,inf}$
$1.15 G_{k,sup} + 0.9 G_{k,inf} + 1.5 Q_{k,1} + 1.5 \sum_{j>1} Q_{k,j} \psi_{0,j}$

D, L, S, W_x^+, W_x^-, W_y^+, W_y^-

Unf → $1.35 D$ (1)

leading Live →
$1.15D + 1.5L$ (2)
$1.15D + 1.5L + 0.7S$
$1.15D + 1.5L + 0.6 W_x^+$
W_x^-
W_y^+
W_y^-
(4)
$1.15D + 1.5L + 0.7S + 0.6 W_x^+$
W_x^-
W_y^+
W_y^-
(4)
(10)

W_x^+ leading
$1.15D + 1.5 W_x^+$
$1.15D + 1.5 W_x^+ + 0.7L$
$1.15D + 1.5 W_x^+ + 0.7S$
$1.15D + 1.5 W_x^+ + 0.7L + 0.7S$
W_x^+ (4)
W_x^- (4)
W_y^+ (4)
W_y^- (4)

Snow →
$1.15D + 1.5S$
$1.15D + 1.5S + 0.7L$
$1.15D + 1.5S + 0.6 W_x^+$
W_x^-
W_y^+
W_y^-
(10)

$1.15D + 1.5S + 0.7L + 0.6 W_x^+$
W_x^-
W_y^+
W_y^-

(1) + 10 + 10 + 4 × 4 = (37) load combinations