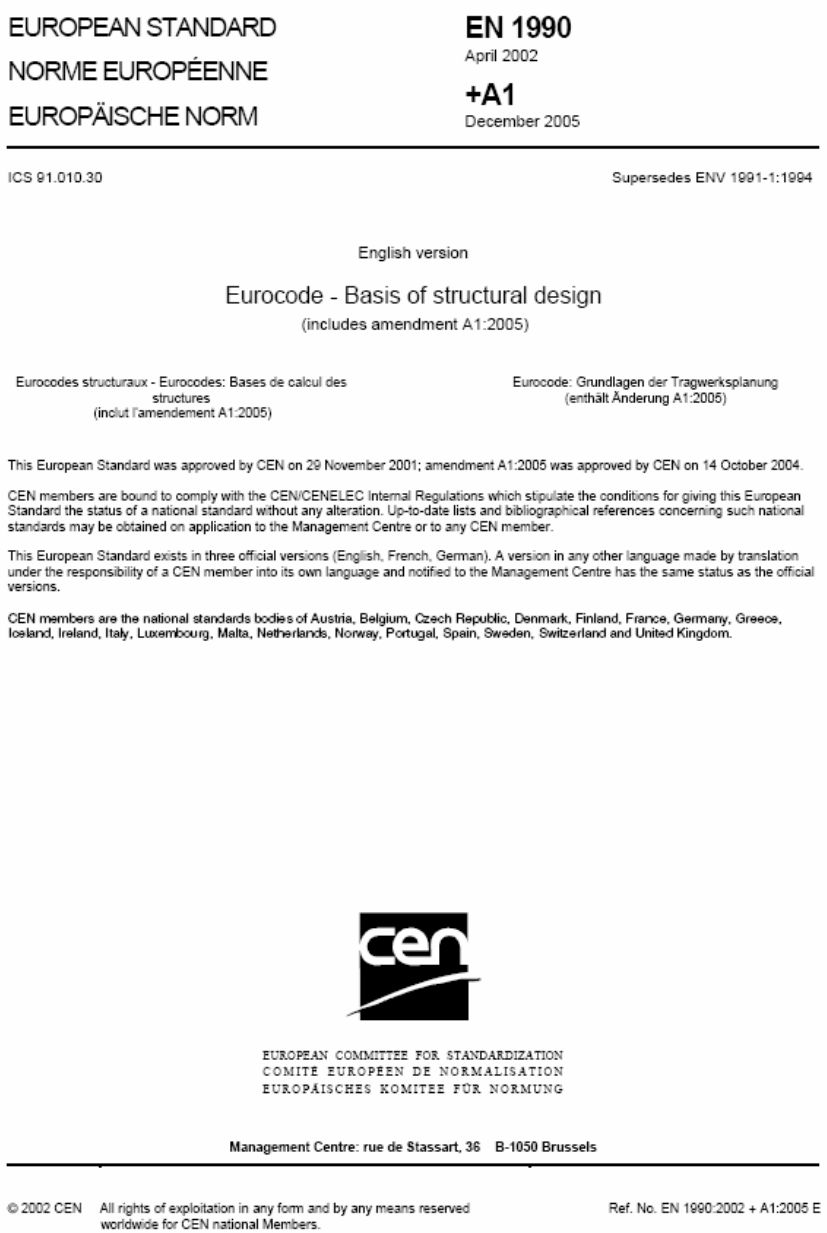
EN 1990 – Section 6, Annexes A1 & A2

EN 1990 “Eurocode : Basis of Structural Design

Jean-Armand Calgaro
Chairman of CEN/TC250



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1990
April 2002
+A1
December 2005

ICS 91.010.30 Supersedes ENV 1991-1:1994

English version

Eurocode - Basis of structural design
(includes amendment A1:2005)

Eurocodes structuraux - Eurocodes: Bases de calcul des structures
(inclut l'amendement A1:2005)

Eurocode: Grundlagen der Tragwerksplanung
(enthält Änderung A1:2005)

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1990:2002 + A1:2005 E

EN 1990 – Section 6, Annexes A1 & A2

Foreword
Section 1 : General
Section 2 : Requirements
Section 3 : Principles of limit states
Section 4 : Basic variables
Section 5 : Structural analysis and design assisted by testing
Section 6 : Verification by the partial factor method

Annex A1 : Application for buildings (N)
Annex A2 : Application for bridges (N) (EN 1990/A1)
Annex B : Management of structural reliability for construction works (I)
Annex C : Basis for partial factor design and reliability analysis (I)
Annex D : Design assisted by testing (I)

EN 1990 – Section 6, Annexes A1 & A2

Design situations		Verifications
Persistent	Normal use	ULS, SLS
Transient	Execution, temporary conditions applicable to the structure, e.g. maintenance or repair	ULS, SLS
Accidental	Normal use	ULS
	During execution	ULS
Seismic	Normal use	ULS,SLS
	During execution	ULS,SLS

The selected design situation shall be sufficiently severe and so varied as to encompass all conditions which can reasonably be foreseen to occur during the execution and use of the structure (3.2(3)P).

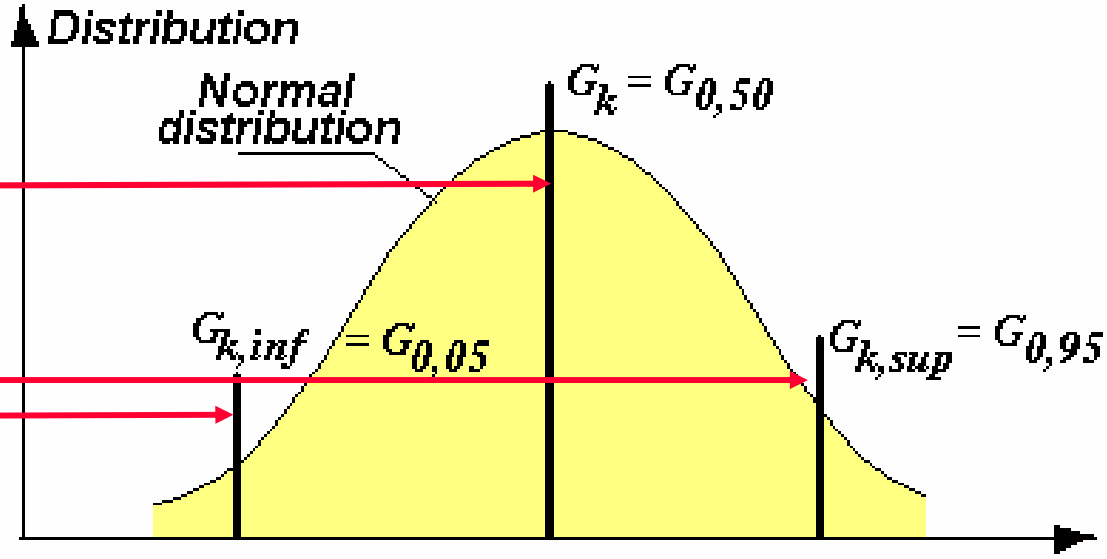
Representative values of actions

	Permanent actions	Variable actions	Accidental actions	Seismic actions
Characteristic value	G_k	Q_k		A_{Ek} or
Nominal value			A_d	$A_{Ed} = \gamma_I A_{Ek}$
Combination value		$\psi_0 Q_k$		
Frequent value		$\psi_1 Q_k$		
Quasi-permanent value		$\psi_2 Q_k$		

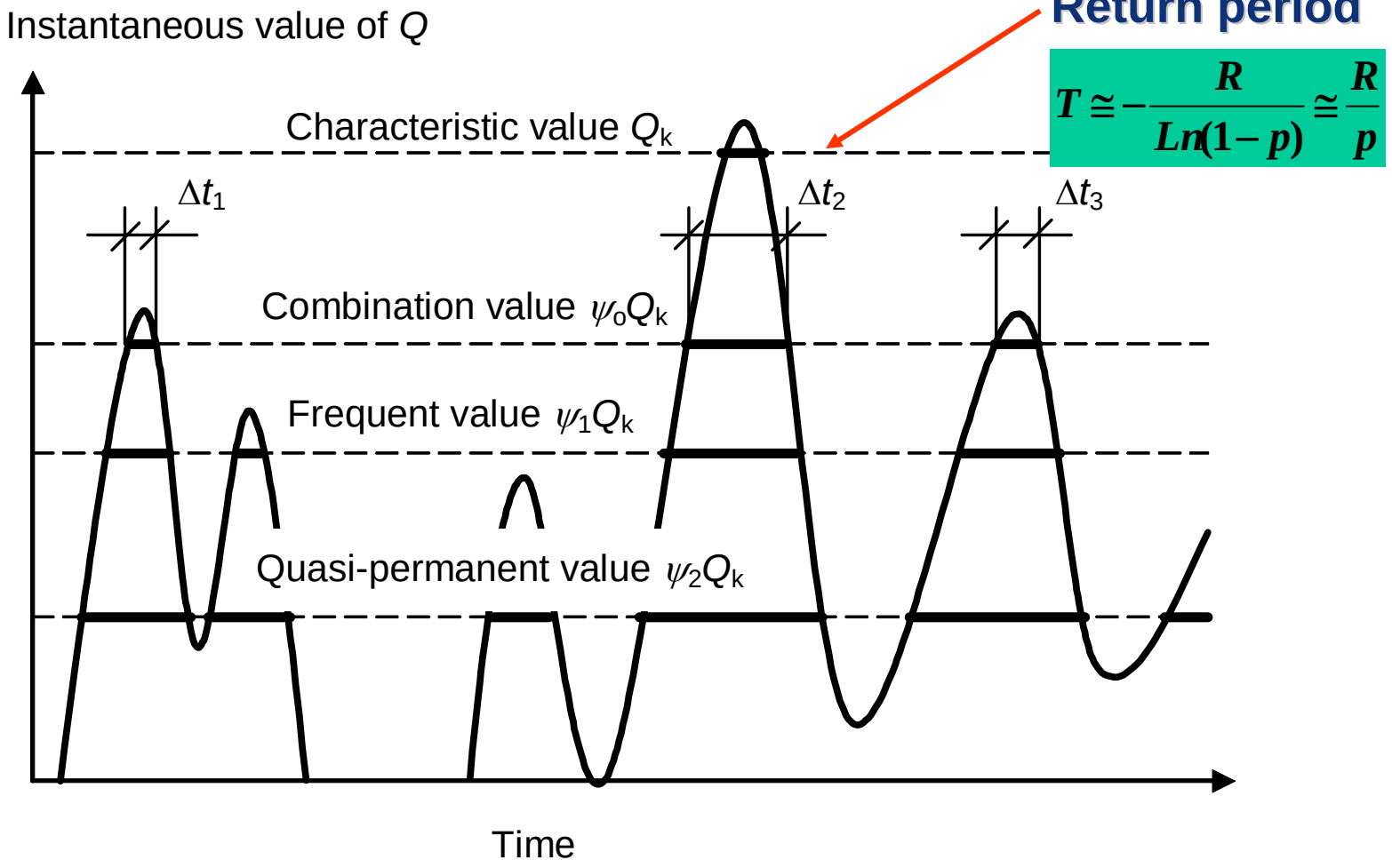
Permanent actions

Small variability

High variability



Variable actions



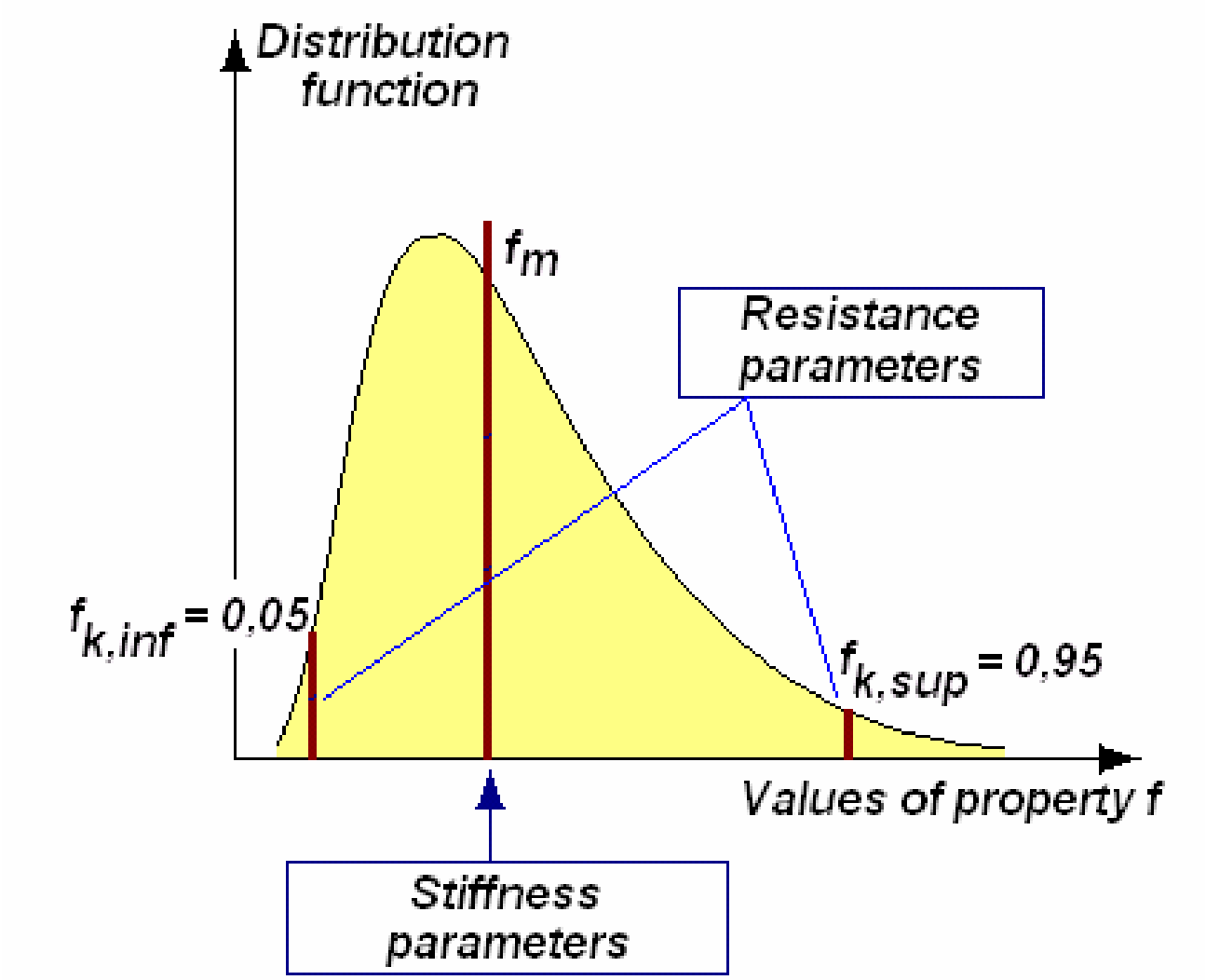
Return period

$$T \cong -\frac{R}{Ln(1-p)} \cong \frac{R}{p}$$

R : reference period (e.g. 1 year or 50 years)

p : probability of exceedance during the reference period

Material and product properties



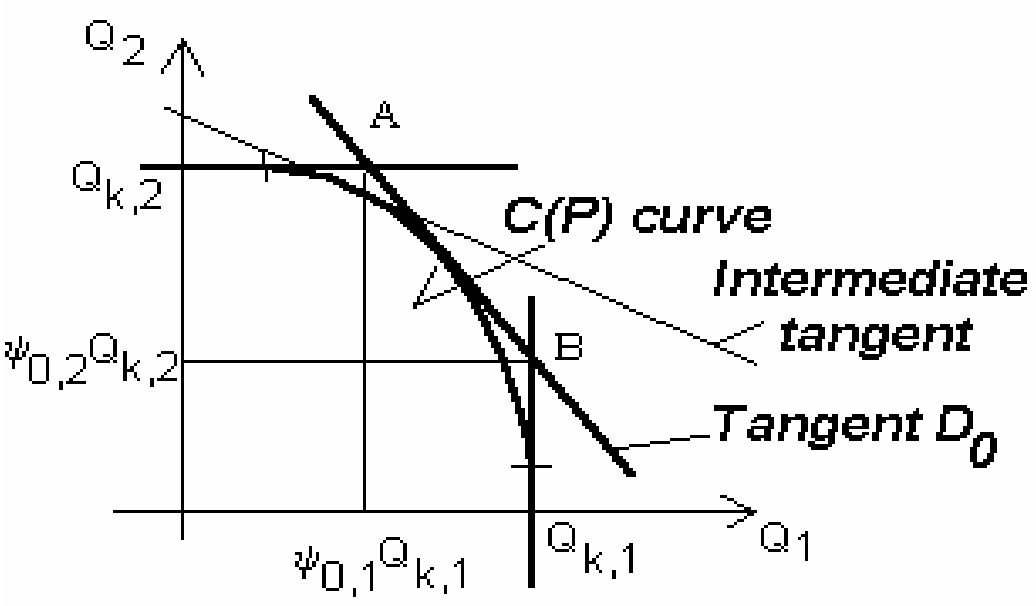
Section 6 - Verification by the partial factor method

6.1 General
6.2 Limitations
6.3 Design values
6.4 Ultimate limit states
6.5 Serviceability limit states

EN 1990 – Section 6, Annexes A1 & A2

Turkstra's rule (1972) : within the set of variable actions applicable to a structure, one of them is selected and called « leading variable action » ; the other variable actions are accompanying actions and are taken into account in the combinations of actions with their combination values.

How to establish a combination of actions



The set including all permanent actions, the leading variable action and the relevant accompanying variable actions forms a combination of actions. The various values of actions used in the verifications are called « representative values ».

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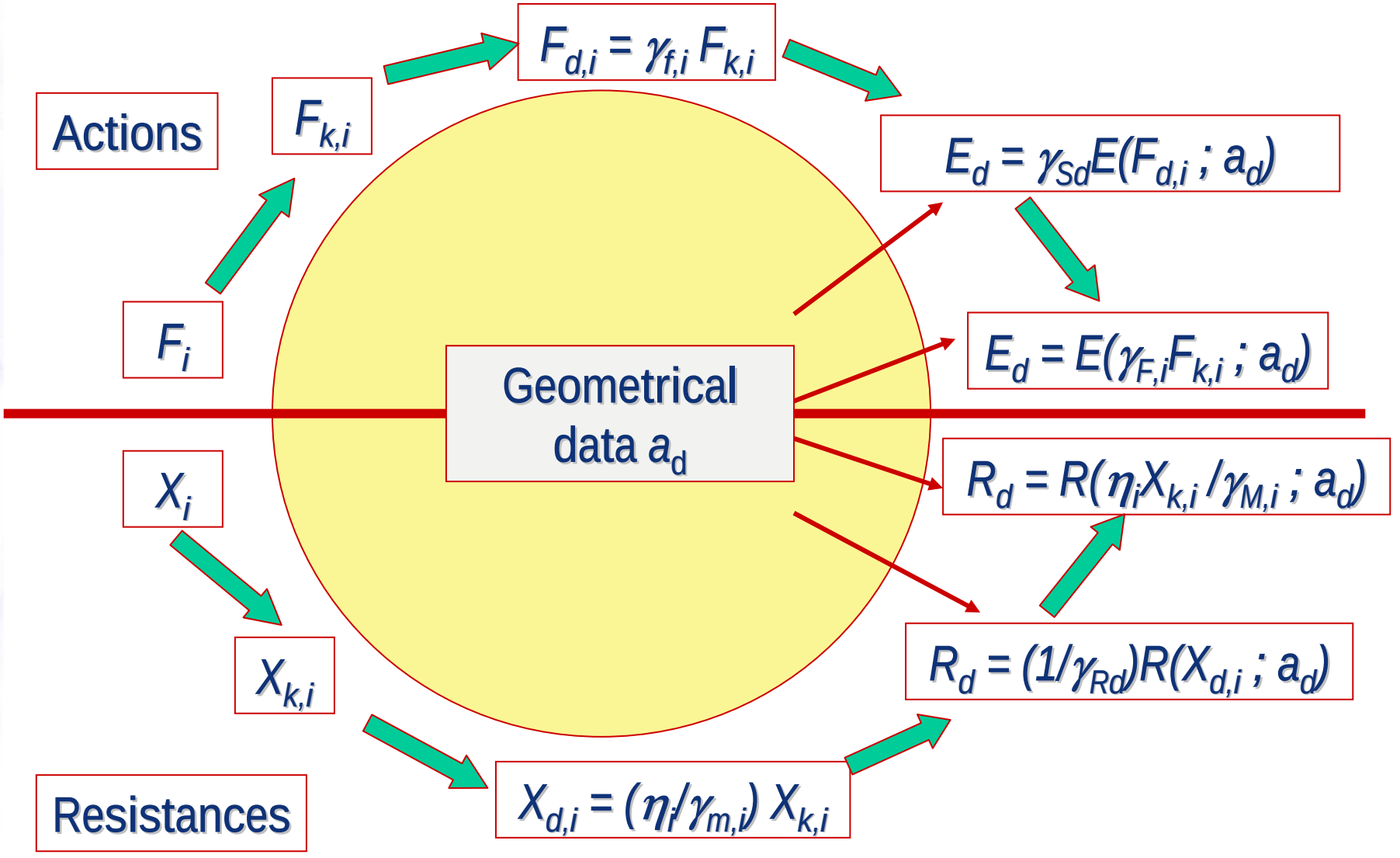

Design values

Ultimate limit states

EQU	Loss of static equilibrium of the structure or any part of it considered as a rigid body, in which : - minor variations in the value or the spatial distribution of actions from a single source are significant ; - the strengths of construction materials or ground are generally not governing
STR	Internal failure of the structure or structural elements, including footings, piles, basement walls, etc., in which the strength of construction materials or excessive deformation of the structure governs
GEO	Failure or excessive deformation of the ground in which the strengths of soil or rock are significant in providing resistance
FAT	Fatigue failure of the structure or structural elements

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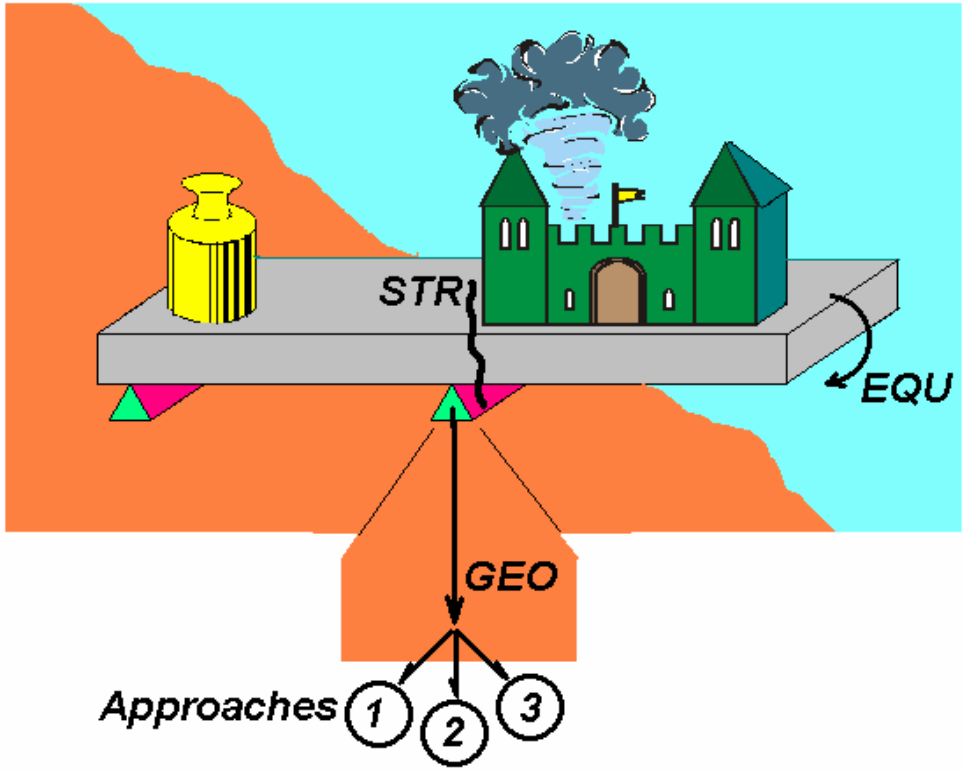
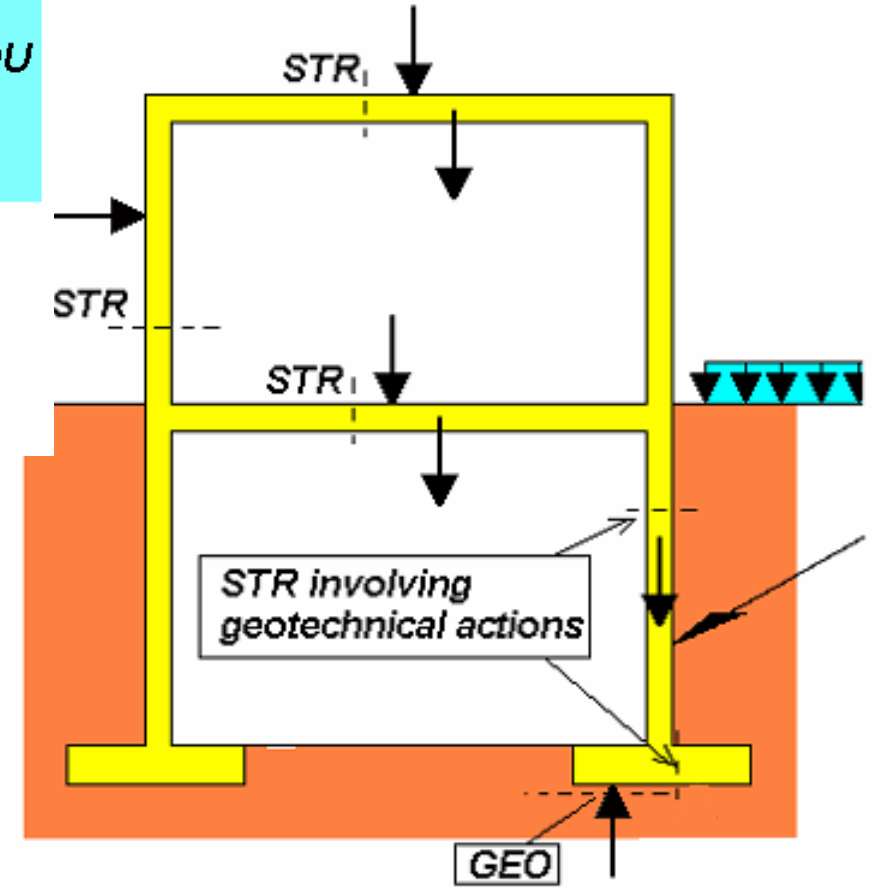


Ultimate limit states



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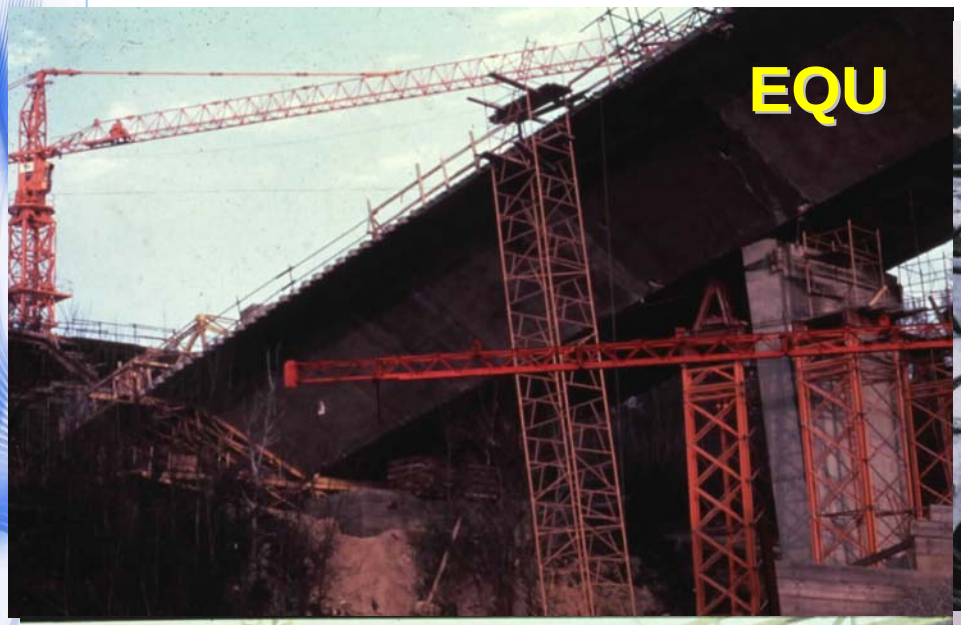
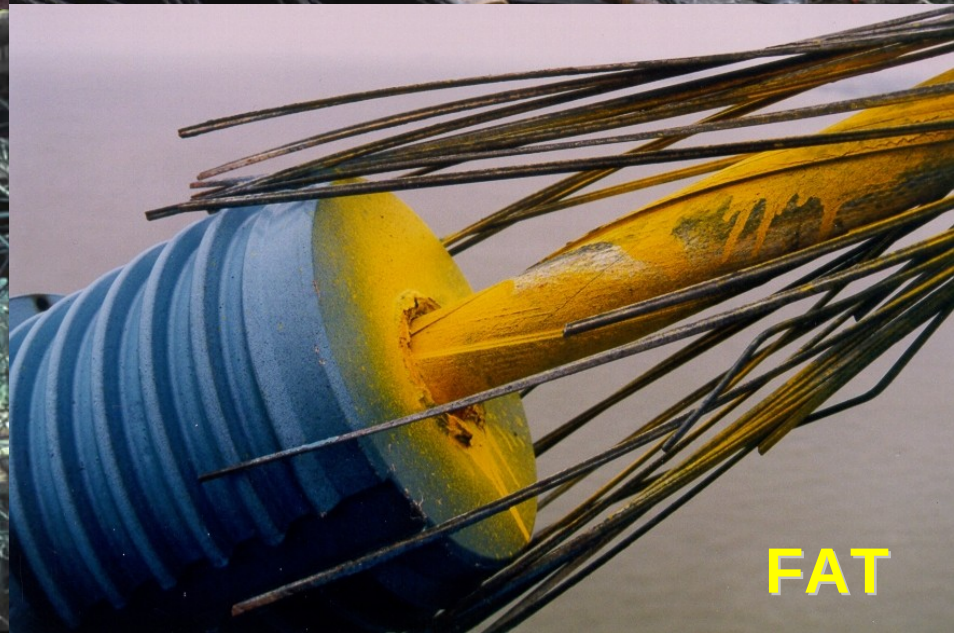




6.4.2 Verifications of static equilibrium and resistance

Ultimate limit states of static equilibrium (EQU) :

$$E_{d,dst} \leq E_{d,stb}$$

Ultimate limit states of resistance (STR/GEO) :

$$E_d \leq R_d$$

6.5 Serviceability limit states

$$E_d \leq C_d$$

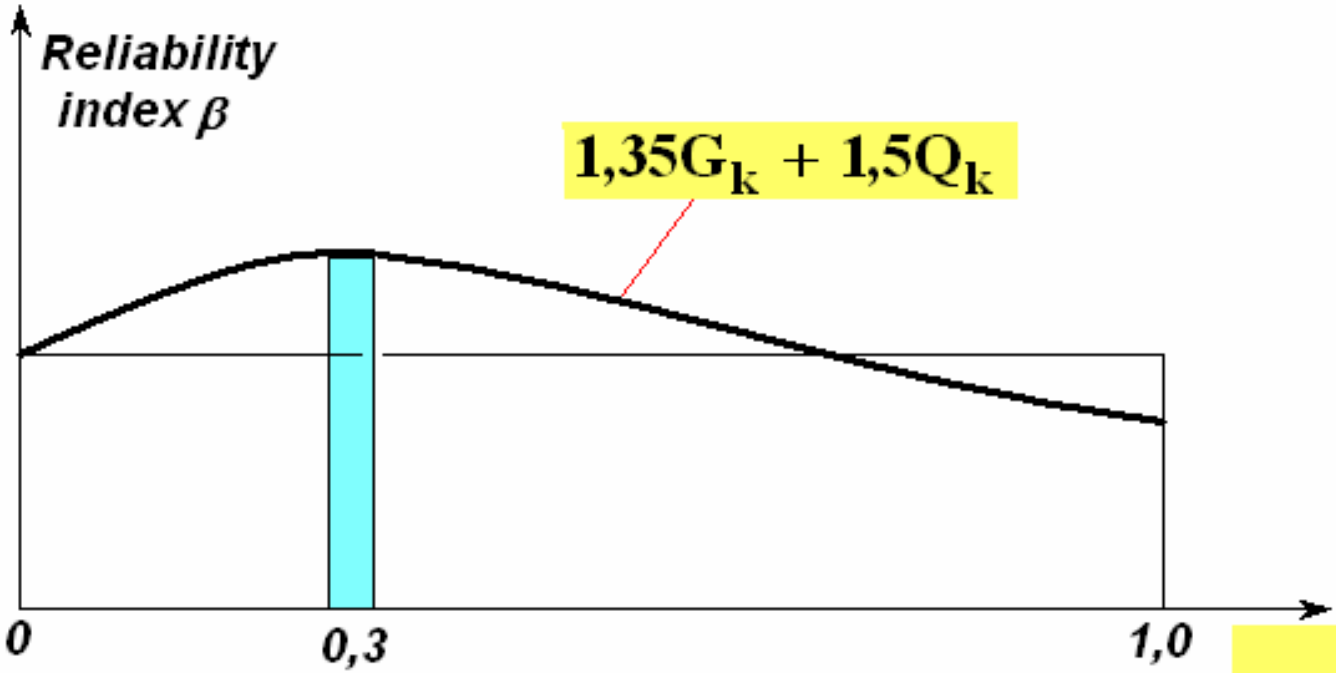
C_d is the limiting design value of the relevant serviceability criterion.

E_d is the design value of the effects of actions specified in the serviceability criterion, determined on the basis of the relevant combination.

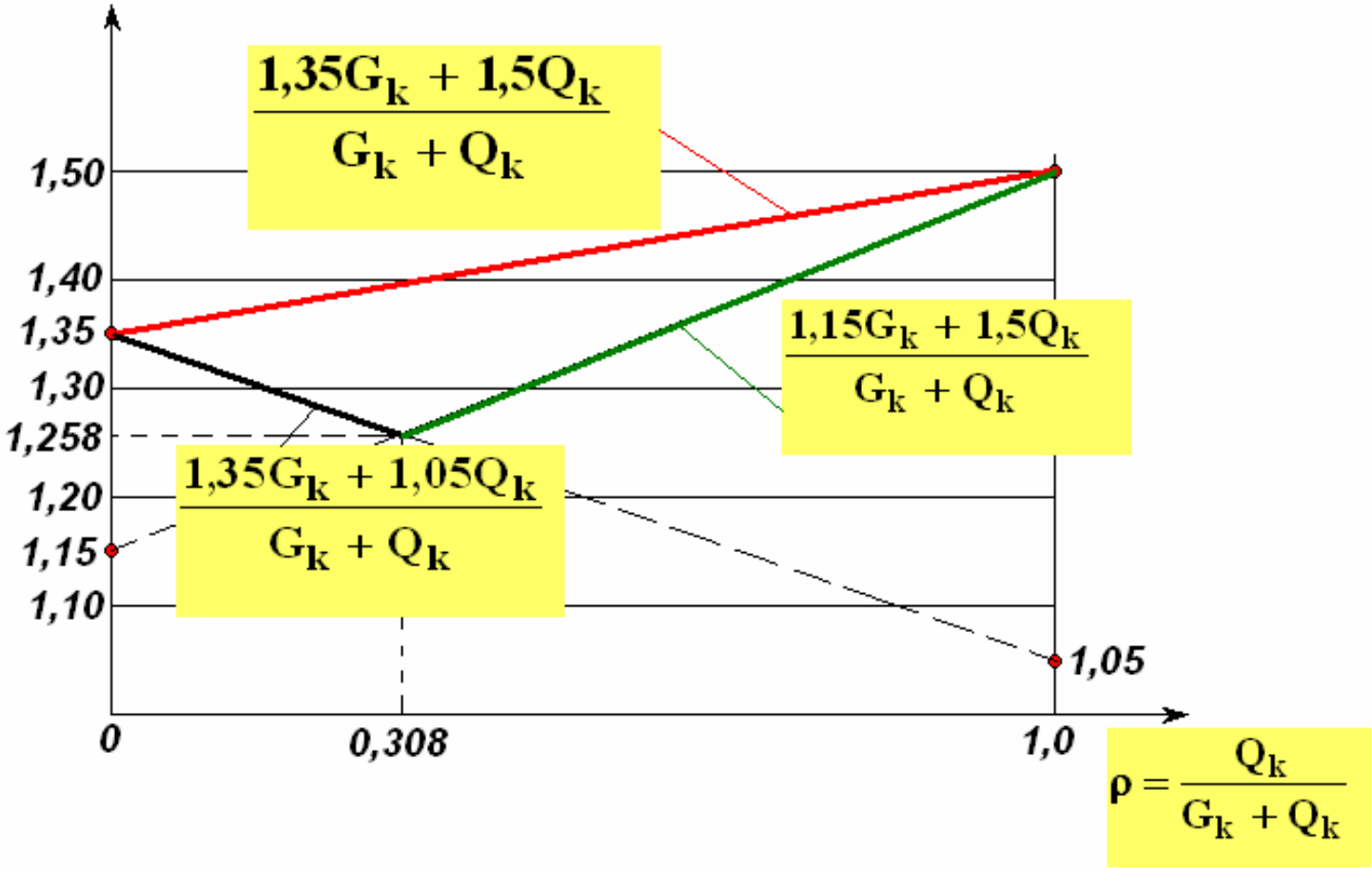
Combinations of actions

Combination	Reference EN 1990	General expression
Fundamental (for persistent and transient design situations)	**6.10**	$\sum_{j\geq 1}\gamma_{Gj}G_{kj}"+"\gamma_P P"+"\gamma_{Q,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}$
	6.10 a/b	$\begin{cases}\sum_{j\geq 1}\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}\psi_{0,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}\\ \sum_{j\geq 1}\xi_j\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}\end{cases}$ $0{,}85 \leq \xi_j \leq 1{,}00$ **for unfavourable permanent actions *G***
Accidental (for accidental design situations)	**6.11**	$\sum_{j\geq 1}G_{kj}"+"P"+"A_d"+"(\psi_{1,1}\ ou\ \psi_{2,1})Q_{k1}"+"\sum_{i\geq 1}\psi_{2,i}Q_{k,i}$
Seismic (for seismic design situations)	**6.12**	$\sum_{j\geq 1}G_{k,j}"+"P"+"A_{Ed}"+"\sum_{i\geq 1}\psi_{2,i}Q_{k,i}$

Origin of expressions 6.10 and 6.10 a/b



« Equivalent » safety factor for a combination based on a unique permanent action and a unique variable action acting together unfavourably, with $\psi_0 = 0,7$ and $\xi = 0,85$



6.5.3 Serviceability limit states : combinations of actions

- **Characteristic Combination (irreversible SLS)**

$$\sum_{j\geq 1} G_{k,j} \text{ "+" } P \text{ "+" } Q_{k,1} \text{ "+" } \sum_{i>1} \psi_{0,i} Q_{k,i}$$

- **Frequent Combination (reversible SLS)**

$$\sum_{j\geq 1} G_{k,j} \text{ "+" } P \text{ "+" } \psi_{1,1} Q_{k,1} \text{ "+" } \sum_{i>1} \psi_{2,i} Q_{k,i}$$

- **Quasi-permanent Combination (reversible SLS)**

$$\sum_{j\geq 1} G_{k,j} \text{ "+" } P \text{ "+" } \sum_{i\geq 1} \psi_{2,i} Q_{k,i}$$

Annex A1 (normative) Application for Buildings

A1.1 Field of application

A1.2 Combinations of actions

A1.2.1 General

A1.2.2 Values of ψ factors

A1.3 Ultimate limit states

A1.3.1 Design values of actions in persistent and transient design situations

A1.3.2 Design values of actions in the accidental and seismic design situations

A1.4 Serviceability limit states

A1.4.1 Partial factors for actions

A1.4.2 Serviceability criteria

A1.4.3 Deformations and horizontal displacements

A1.4.4 Vibrations

Table A1.1 - Recommended values of ψ factors for buildings

Action	ψ_0	ψ_1	ψ_2
Imposed loads in buildings, category (see EN 1991-1-1)			
Category A : domestic, residential areas	0,7	0,5	0,3
Category B : office areas	0,7	0,5	0,3
Category C : congregation areas	0,7	0,7	0,6
Category D : shopping areas	0,7	0,7	0,6
Category E : storage areas	1,0	0,9	0,8
Category F : traffic area, vehicle weight ≤ 30kN	0,7	0,7	0,6
Category G : traffic area, 30kN < vehicle weight ≤ 160kN	0,7	0,5	0,3
Category H : roofs	0	0	0
Snow loads on buildings (see EN 1991-1-3)*			
– Finland, Iceland, Norway, Sweden	0,70	0,50	0,20
– Remainder of CEN Member States, for sites located at altitude H > 1000 m a.s.l.	0,70	0,50	0,20
– Remainder of CEN Member States, for sites located at altitude H ≤ 1000 m a.s.l.	0,50	0,20	0
Wind loads on buildings (see EN 1991-1-4)	0,6	0,2	0
Temperature (non-fire) in buildings (see EN 1991-1-5)	0,6	0,5	0

NOTE The ψ values may be set by the National annex.
* For countries not mentioned below, see relevant local conditions.

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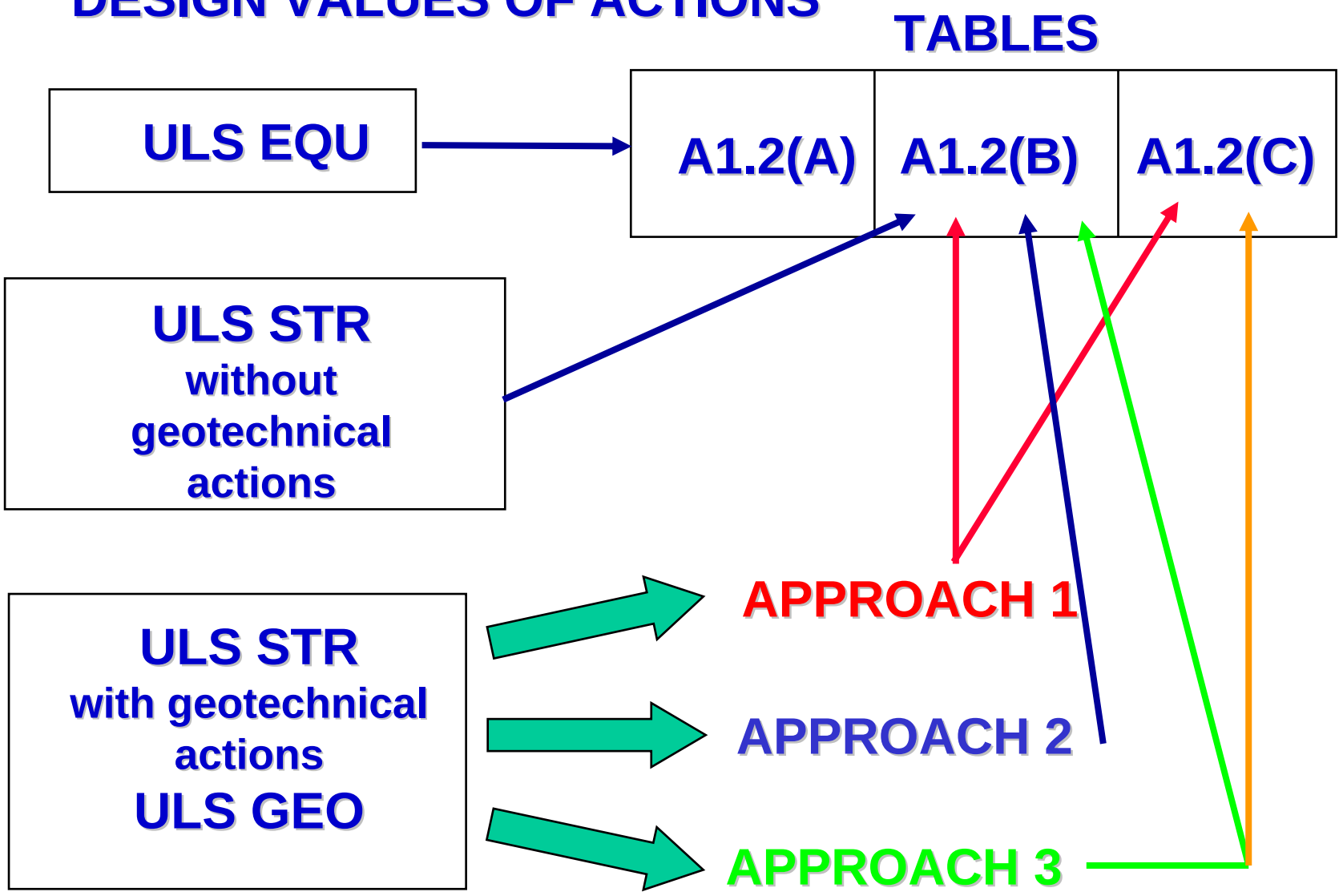
DESIGN VALUES OF ACTIONS



Approaches 2 and 3 in geotechnical design

$$k_a = \tan^2\left(\frac{\pi}{4} - \frac{\varphi}{2}\right)$$

$$\varphi = \varphi_k \quad F_{a,d} = \gamma_{F_a} F_a(\varphi_k)$$

$$\varphi = \varphi_d \quad F_{a,d} = F_a(\varphi_d)$$

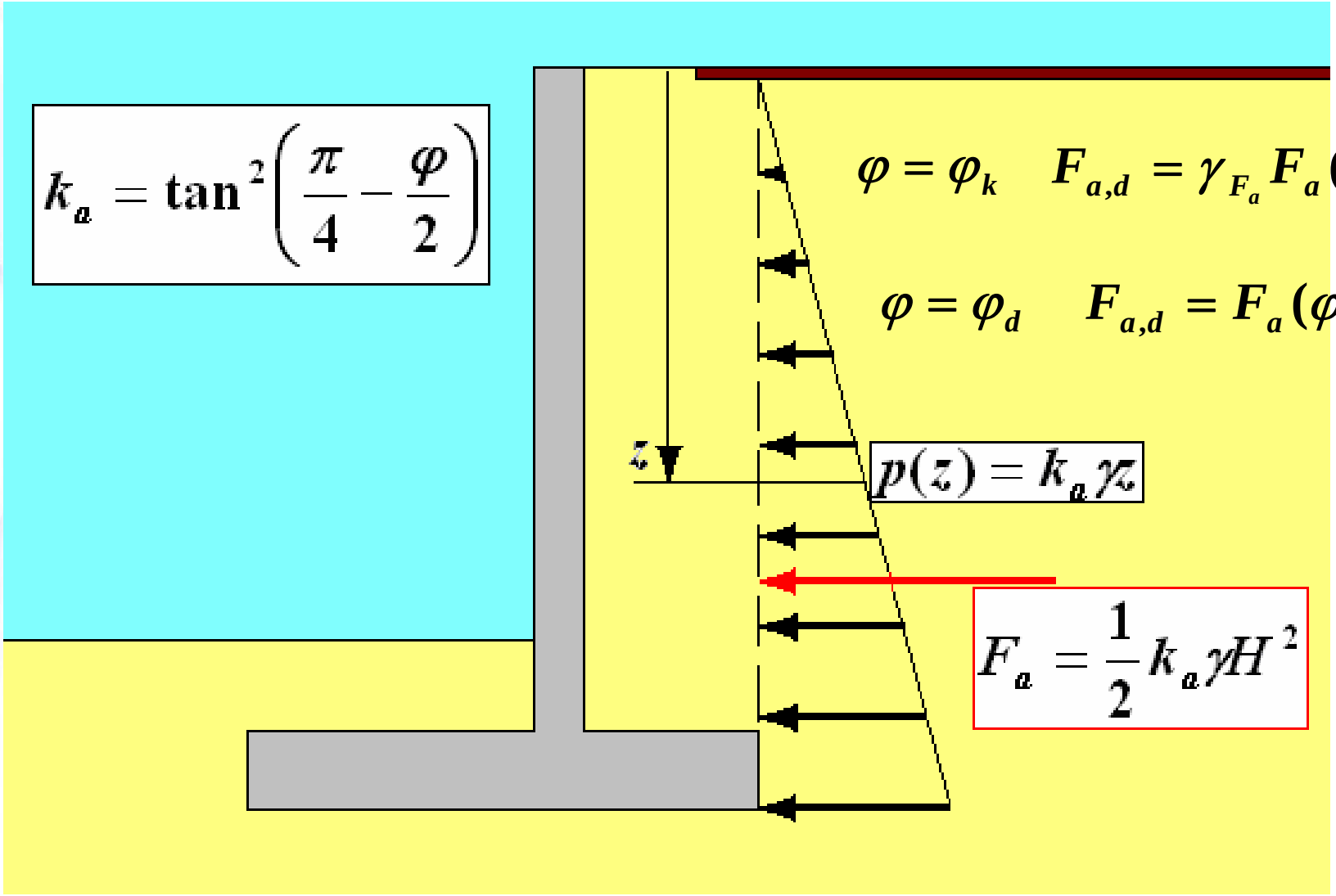


Table A1.2(A) – Design values of actions (EQU) (Set A)

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

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

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

$\gamma_{Gj,sup} = 1,10$

$\gamma_{Gj,inf} = 0,90$

$\gamma_{Q,1} = 1,50$ 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.

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

$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

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

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

Persistent and transient design situation	Permanent actions		Prestress	Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable			Main (if any)	Others
(Eq. 6.10)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(Eq. 6.10a)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$		$\gamma_{Q,1} \psi_{0,1} Q_{k,1}$	$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(Eq. 6.10b)	$\xi \gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(*) Variable actions are those considered in Tables A2.1 to A2.3.						

EN 1990 – Section 6, Annexes A1 & A2

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.

$\gamma_{Gj,sup} = 1,35$

$\gamma_{Gj,inf} = 1,00$

$\gamma_{Q,1} = 1,50$ where unfavourable (0 where favourable)

$\gamma_{Q,i} = 1,50$ where unfavourable (0 where favourable)

$\xi = 0,85$ (so that $\xi\gamma_{Gj,sup} = 0,85 \times 1,35 \cong 1,15$).

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

EN 1990 – Section 6, Annexes A1 & A2

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.

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

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

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

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

$\gamma_{Gj,sup} = 1,00$

$\gamma_{Gj,inf} = 1,00$

$\gamma_{Q,1} = 1,30$ where unfavourable (0 where favourable)

$\gamma_{Q,i} = 1,30$ where unfavourable (0 where favourable)

Table A1.3 - Design values of actions for use in accidental and seismic combinations of actions

Design situation	Permanent actions		Leading accidental or seismic action	Accompanying variable actions (**)	
	Unfavourable	Favourable		Main (if any)	Others
Accidental (*) (Eq. 6.11a/b)	$G_{kj,sup}$	$G_{kj,inf}$	A_d	ψ_{11} or $\psi_{21} Q_{k1}$	$\psi_{2,i} Q_{k,i}$
Seismic (Eq. 6.12a/b)	$G_{kj,sup}$	$G_{kj,inf}$	$\gamma_I A_{Ek}$ or A_{Ed}		$\psi_{2,i} Q_{k,i}$

(*) In the case of accidental design situations, the main variable action may be taken with its frequent or, as in seismic combinations of actions, its quasi-permanent values. The choice will be in the National annex, depending on the accidental action under consideration. See also EN 1991-1-2.

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

Table A1.4 - Design values of actions for use in the combination of actions (SLS)

Combination	Permanent actions G_d		Variable actions Q_d	
	Unfavourable	Favourable	Leading	Others
Characteristic	$G_{kj,sup}$	$G_{kj,inf}$	$Q_{k,1}$	$\psi_{0,i}Q_{k,i}$
Frequent	$G_{kj,sup}$	$G_{kj,inf}$	$\psi_{1,1}Q_{k,1}$	$\psi_{2,i}Q_{k,i}$
Quasi-permanent	$G_{kj,sup}$	$G_{kj,inf}$	$\psi_{2,1}Q_{k,1}$	$\psi_{2,i}Q_{k,i}$

Annex A2 - Application for bridges (N)

National Annex for EN 1990 Annex A2

A2.1 Field of application

A2.2 Combination of actions

A2.3 Ultimate limit states (verifications for fatigue excluded)

A2.4 Serviceability and other specific limit states

Examples of combinations of actions for road bridges

Note 1 : The combinations of actions are based on the recommended values given in Annex A2

Note 2 : Except for roofed bridges, it is assumed that snow loads on road bridges may be assessed as snow loads on the ground.

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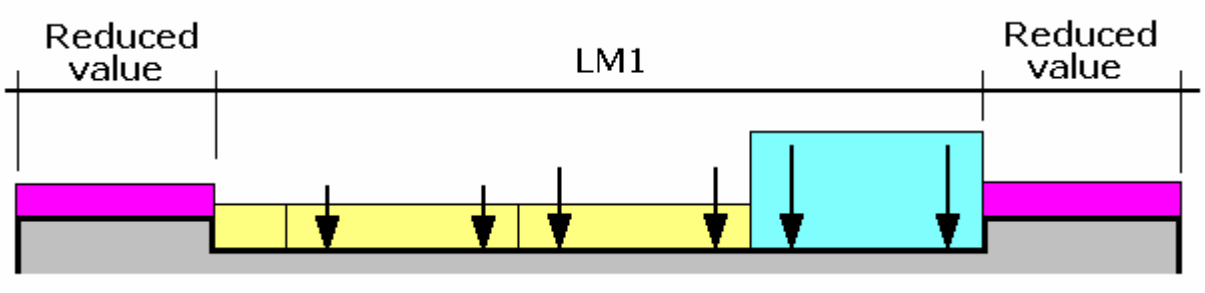
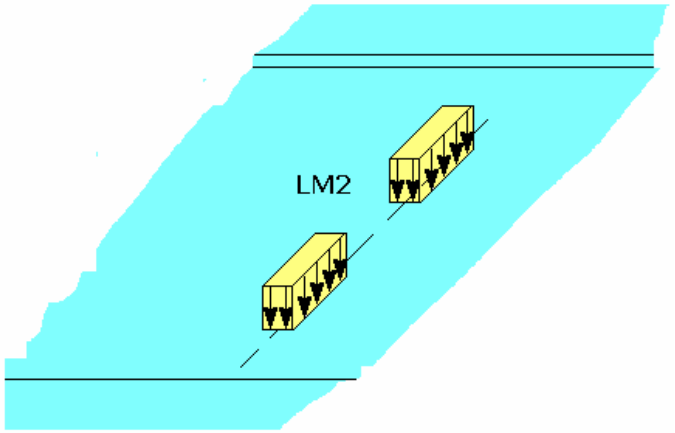
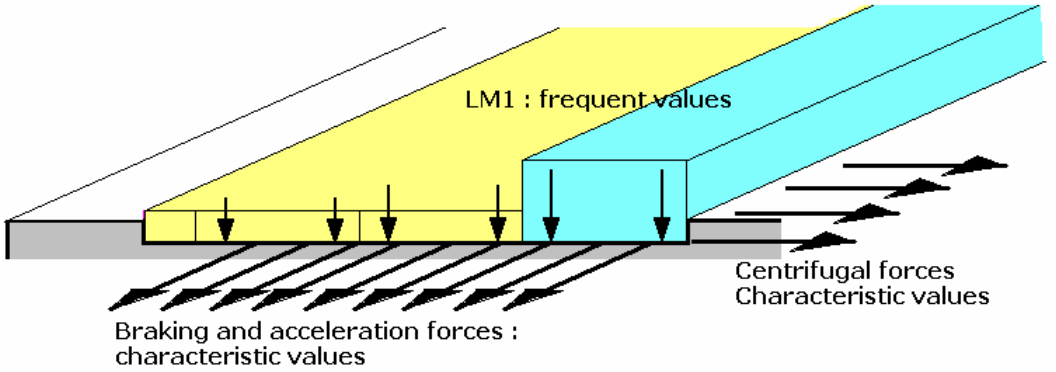
Group of loads gr1a : LM1 + reduced (combination) value of pedestrian and cycle loads



Group of loads gr1b : LM2 (single axle)



Group of loads gr2 : characteristic values of horizontal forces, frequent values of LM1



EN 1990 – Section 6, Annexes A1 & A2

Group of loads gr3 : loads on footways and cycle tracks

Crowds packed Sydney Harbour Bridge yesterday to celebrate the sixtieth anniversary of its opening. During the three-hour closure to traffic, people were shoulder to shoulder from the north to the south approaches of the bridge

Group of loads gr4 : crowd loading

Group of loads gr5 : special vehicles

(+ special conditions for normal trafic)

EN 1990 – Section 6, Annexes A1 & A2

Action	Symbol		ψ_0	ψ_1	ψ_2
Traffic loads (see EN 1991-2, Table 4.4)	gr1a (LM1+pedestrian or cycle-track loads)[1)]	TS	0,75	0,75	0
		UDL	0,40	0,40	0
		Pedestrian+cycle-track loads [2)]	0,40	0,40	0
	gr1b (Single axle)		0	0,75	0
	gr2 (Horizontal forces)		0	0	0
	gr3 (Pedestrian loads)		0	0	0
	gr4 (LM4 – Crowd loading))		0	0,75	0
	gr5 (LM3 – Special vehicles))		0	0	0
Wind forces	F_{Wk}				
	- Persistent design situations		0,6	0,2	0
	- Execution		0,8	-	0
	F_w^*		1,0	-	-
Thermal actions	T_k		0,6 [3)]	0,6	0,5
Snow loads	$Q_{Sn,k}$ (during execution)		0,8	-	-
Construction loads	Q_c		1,0	-	1,0

1) The recommended values of ψ_0, ψ_1 and ψ_2 for gr1a and gr1b are given for road traffic corresponding to adjusting factors α_{Qi}, α_{qi}, α_{qr} and β_Q equal to 1. Those relating to UDL correspond to common traffic scenarios, in which a rare accumulation of lorries can occur. Other values may be envisaged for other classes of routes, or of expected traffic, related to the choice of the corresponding α factors. For example, a value of ψ_2 other than zero may be envisaged for the UDL system of LM1 only, for bridges supporting severe continuous traffic. See also EN 1998.

2) The combination value of the pedestrian and cycle-track load, mentioned in Table 4.4a of EN 1991-2, is a "reduced" value. ψ_0 and ψ_1 factors are applicable to this value.

3) The recommended ψ_0 value for thermal actions may in most cases be reduced to 0 for ultimate limit states EQU, STR and GEO. See also the design Eurocodes.

Table A2.1

Recommended values of ψ factors for road bridges

EN 1990 – Section 6, Annexes A1 & A2

Persistent and Transient Design Situation	Permanent actions		Prestress	Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable			Main (if any)	Others
(Eq. 6.10)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$

(*) Variable actions are those considered in Tables A2.1 to A2.3.

NOTE 1 The γ values for the persistent and transient design situations may be set by the National Annex.

For persistent design situations, the recommended set of values for γ are :

$\gamma_{G,sup}$ = 1,05

$\gamma_{G,inf}$ = 0,95(1)

γ_Q = 1,35 for road and pedestrian traffic actions, where unfavourable (0 where favourable)

γ_Q = 1,45 for rail traffic actions, where unfavourable (0 where favourable)

γ_Q = 1,50 for all other variable actions for persistent design situations, where unfavourable (0 where favourable).

γ_P = recommended values defined in the relevant design Eurocode.

For transient design situations during which there is a risk of loss of static equilibrium, $Q_{k,1}$ represents the dominant destabilising variable action and $Q_{k,i}$ represents the relevant accompanying destabilising variable actions.

During execution, if the construction process is adequately controlled, the recommended set of values for γ are :

$\gamma_{G,sup}$ = 1,05

$\gamma_{G,inf}$ = 0,95(1)

γ_Q = 1,35 for construction loads (0 where favourable)

γ_Q = 1,50 for all other variable actions, where unfavourable (0 where favourable)

…….

Table A2.4(A) Design values of actions (EQU) (Set A)

Table A2.4(B) - Design values of actions (STR/GEO) (Set B)

Persistent and transient design situation	Permanent actions		Prestress	Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable			Main (if any)	Others
(Eq. 6.10)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(Eq. 6.10a)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$		$\gamma_{Q,1} \psi_{0,1} Q_{k,1}$	$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(Eq. 6.10b)	$\xi \gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1} Q_{k,1}$		$\gamma_{Q,i} \psi_{0,i} Q_{k,i}$
(*) Variable actions are those considered in Tables A2.1 to A2.3.						

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1) The recommended values of ψ_0 , ψ_1 ,and ψ_2 for gr1a and gr1b are given for road traffic corresponding to adjusting factors α_{Qi} , α_{qi} , α_{qr} and equal to 1. Those relating to UDL correspond to common traffic scenarios, in which a rare accumulation of lorries can occur. Other values may be envisaged for other classes of routes, or of expected traffic, related to the choice of the corresponding α factors. For example, a value of ψ_2 other than zero may be envisaged for the UDL system of LM1 only, for bridges supporting a severe continuous traffic. See also EN 1998.

2) The combination value of the pedestrian and cycle-track load, mentioned in Table 4.4a of EN 1991-2, is a “reduced” value. ψ_0 and ψ_1 factors are applicable to this value.

3) The recommended ψ_0 value for thermal actions may in most cases be reduced to 0 for ultimate limit states EQU, STR and GEO. See also the design Eurocodes.

Table A2.4(C) - Design values of actions (STR/GEO) (Set C)

Persistent and Transient Design Situation	Permanent actions		Prestress	Leading variable action (*)	Accompanying variable actions (*)	
	Unfavourable	Favourable			Main (if any)	Others
(Eq. 6.10)	$\gamma_{Gj,sup} G_{kj,sup}$	$\gamma_{Gj,inf} G_{kj,inf}$	$\gamma_P P$	$\gamma_{Q,1}\ Q_{k,1}$		$\gamma_{Q,i}\ \psi_{0,i} Q_{k,i}$

(*) Variable actions are those considered in Tables A2.1 to A2.3

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

$\gamma_{G,sup}$ = 1,00

$\gamma_{G,inf}$ = 1,00

γ_{Gset} = 1,00

γ_Q = 1,15 for road and pedestrian traffic actions where unfavourable (0 where favourable)

γ_Q = 1,25 for rail traffic actions where unfavourable (0 where favourable)

γ_Q = 1,30 for the variable part of horizontal earth pressure from soil, ground water, free water and ballast, for traffic load surcharge horizontal earth pressure, where unfavourable (0 where favourable)

γ_Q = 1,30 for all other variable actions where unfavourable (0 where favourable)

γ_{Gset} = 1,00 in case of linear elastic or non linear analysis, for design situations where actions due to uneven settlements may have unfavourable effects. For design situations where actions due to uneven settlements may have favourable effects, these actions are not to be taken into account.

γ_P = recommended values defined in the relevant design Eurocode.

Fundamental combinations of actions based on expression 6.10

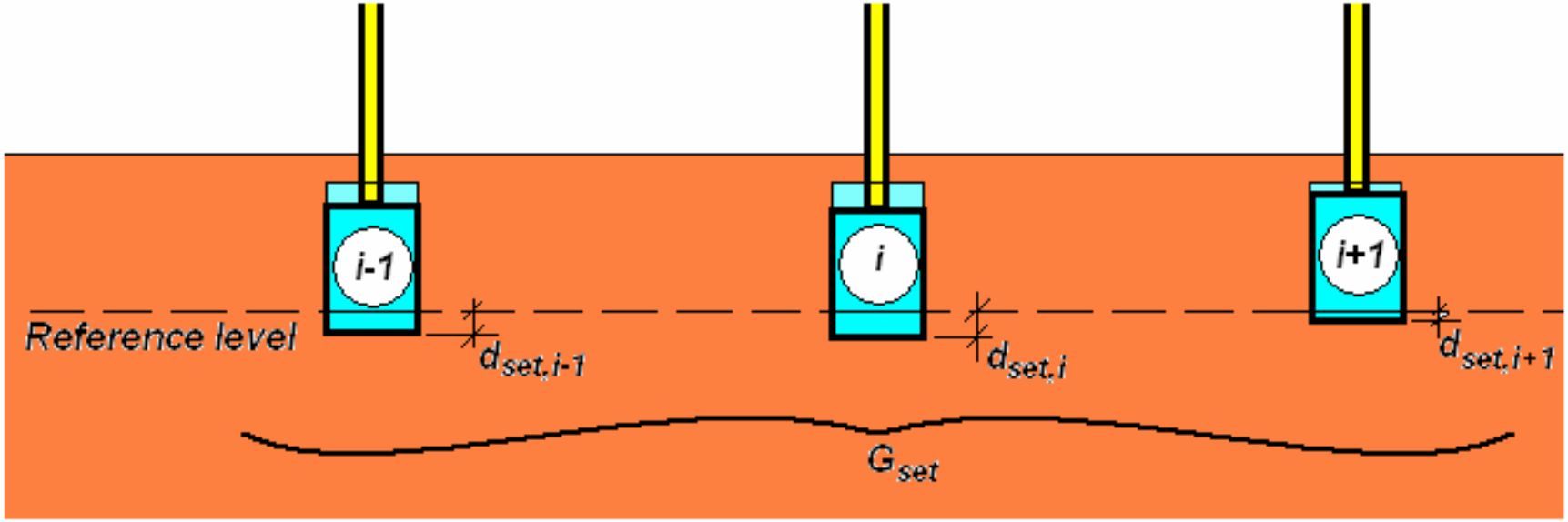
$$\left\{\sum_{j\geq 1}(1{,}35G_{kj,\sup}\text{ "+" }1{,}00G_{kj,\inf})\right\}\text{"+"}\gamma_P P_k\text{"+"}\begin{cases}\overbrace{1{,}35(TS+UDL+q^*_{fk})}^{\text{gr1a}}+1{,}5\times 0{,}6F_{Wk,traffic}\\ 1{,}35\,gri_{i=1b,2,3,4,5}\\ 1{,}5T_k+1{,}35(\underbrace{0{,}75TS+0{,}4UDL+0{,}4q^*_{fk}}_{\psi_0\text{gr1a}})\\ 1{,}5F_{Wk}\\ 1{,}5Q_{Sn,k}\end{cases}$$

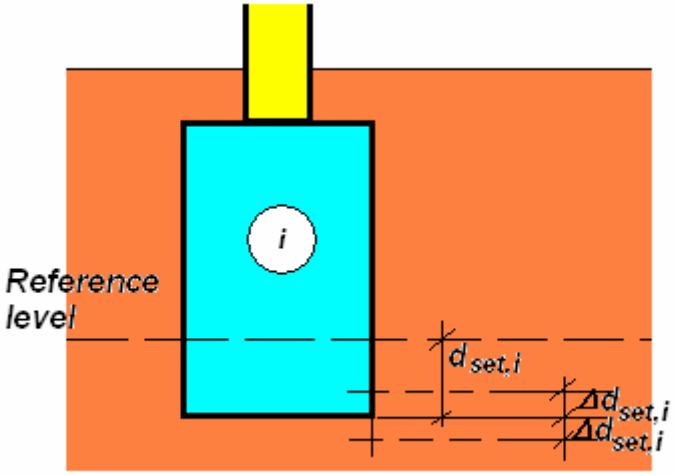
q^*_{fk} **Reduced value of the load on footways for group gr1a – To be defined in the National Annex (for example : 2,5 kN/m²)**

P_k **Prestressing : Definition in design Eurocodes. Usually P = P_m et γ_P = 1**

G_{set} **Uneven settlements to be taken into account where relevant, with γ_{Gset} = 1,20 or 1,00 in case of linear analysis.**

Representation of the action of uneven settlements Gset.





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Characteristic combinations of actions

$$\left\{\sum_{j\geq 1}\left(G_{kj,\sup}\text{"+"}G_{kj,\inf}\right)\right\}\text{"+"}P_k\text{"+"}\left\{\begin{array}{l}\overbrace{\left(TS+UDL+q^*_{fk}\right)\text{"+"}0{,}6F_{Wk,traffic}}^{\mathbf{gr1a}}\\ gri_{i=1b,2,3,4,5}\text{"+"}0{,}6T_k\\ gr1b\\ T_k\text{"+"}\underbrace{\left(0{,}75TS+0{,}4UDL+0{,}4q^*_{fk}\right)}_{\boldsymbol{\psi_0}\mathbf{gr1a}}\\ F_{Wk}\\ Q_{Sn,k}\end{array}\right.$$

P_k Characteristic value of the prestressing force

G_{set} Uneven settlements to be taken into account where relevant

Frequent combinations of actions

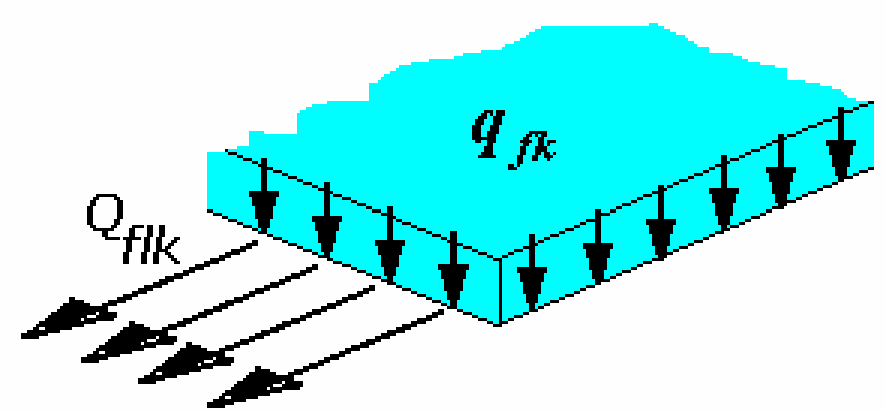
$$\left\{\sum_{j\geq 1}(G_{kj,\sup}\text{"+"}G_{kj,\inf})\right\}\text{"+"}P_k\text{"+"}\begin{cases}(0{,}75TS+0{,}4UDL)\text{"+"}0{,}5T_k\\0{,}75gr1b\\0{,}75gr4\text{"+"}0{,}5T_k\\0{,}6T_k\\0{,}2F_{Wk}\\0{,}5Q_{Sn,k}\end{cases}$$

Quasi-permanent combinations of actions

$$\left\{\sum_{j\geq 1}(G_{kj,\sup}\text{"+"}G_{kj,\inf})\right\}\text{"+"}P_k\text{"+"}0{,}5T_k$$

EN 1991-2 – Groups of loads for footbridges

Group of loads gr1



Group of loads gr2

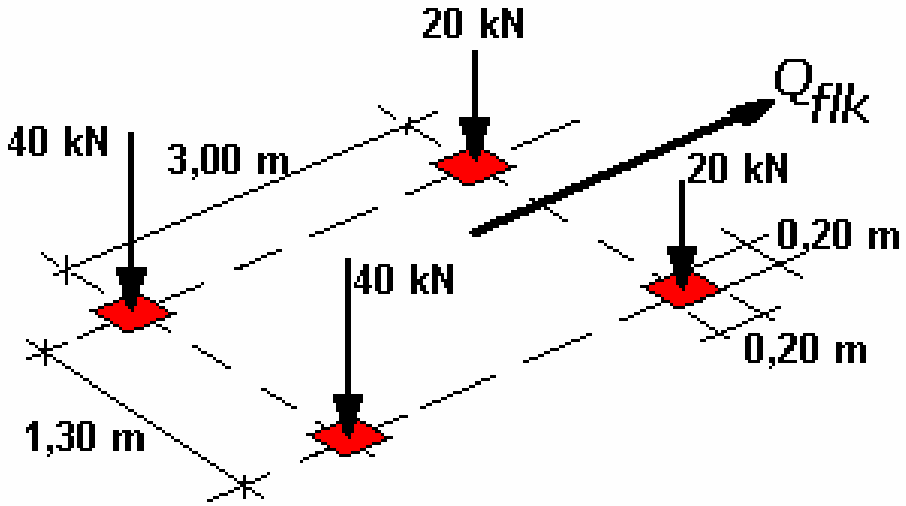


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Table A2.2

Recommended values of ψ factors for footbridges

Action	Symbol	ψ_0	ψ_1	ψ_2
Traffic loads	gr1	0,40	0,40	0
	Q_{fwk}	0	0	0
	gr2	0	0	0
Wind forces	F_{Wk}	0,3	0,2	0
Thermal actions	T_k	0,6 [1)]	0,6	0,5
Snow loads	$Q_{Sn,k}$ (during execution)	0,8	-	0
Construction loads	Q_c	1,0	-	1,0

1) The recommended ψ_0 value for thermal actions may in most cases be reduced to 0 for ultimate limit states EQU, STR and GEO. See also the design Eurocodes.

Fundamental combinations of actions based on expression 6.10

$$\left\{\sum_{j\geq 1}\left(1{,}35G_{kj,\sup}\text{"+"}1{,}00G_{kj,\inf}\right)\right\}\text{"+"}\gamma_P P_k\text{"+"}\begin{cases}1{,}35gr1\text{"+"}1{,}5\times 0{,}3F_{Wk}\\1{,}35gr2\text{"+"}1{,}5\times 0{,}3F_{Wk}\\1{,}35Q_{fwk}\\1{,}5T_k\text{"+"}1{,}35\times 0{,}4gr1\\1{,}5F_{Wk}\\1{,}5Q_{Sn,k}\end{cases}$$

P_k **Prestressing : Definition in design Eurocodes. Usually P = P_m et γ_P = 1**

G_{set} **Uneven settlements to be taken into account where relevant, with γ_{Gset} = 1,20 or 1,00 in case of linear analysis.**

Frequent combinations of actions

$$\left\{\sum_{j\geq 1}(G_{kj,\sup}\text{"+"}G_{kj,\inf})\right\}\text{"+"}P_k\text{"+"}\begin{cases}0{,}4gr1\text{"+"}0{,}5T_k\\0{,}6T_k\\0{,}2F_{Wk}\\0{,}8Q_{Sn,k}\end{cases}$$

Quasi-permanent combinations of actions

$$\left\{\sum_{j\geq 1}(G_{kj,\sup}\text{"+"}G_{kj,\inf})\right\}\text{"+"}P_k\text{"+"}0{,}5T_k$$

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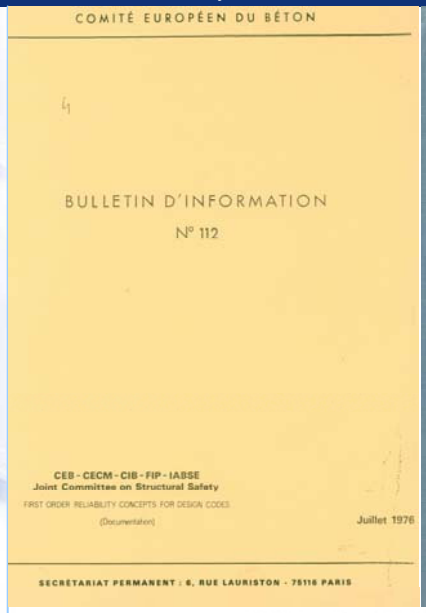

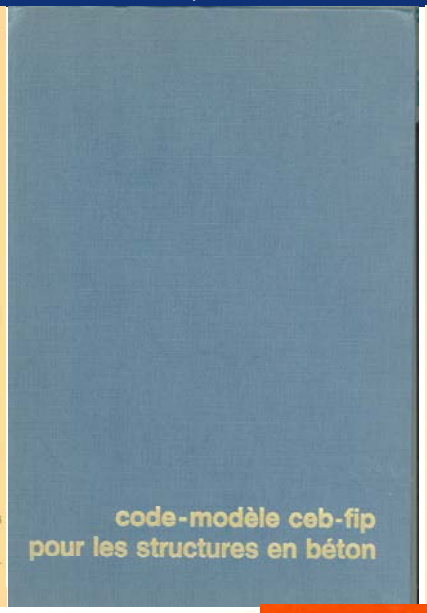

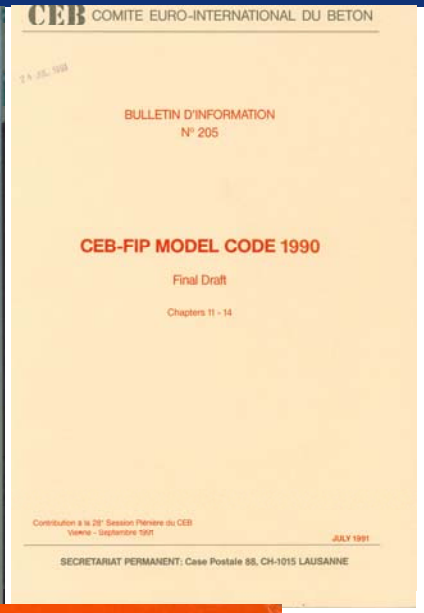

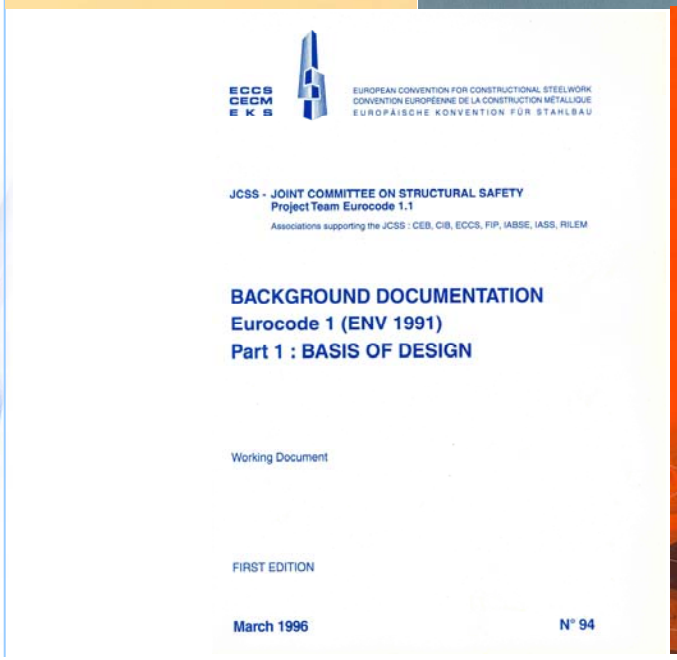

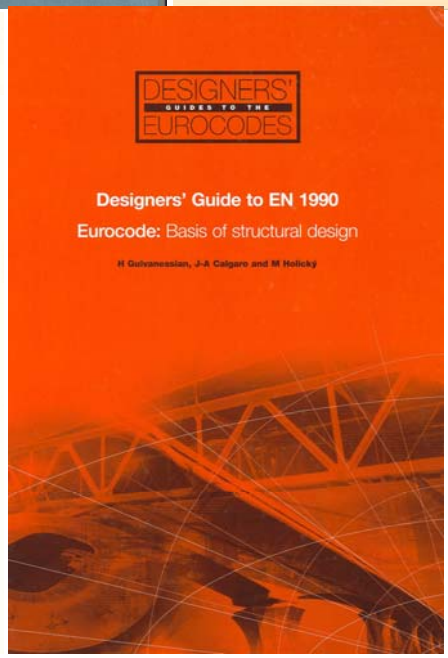

Some dates and backgrounds

Thank you for your attention