The discussion of the contents of Eurocode EN 1990

General provisions

The chapter includes the principles and requirements concerning safety, serviceability and durability of the structure, the basis for their calculations and verification, as well as the guidelines with regard to assuring the reliability of the structure. The design in compliance with the principles and rules of application is assumed to fulfill the requirements, on condition that the requirements given by the EN 1990 to EN 1999 have been fulfilled.

The general provisions of EN 1990 are as follows:

- The structural framework was chosen, and the structure design was developed by appropriately qualified and experienced personnel,
- The construction work is performed by appropriately qualified and experienced personnel,
- An appropriate supervision and quality control are ensured during construction, i.e. in the design office, plants, and on the construction site,
- Building materials and products are used in compliance with EN 1990 or with EN 1991 to 1999, with appropriate standards regarding construction, or reference documentation, or in compliance with technical specifications,
- The structure will be maintained in an appropriate technical condition,
- The use of the structure will be in compliance with the design provisions.

The above provisions are valid also for our building and engineering practice. However, they have not been presented in such a way in design standards.

Requirements

The basic requirement includes such a design and structure construction, that in a foreseen service period, with a proper reliability and with no excessive costs:

- it will take over all actions and impacts which one can expect to appear during construction and the service period, and
- it will remain useful for the foreseen service period.

Furthermore, it is required that the structure is designed and constructed in a way assuring that following a local damage as a result of an explosion, impact and human factor, the structure will not be damaged in an unparalleled way with regard to the initial cause. It is also specified how one should avoid or limit the possibility of damaging the structure thanks to a proper selection of adequate safety mechanisms.

- limiting, eliminating or reducing the hazard, which the structure can be exposed to;
- choosing the structure with low susceptibility to potential dangers;
- choosing the structure and calculating it in such a way, that it would withstand after a loss of a single element or a part of a structure;
- avoiding, as much as it can be, structures which can be destroyed without prior warning;
- interconnection of structure elements with each other.

It is recommended that the basic requirements will be fulfilled as a result of

- proper material selection,
- proper design and calculation of the structure and developing the structure details and
- establishing control procedures regarding design, production, construction and use, proper for a given design.
- skillful and scrupulous structure design development, using current knowledge and practical experience.

The fulfillment of the requirements may be achieved not only through designing according to the EN standards, but also through proper activities concerning the quality assurance, (reliability management), with differentiating between levels of the structure reliability, selection of the designed service period, with assuring the expected durability, as well as activities concerning the quality assurance. It concerns mainly organizational and control enterprises during all stages of the constructional process. These issues were widely discussed both in the standard as well as in the informative Annex B. It shows a certain philosophy in order to assure the reliability trough:

1. Design in compliance with EN 1990 to EN 1999,

2. Proper realization,
3. Use of measures for quality assurance .

While verifying the limiting states there are three calculation situations:

- Permanent, corresponding to normal use conditions,
- Transient, corresponding to conditions during construction or fixing,
- Exceptional, corresponding to conditions resulting from exceptional load (explosion, impact, etc.,)

Rules of design according to limiting states

Design according to the limiting states method is conducted after considering calculation models of the structure and loads corresponding to given calculation situations and taking into consideration in those calculation models load values, material properties and geometrical data.

The notions are corresponding to those adopted in the Polish standards as well as in PN ISO 2394.

Basic variables

Basic variables, similarly as in PN-76/B-03002, are actions, material properties and geometrical data.

There are two kinds of actions:

- Direct actions, e.g. forces (loads) applied to the structure,
- Indirect actions, e.g. forced deformations caused by temperature or humidity level changes, or uneven settlement.

Additionally, similarly to the Polish standards, actions are classified according to:

- Changes in time (permanent – G, e.g. deadweight of the structure, systems and fixed equipment, variable Q, e.g. functional load, wind load, snow load, or after a car impact),
- Variability in space (free and bounded),
- Action character (static and dynamic).
- Some actions, e.g. after earthquake, may be treated as variable or exceptional.

While verifying limiting states there are four **representative load values**:

- Characteristic values Q_k,
- Combination values Y 0 Q_k, taking into consideration simultaneity of loads appearing (for verification of limiting states of load bearing capacity and irreversible functional limiting states),
- Frequent values y 1 Q_k, used while verifying limiting states of load bearing capacity taking into consideration exceptional actions and while checking reversible limiting states;

- Quasi-permanent values y 2 Q_k, used while checking limiting states of load bearing capacity taking into consideration exceptional actions and while checking irreversible functional limiting states. Quasi-permanent values are used also for calculating long term effects.

The definitions of these values are thus a bit widened in comparison do the definitions given in PN-76/B-030001.

The main representative value is a characteristic value of action F_k, which is described as:

- an average value, top value, or bottom value, or as a nominal value (which does not refer to a known statistical distribution);

- In the design documentation as well as according to the standard collection EN 1991.

The characteristic value of permanent action should be established in the following way:

if the variability G can be considered small, one can use a one, single G_k value; in case of structure very sensitive to variability G (e.g. certain kinds of compressed concrete structures), it is recommended to consider two values, even when the variability coefficient is small. G_k , inf is then a 5 % quantile, and G_k , sup is a 95 % quantile statistical distribution, which can be used in a Gaussian form.

The structure deadweight can be described as s single characteristic value and it can be calculated for nominal measurements and average unit weight, according to EN 1991-1-1.

The characteristic value of variable action (Q_k) is described in the same way as that according to PN-76/B-03001, as:

- Top value with assumed probability, that it will not be exceeded, or bottom value with assumed probability, that it will be reached in a defined return period; or
- Nominal value, which can be assumed in case when the statistical distribution is not known.

For loads of floor/ceilings of buildings quasi-permanent value is determined in such a way, so that the time during which the value is exceeded, does not constitute less then 0.5 of the reference period. The quasi-permanent value may also be established as an average value of a chosen period of time. In case of wind action or road traffic load, the quasi-permanent value is usually taken as zero.

Material properties are described using characteristic values corresponding to the defined (5%) probability of not being exceeded in tests with a hypothetically unlimited number of samples. In case of the lack of statistical data, nominal values are assumed.

Geometrical data are described with nominal values according to the design. More detailed provisions are specified in EN 1992 to EN 1999.

Analysis of the structure and design supported by tests

The chapter includes provisions regarding building and engineering structures modeling in order to determine the **effects of actions** (internal forces and deformations) and **load bearing capacity**. These provisions are generally in compliance with the provisions of the Polish standards. Additionally, the requirements regarding design considering fire conditions and design supported by tests are emphasized. The recommendations are general in nature with references to detailed recommendations specified in EN 1991 to EN 1999.

The calculations should be performed using appropriate structure models considering important variables. It is recommended that one should use structure models allowing the determination of the structure behavior with acceptable accuracy. It is also recommended that they are proper for considered limiting states. Moreover, it is stressed that the structure models are established according to the acknowledged theory and engineering practice, and if it is necessary, that they are verified in experiments.

Modeling of actions should be based on appropriately selected dependencies between force and deformation of the structure elements and their actions with the base. The assumed boundary conditions in the model should represent conditions existing in the structure. The structure model used for calculation of effects of actions should take into consideration all the essential structure elements and the influence of all basic variables .

The effects of dislocations and deformations should be taken into consideration while verifying load bearing limiting states, when they significantly increase the effects of the actions.

The calculations of the fire resistance of the structure should be based on a calculated fire scenario (according to EN 1991-1-2 "Fire caused actions") and take into consideration models of temperature changes inside the structure, as well as rules of mechanics of the structure exposed to high temperatures. The behavior of the structure exposed to high temperatures is recommended to be evaluated according to EN 1992 to EN 1996 and EN 1999, in which the temperature and structure calculation models were specified. It is recommended that the models of mechanical behavior of the structures under fire conditions were not linear.

The designing can be performed based on **tests and calculations**. The tests may be needed, for instance:

- If it is not possible to use proper calculation models;
- If a great number of the same elements are used;

- In order to confirm the assumptions made in calculations.

The measuring supported by test results should assure the reliability level required for a specific calculation situation. It is necessary to take into consideration statistical uncertainty resulting from limited number of test results. It is recommended to use partial coefficients (including those considering the uncertainty of the model), which can be compared to partial coefficients specified in EN 1991 to EN 1999.

Analysis of the structure and design supported by tests

The general rules of verification are identical to those from the Polish standards. A number of changes have been introduced concerning describing limiting states and rules of combinations of actions.

The following limiting states of load bearing can be described:

a) **EQU:** The loss of a static equilibrium of the structure, or any part of it which is recognized as rigid, when

- Small changes of values or distribution in the actions area, induced by a single cause, are significant
- Structure materials strength or base strength do not generally matter;

b) **STR:** Internal damage or excessive deformations of the structure, or structure elements, including foundations, piles, subsurface walls etc., in the case of which structure materials strength is of a great importance;

c) GEO : Damage or excessive base deformations, when base or rock strength is of a significant importance with regard to the load bearing capacity of the structure;

d) **FAT:** Wear off damage of the structure or the structural element.

The combinations of actions in the case of permanent or transient calculation situations (basic combinations) take a general form :

$$E_d = \gamma_{Sd} E\{\gamma_{g,j} G_{k,j}; \gamma_p P; \gamma_{q,1} Q_{k,1}; \gamma_{q,i} \psi_{0,i} Q_{k,i}\} \quad j \geq 1; i > 1 \qquad (6.9a)$$

It is recommended that the combination of the effects of the actions included

- Calculation values of the leading variable actions, as well as
- Calculation combination of the accompanying values of the variable actions:

$$E_d = E\{\gamma_{G,j} G_{k,j}; \gamma_P P; \gamma_{Q,1} Q_{k,1}; \gamma_{Q,i} \psi_{0,i} Q_{k,i}\} \quad j \geq 1; i > 1 \qquad (6.9b)$$

Expression (6.9b), although presented in a slightly different form, is identical to that according to PN-82/B-02003.

The combination of actions given in brackets { } in (6.9b) can 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, alternately, for limiting states STR and GEO, as a less favorable expression of the two given below

$$\left\{ \begin{array}{l} \\ \sum_{j\geq 1}\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}\psi_{0,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \end{array} \right. \quad (6.10a)$$

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

where:

„+" – means "should be considered in combination with"
Σ- means "combined effect"
ξ - reduction coefficient for unfavorable permanent actions G

Further information concerning this choice is given in Annex A.

If the relationship between the actions and their effects is non linear, it is recommended to use expression (6.9a) or (6.9b) directly, depending on relative accumulation of the actions effects compared to the increase of the extent of actions (see also 6.3.2(4)).

The combination of actions in the case of exceptional calculation situations takes a general form :

$$E_d = E\{G_{k,j};P;A_d;(\psi_{1,1}\text{ lub }\psi_{2,1})Q_{k,1};\psi_{2,i}Q_{k,i}\} \quad j\geq 1; i>1 \quad (6.11a)$$

The combination of actions given in brackets { } can be also expressed as

$$\sum_{j\geq 1}G_{k,j}"+"P"+"A_d"+"(\psi_{1,1}\text{ lub }\psi_{2,1})Q_{k,1}"+"\sum_{i>1}\psi_{2,i}Q_{k,i} \quad (6.11b)$$

It is recommended to choose between y 1,1 Q_k,1 and y 2,1 Q_k,1 appropriately to the reliable calculation situation (impact, fire, the structure condition after an exceptional event). The guidelines are presented in the corresponding parts of EN 1991 to 1999.

The combination of actions in the case of seismic calculation situatiF_k**ons** should be expressed as follows

It is recommended that the general form of the actions effect be as follows

$$E_d = E\{G_{k,j};P;A_{Ed};\psi_{2,1}Q_{k,i}\} \quad j\geq 1; i\geq 1 \quad (6.12a)$$

The combination of actions given in brackets can be expressed as

$$\sum_{j\geq 1}G_{k,j}"+"P"+"A_{Ed}"+"\sum_{i\geq 1}\psi_{2,i}Q_{k,i} \quad (6.12b)$$

In the Polish conditions the combination (6.12) refers to quasi-seismic actions in the mining damage areas.

Partial coefficients for actions and combinations of actions are recommended to be used with values of the coefficients g and y in compliance with EN 1991 and Annex A.

Partial coefficients for materials and products are recommended to be used according to EN 1992 to EN 1999.

While checking the functional limiting states the deformations should be determined in the way presented in the appropriate part of Annex A, regarding deformations specified in EN 1991 to EN 1999.

The combinations of actions for functional limiting states are symbolically determined by the below expressions, where all partial coefficients are equal to 1. There are the following actions combinations:

a) characteristic combination

$$E_d = E\{G_{k,j}; P; Q_{k,1}; \psi_{0,1} Q_{k,i}\} \quad j \geq 1; i \geq 1 \qquad (6.14a)$$

where, the combination of actions presented in brackets { } (called characteristic combination) can be expressed as

$$\sum_{j\geq 1} G_{k,j} \text{"+"} \text{"}P\text{"+"} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{0,i} Q_{k,i} \qquad (6.14b)$$

The characteristic combination is usually used for irreversible limiting states.

b) frequent combination

$$E_d = E\{G_{k,j}; P; \psi_{1,1} Q_{k,1}; \psi_{2,1} Q_{k,i}\} \quad j \geq 1; i > 1 \qquad (6.15a)$$

where, the combination of actions, given in brackets { } (called frequent combination) can be expressed as

$$\sum_{j\geq 1} G_{k,j} \text{"+"} \text{"}P\text{"+"} \psi_{1,1} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{2,i} Q_{k,i} \qquad (6.15b)$$

The frequent combination is usually applied for reversible limiting states.

c) quasi-permanent combination

$$E_d = E\{G_{k,j}; P; \psi_{2,1} Q_{k,i}\} \quad j \geq 1; i \geq 1 \qquad (6.16a)$$

where, the combination of actions, given in brackets { } (called quasi-permanent combination) can be expressed as

$$\sum_{j\geq 1} G_{k,j} \text{"+"} \text{"}P\text{"+"} \sum_{i\geq 1} \psi_{2,i} Q_{k,i} \qquad (6.16b)$$

Quasi-permanent combination is usually applied for evaluation of long term effects and the look of the structure. It corresponds to the long term loads according to PN-82/B-02000 "Building loads. The rules of value determination".

Partial coefficients for materials. For functional limiting states it is recommended to use partial coefficients g M for materials equal to 1.0, with the exception of cases when in EN 1992 to EN 1999 was stated otherwise.

Annex A1
(normative)

Provisions with regard to buildings

Annex A1 presents rules and methods of establishing combinations of actions on buildings. It also includes recommended calculation values of permanent, transient and exceptional actions, as well as coefficients y to be used in building calculations. The values are recommended values, which can be changed in the National Annex.

Recommended values of coefficients y for commonly appearing actions can be taken from Table A 1.1.

Table A 1.1 Recommended values of coefficients y for buildings

Actions	**0**	**1**	**2**
Variable load in buildings, category (see EN 1991-1-1)			
Category A: habitable space	0.7	0.5	0.3
Category B: office space	0.7	0.5	0.3

Category C: meeting space	0.7	0.7	0.6
Category D: commercial space	0.7	0.7	0.6
Category E: warehouse space	1.0	0.9	0.8
Category F: vehicles traffic space			
vehicles <= 30 kN	0.7	0.7	0.6
Category G: vehicles traffic space			
30 kN < vehicle weight <= 160 kN	0.7	0.5	0.3
Category H: roofs	0	0	0.0
Snow load (see EN 1991-1-3) *)			
Finland, Island, Norway, Sweden	0.70	0.50	0.20
Other countries CEN, places located at elevations H > 1000 m over see level	0.70	0.50	0.20
Other countries CEN, places located at elevations H <= 1000 m over see level	0.50	0.20	0.20
Wind load (see EN 1991-1-4)	0.6	0.2	0
Temperature (non fire) in building (see EN 1991-1-5)	0.6	0.5	0
NOTE: Values y may be determined in National Annex *) Valid for countries not mentioned below – see reliable local conditions.			

It is recommended that the calculation action values for limiting states of the load bearing capacity in permanent and transient situations (expressions 6.9a to 6.10b) be established in compliance with Tables A1.2(A) to (C). While using Tables A1.2(A) to A1.2(C), when, the limiting state depends, to a great extent, on permanent action values, it is recommended to take top and bottom characteristic values.

Static equilibrium (EQU) of the building structure should be checked using action calculation values, listed in Table A1.2(A).

Structure elements calculations (STR), which do not take into consideration geotechnical actions, should be verified, using action calculation values, listed in Table A1.2(B). Structure elements calculations (foundation footings, piles, subsurface walls, etc.) (STR) which take into consideration geotechnical actions and ground load bearing capacity (GEO), should be verified, using one of the following three approaches, supplemented, as far as geotechnical actions and load bearing capacity are concerned, with provisions listed in EN 1997:

- Approach 1 : Calculation values from Table A1.2(C) and calculation values from Table A1.2(B) are used in separate calculations, both for geotechnical actions, as well as for other actions applied to the structure, or originated within the structure. Usually the measuring of foundations is performed based on Table A1.2(C), and load bearing capacity of the structure based on Table A1.2(B);

- Approach 2 : Calculation values from Table A1.2(B) are used for geotechnical, as well as for other actions;

- Approach 3 : Calculation values from Table A1.2(C) are used for geotechnical actions, utilizing at the same time partial coefficients from Table A1.2(B) for other actions applied to the structure or originated within the structure.

The application of approach 1.2 or 3 is determined in the National Annex.

Permanent and transient calculation situations	**Permanent actions**		**Leading variable action(*)**	**Accompanying variable actions**	
	Unfavorable	Favorable		Main (if existing)	Other
(Expression 6.10)	$\gamma_{Gj,sup}G_{kj,sup}$	$\gamma_{Gj,inf}G_{kj,inf}$	$\gamma_{Q,1}\ Q_{k,1}$		$\gamma_{Q,1}\ \psi_{0,i}Q_{k,i}$

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

NOTE 1 Values γ may be specified in the National Annex.

Recommended values are listed below:

$\gamma_{Gj,sup}$ = 1.10
$\gamma_{Gj,inf}$ = 0.90
$\gamma_{Q,1}$ = 1.50 if unfavorable (0 if favorable)
$\gamma_{Q,i}$ = 1.50 if unfavorable (0 if favorable)

NOTE 2 When the process of verifying the static equilibrium takes into account also the load bearing capacity of structure elements, it is possible – if permitted by the National Annex – instead of double checking using Table A1.2(A) and A1.2(B) – perform a single check, using Table A1.2(A) with the following recommended values set:

$\gamma_{Gj,sup}$ = 1.35
$\gamma_{Gj,inf}$= 1.15
$\gamma_{Q,1}$ = 1.50 if unfavorable (0 if favorable)
$\gamma_{Q,i}$ = 1.50 if unfavorable (0 if favorable)

The recommended values may be changed in the National Annex, on condition that, when g Gj,inf = 1.00 both for favorable and unfavorable part of permanent actions, there are no less favorable effects.

Table A1.2(B) – Calculation values of actions (STR/GEO) (set B)

Permanent and transient calculation situations	**Permanent actions**		**Leading variable action**	**Accompanying variable actions (*)**	
7	Unfavorable	Favorable		Main (if existing)	Other
(Expression 6.10)	$\gamma_{Gj,sup}G_{kj,sup}$	$\gamma_{Gj,inf}G_{kj,inf}$	$\gamma_{Q,1}\ Q_{k,1}$		$\gamma_{Q,1}\ \Psi_{0,i}Q_{k,i}$
Permanent and transient calculation situations	**Permanent actions**		**Leading variable action(*)**	**Accompanying variable actions (*)**	
	Unfavorable	Favorable W		Main (if existing)	Other
(Expression 6.10a)	$\gamma_{Gj,sup}G_{kj,sup}$	$\gamma_{Gj,inf}G_{kj,inf}$		$\gamma_{Q,1}\ \Psi_{0,1}Q_{k,1}$	$\gamma_{Q,1}\ \Psi_{0,i}Q_{k,i}$
(Expression 6.10b)	$\zeta\gamma_{Gj,sup}G_{kj,sup}$	$\gamma_{Gj,inf}G_{kj,inf}$	$\gamma_{Q,1}Q_{k,1}$		$\gamma_{Q,1}\ \Psi_{0,i}Q_{k,i}$
(*) Variable actions are those included in Table A1.1.					

NOTE 1 The selection of 6.10 or 6.10a and 6.10b will be presented in the National Annex. In the case of 6.10a and 6.10b the National Annex may additionally change 6.10a, introducing only permanent actions.

NOTE 2 Values g and x may be presented in the National Annex. Recommended values g and x to be used in expressions 6.10 or 6.10a and 6.10b are given below:

$\gamma_{Gj,sup} = 1.35$

$\gamma_{Gj,inf} = 1.00$

$\gamma_{Q,1} = 1.50$ if unfavorable (0 if favorable)

$\gamma_{Q,i} = 1.50$ if unfavorable (0 if favorable)

$\zeta = 0.85$ (so that $\zeta\gamma_{Gj,sup} = 0.85 \times 1.35 \approx 1.15$).

See also EN 1991 to EN 1999 regarding values g for forced deformations.

NOTE 3 The characteristic values of all permanent actions, originating from a single source, is multiplied by g G,sup if the total resulting effect is unfavorable, by g G,inf , when the effect is favorable. For instance, all actions originating from structure's own weight may be considered as coming from a single source; it is valid when materials are different.

NOTE 4 In the case of a specific verifying of values g G and g Q can be divided into g g and g q and coefficient g Sd taking into account model uncertainty. Values g Sd are usually within the range from 1.05 to 1.15 and may be differentiated in the National Annex.

Permanent and transient calculation situations	**Permanent actions**		**Leading variable action**	**Accompanying variable actions (*)**	
	Unfavorable	Favorable		Main (if existing)	Other
(Expression 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 included in Table A1.1.

NOTE Values g may be presented in the National Annex. Recommended values are given below:

$\gamma_{Gj,sup} = 1.00$
$\gamma_{Gj,inf} = 1.00$
$\gamma_{Q,1} = 1.30$ if unfavorable (0 if favorable)
$\gamma_{Q,i} = 1.30$ if unfavorable (0 if favorable)

It is recommended that the values of partial coefficients for actions in load bearing capacity limiting states in exceptional and seismic calculation situations (expressions from 6.11a to 6.12b) be equal to 1.0. Values y are given in Table A1.1.

Table A1.3 – Calculation values of actions assumed for exceptional and seismic action combinations

Calculation situation	**Permanent actions**		**Leading exceptional or seismic action**	**Accompanying variable actions (**)**	
	Unfavorable	Favorable		Main (if existing)	Other
Exceptional (*) (expression 6.11a/b)	$G_{kj,sup}$	$G_{kj,inf}$	A d	Ψ_{11} or Ψ_{21} Q_{k1}	Ψ_{11} or Ψ_{21} Q_{k1} $\Psi_{2,i}$ $Q_{ki,i}$
Seismic (expression 6.12a/b)	$G_{kj,sup}$	$G_{kj,inf}$	γ_I A_{Ek} or A_{Ed}	$\Psi_{2,i}$ $Q_{k,i}$i	
(*) In the case of exceptional calculation situations, the value of the main variable action may be determined by considering it as a frequent action, or – as in seismic combination of actions – as a quasi-permanent action. The selection will be presented in the National Annex, respective to the kind of assumed exceptional action. See also EN 1991-1-2. (**)Variable actions are those included in Table A1.1.					

Table A1.4 – Calculation values in combination of actions

Combination	**Permanent actions G d**		**Variable actions Q d**	
	Unfavorable	Favorable	Leading	Other
Characteristic	$G_{kj,sup}$	$G_{kj,inf}$	$G_{kj,inf}$	$\Psi_{0,i}$ $Q_{k,i}$
Frequent	$G_{kj,sup}$	$G_{kj,inf}$	$\Psi_{1.1}$ $Q_{k,1}$	$\Psi_{2,i}$ $Q_{k,i}$
Quasi-permanent	$G_{kj,sup}$	$G_{kj,inf}$	$\Psi_{2.,}$ $Q_{k,1}$	$\Psi_{2,i}$ $Q_{k,i}$

It is recommended that functional limiting states be defined by applying such criteria as, e.g. ceiling/floor rigidity, differences of ceiling/floor level, shift of the floor level, and/or displacement of the building, and ceiling/floor rigidity.

The rigidity criteria may be limits of vertical deflection or vibrations. The limits of horizontal displacement may be the horizontal displacement criteria.

Annex B
(informative)

Reliability management of building objects

Practical recommendations EN 1990 introduce:

- Notion of consequence class defined according to Tab. B1,

Table B1. Definition of consequence class

Consequence class	Description	Examples of engineering building structures
CC1	**High** risk to human life and **very severe** economic and environmental consequences	Auditoria, public utility buildings, whose destruction brings about severe consequences
CC2	**Medium** risk to human life and **significant** economic and environmental consequences	Habitable and office buildings and public utility buildings, whose destruction brings about medium consequences
CC3	**Low** risk to human life and **small or insignificant** economic and environmental consequences	Agricultural buildings where people normally are not present and greenhouses

- Recommended target values of reliability coefficients b assigned to reliability classes according to Tab. .B2,

Table B2. Recommended target values of reliability coefficients b

Reliability classes	Minimal target values b	
	1 year reference period	**50 year reference period**
RC3	>= 5.2	>= 4.3
RC2	>= 4.7	>= 3.8
RC1	>= 4.2	>= 3.3

- The values of “validity” coefficients K FI for differentiating reliability through correction of partial safety coefficients for actions according to Tab. B3,

Table B3. Values of “validity” coefficients K FI

Validity coefficient for actions	Reliability classes		
	RC1	**RC2**	**RC3**
K_{F1}	0.9	1.0	1.1

differentiation of supervision levels during designing, according to Tab. B4,

Table B4. Differentiation of design supervision levels

Design supervision levels	Characteristics	Minimal recommended requirements upon verifying calculations, drawings and specifications
DSL 3	Extended supervision	Verifying by a third party, Verifying by another design unit
DSL 2	Normal supervision	Verifying according to procedures of design unit
DSL 1	Normal supervision	Auto-control Verifying by the author of a design

- levels of performance inspections according to Tab. B5.

Table B5. Levels of performance inspections

Inspection levels	Characteristics	Requirements
IL3 Referred to RC3	Extended inspection	Inspection by a third party
IL2 Referred to RC2	Normal inspection	Inspection according to procedures of executive unit
IL1 Referred to RC1	Normal inspection	Auto-inspection

The criterion of classification according to a consequence class according to Tab. B1 is illustrated with examples of structures. It can refer to the whole structure, or its chosen elements with smaller or greater consequences of destruction.

The reliability classes according to Tab. B2 may be identified with consequences classes according to Tab. B1. Basic class (reference) assumed and recommended to be used in particular Eurocodes is class RC2 with target values of reliability indices 3.8 ($p_f \approx 10^{-4}$) during structure life time and 4.7($p_{f1} \approx 10^{-6}$) with regard to one year.

Validity coefficients K_{FI} according to Tab. B3 are used as multipliers for partial safety coefficients for actions during structure design in compliance with normative rules. The differentiation of reliability through the correction of partial coefficients for materials is also allowed.

The differentiation of the supervision levels and quality assurance. Particular levels may be linked with reliability classes according to Tab. B2 and include designers' and/or verifiers' consultants' classification as well as construction authorities depending on their competence, experience and organizational efficiency.

The inspection classes during realization according to Tab. B5 may be linked with reliability classes according to Tab. B2 including appropriate measures of quality assurance. It is stressed, that the inspection levels include both product inspection and works realization inspection. The rules of inspection may differ depending on the construction material used, and they should be expressed in relevant realization standards. It is worth pointing out, that in the case of applying higher inspection class than required according to Tab. B5, it is possible to lower partial safety coefficients for materials, on condition that they are properly justified based on the test results and verification by the third party. Reduction coefficient values K MI may usually fit in the range 0.9 – 1.0.

Reliability indicators in the form of reliability indicators b are determined assuming the function of the limiting state as:

$$Z = g(X1\ X2\ X3\ ,...)$$

or in the form of a subtraction of load bearing capacity R and internal force S

$$Z = R(X\ i) - S(X\ j)$$

where X i, X j are basic random variables determining the material properties, geometrical measurements, actions, inaccurateness of calculation hypotheses, etc., are interpreted as probability of destruction p f (Fig. 1) (or does not fulfill the functional requirements p fu). In the simplified methods of the II kind, to the values p f and p fu reliability indicators can be assigned (safety and serviceability) b and b u defined according to the formula:

$$\beta = z_m/\sigma_z$$

and, there is a dependency between the measures

$$pf=p(Z\leq 0)=\Phi(-\beta)$$

where z m and s z is an average value and a standard deviation of the random variable Z a F (- b) Laplacea's function.

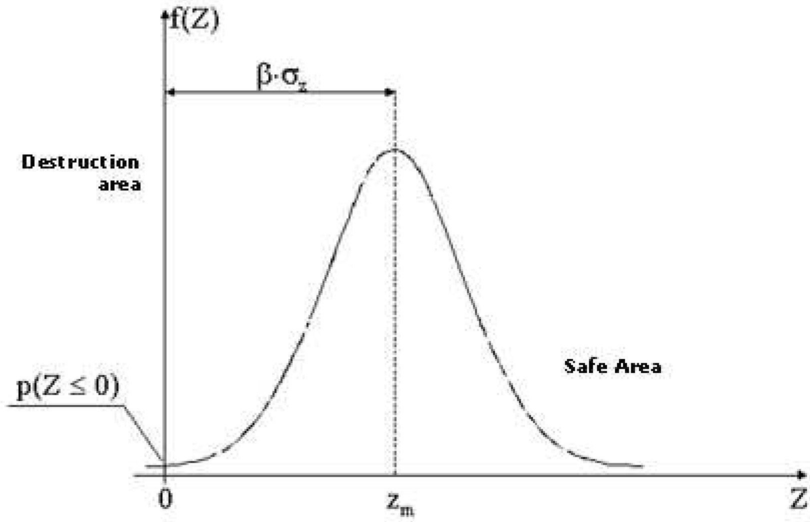


Fig. 1. Interpretation of the structure reliability indicators in the load bearing capacity limiting state: a) according to formula (1a) - p f=p(Z £ 0) , b) according to formula (1b) - p f=p(R ³ S)

Annex C
(informative)

Basis of analysis of reliability according to the partial coefficient method

The Annex includes provisions regarding to calibration of partial safety coefficients with probabilistic methods. These methods are also recommended for probabilistic direct design.

In the presented versions of EN partial coefficients are established based on practical experience.

Annex D
(informative)

Design supported by tests

Part of calculations, especially regarding new types of structures, can be performed using the test results. In such cases, it is required that the structure reliability be not less than according to the recommendations of EN 1990 to EN 1999. The Annex lists rules for tests and rules for probabilistic results interpretation.

Discussion of the contents of EN 1990

Chapter 1. General provisions

The scope of the standard covering the rules and requirements regarding establishing the permanent load in buildings is determined. Compared to the Polish equivalent PN-82/B-02003, it introduces certain changes regarding especially characteristic load values, depending on the way of using the space.

Chapter 3. Calculation situations

It is recommended to consider calculation situations properly according to provisions of EN 1990.

Chapter 4. Volume weights of building and component materials

Characteristic values of the weights of building and component materials should be established in compliance with the provisions of EN 1990 according to Annex A.

Chapter 5. Building structures' own weight

The kinds of permanent loads are differentiated and the ways of establishing, the same as in PN-82/B-02003, based on nominal measurements and volume weights given in Annex A.

Chapter 6. Functional loads in buildings

An essential part of the chapter is devoted to the characteristic values of functional loads determined depending on the category (way of utilization) of rooms' surface according to 6.1.

Table 6.1- Use categories

Category	Specific use	Example
A	Habitable areas	Rooms in habitable buildings and in houses, rooms and halls in hospitals, rooms in hotels, kitchens, toilets
B	Office space	.
C	Areas where people can gather (excluding areas specified according to categories A,B i D 1)	**C1:** Areas with tables, etc., e.g. in schools, coffee bars, restaurants, dinners, reading rooms, reception desks. **C2:** Areas with fixed seats, e.g. in churches, theatres, cinemas, conference rooms, lecture rooms, meeting rooms, waiting rooms, railway waiting rooms **C3:** Areas without obstacles which could impede people's movements, e.g. in museums, exhibition rooms, etc., as well as freely accessible areas in public utility and administration buildings, hotels, hospitals, railway areas. **C4:** Areas with possible physical activities, e.g. dance rooms, gymnastic halls, stages. **C5** .

		Areas generally accessible for crowds, e.g. in public utility buildings such as concert halls, sports halls, excluding auditoria, terraces and approach areas and railway platforms.
D	Commercial areas	**D1** : Areas in retail stores **D2** : Areas in shopping malls.
1) Point 6.3.1.1(2) is emphasized, especially in reference to C4 and C5. If dynamic effects are to be considered, see EN 1990. In the case of category E, see Table 6.3. .		
NOTE 1 Depending on the foreseen use, areas from categories C2, C3, C4 may be included in category C5 based on the decision of the investor and/or based on the National Annex. NOTE 2 The National Annex may establish subcategories A, B, C1 to C5, D1 and D2 NOTE 3 With regard to warehouse areas and industrial activity areas, see 6.3.2		

The categories of loaded areas listed in Table 6.1 should be determined assuming characteristic values of evenly distributed loads q k and concentrated Q_k according to Table 6.2.

Table 6.2 Functional loads of floor/ceilings, balconies and stairs in buildings

Categories of loaded surfaces	q_k **[kN/m 2]**	Q_k **[KN]**
Category A		
-Floor/ceilings	1.5 to 2.0	2.0 to 3.0
-Stairs	2.0 to 4.0	2.0 to 4.0
-Balconies	2.5 to 4.0	2.0 to 3.0
Category B	2.0 to 3.0	1.5 to 4.5
Category C		
-C1	2.0 to 3.0	3.0 to 4.0
-C2	3.0 to 4.0	2.5 to 7.0 (4.0)
-C3	3.0 to 5.0	4.0 to 7.0
-C4	4.5 to 5.0	3.5 to 7.0
-C5	5.0 to 7.5	3.5 to 4.5
Category D		
-D1	4.0 to 5.0	3.5 to 7.0(4.0)
-D2	4.0 to 5.0	3.5 to 7.0

If it is necessary, it is recommended to increase in calculations the values q k and Q_k (e.g. for stairs and balconies depending on the way of use and sizes).

If the floor/ceiling structure allows for a perpendicular load distribution, moveable division walls' own weight may be considered as uniformly distributed load q_k, and it is recommended to add it to functional loads established according to Table 6.2. The value of evenly distributed load determined in this way depends on the division walls' own weight and is as follows:

- In the case of moveable division walls with their own weight ≤ 1,0 kN/m of the wall's length:

q_k=0,50 kN/m 2;

- In the case of moveable division walls with their own weight ≤ 2,0 kN/m of the wall's length:

q_k=0,80 kN/m 2;

- In the case of moveable division walls with their own weight ≤ 3,0 kN/m of the wall's length:

q_k=1,20 kN/m 2.

The given values of loads from division walls are close to the values according to PN-82/B-02003. Heavier division walls should be designed considering:

- location and location direction;
- the kind of the floor/ceiling structure.

The recommended value of the reduction coefficient due to the size of the room area α_A for categories A to E is determined by the formula:

$$\alpha_A = (5/7)\,\psi_0 + (A_0/A) \leq 1.0 \qquad (6.1)$$

with limitation for categories C and D: $\alpha_A \geq 0.6$

where:

ψ_0 is a coefficient according to EN 1990 Annex A1 Table A1.1
$A_0 = 10.0\ m^2$
A is a load surface

In categories A to D, the total functional load of piles and walls from many floors may be multiplied by the reduction coefficient α_n . The recommended values α_n are determined by the formula:

$$\alpha_n = [2+(n-2)\,\psi_0]/n \qquad (6.2)$$

where:

n- number of floors (>2) over loaded structural elements of the same category.
ψ_0 - according to EN 1990, Annex A1, Table A1.1.

Values α_A and α_n are very close to the values according to PN-82/B-02003.

Annex A
(informative)

The characteristic values of the volume weights are generally little different from those specified by PN-82/B-02003. The differences regard mainly the ranges of those weights.

Annex B
(informative)

Vehicles barriers and limiting walls on parking lots

The Annex specifies the rules of determination of loads originating from vehicles on barriers and limiting walls on parking lots.

Drafts of the Polish National Annexes to EN 1990 and EN 1991-1-1

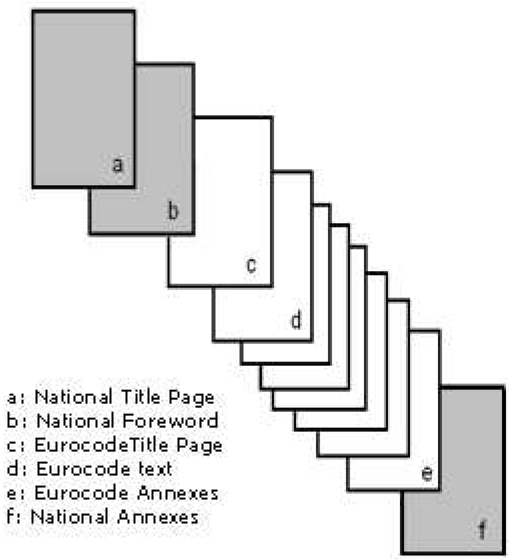
The national standards implementing particular sets and parts of the Eurocodes should include full text and its annexes published by CEN. They may be preceded by the National Title Page and the National Foreword and they may be supplemented with the National Annex including all specific changes of the numerical values in the form of parameters determined by the national authorities. The pictorial contents of the part of Eurocodes to be implemented in member states are illustrated in Fig. 2.

The National Annexes should include:

- parameters determined by national normative authorities, whose numerical values are different than those published by CEN,

- decisions concerning the implementation of informative annexes given in particular parts of Eurocodes.

The National Annexes cannot change or modify the contents of particular EN, with the exception of clearly declared situations when the "choice" of parameters determined by national normative organizations is possible. For instance, in EN 1990 all partial safety coefficients are given in the form of symbols, whose recommended values are included in "NOTES". In such case, the recommended values can be adopted in the National Annex, or alternative values based on national experiences and design tradition can be given.



Technical Committee PKN/TK 102 developed drafts of National Annexes to EN 1990 and EN 1991-1-1. Annex to EN 1991-1-1 does not introduce significant changes concerning the characteristic load values given in current standards PN-82/B-2002 and PN 82/B-02003. All recommended load values specified in particular Tables were adopted, with the exception of Table 6.2, in which the values that are not lower than the bottom ones from a given range, were adopted. In this way, a high consistency of these values with the values in current Polish standards was achieved. However, some commentary is necessary to the National Annex to the EN 1990, according to which a load combination should be considered in compliance with expressions (6.10a) and (6.10b) EN 1990.

It is easily noticeable, that the expressions (6.10) and (6.10b) are in accordance with expressions for basic combination according to PN-82/B-02000. However, the expression (6.10a) is quite controversial, and already the first variable load reduces in the ratio of combination coefficient w y 0,1 (with values usually from 0.6 to 0.7). It is a totally arbitrary rule, since formally there is no load combination in the case of a single variable load action only. It just regards a certain internal forces reduction due to over exceeding the permanent load action (g G =1.35), which is achieved through decreasing action of the variable loads (in relation to combination coefficient y 0,1 with values usually from 0.6 to 0.7)

The value of coefficient x , according to Annex A1 to EN 1990, is 0.85. That is why, functional formulas of the internal forces values (for simplification purposes, excluding P forces from compression) take the following form:

$$1.35\sum_{j\geq 1} G_{k,j} \text{"+"} 1.50 Q_{k,1} \text{"+"} 1.50 \sum_{i>1} \psi_{0,i} Q_{k,i} \qquad (6.10)$$

or, alternately, for limiting states STR and GEO, as a less favorable value calculated from the following two expressions

$$1.35\sum_{j\geq 1} G_{k,j} \text{"+"} 1.50 \psi_{0,1} Q_{k,1} \text{"+"} 1.50 \sum_{i>1} \psi_{0,i} Q_{k,i} \qquad (6.10a)$$

$$1.15\sum_{j\geq 1} G_{k,j} \text{"+"} 1.50 Q_{k,1} \text{"+"} 1.50 \sum_{i>1} \psi_{0,i} Q_{k,i} \qquad (6.10b)$$

Formulas (10) and (10b) are, with the exception of the numerical coefficients values, identical to those given in PN-82/B-02000, according to which, instead of 1.35 in the formula (6.10) there is "on average" 1.15, and instead of 1.50 there are values from the range from 1.2 to 1.4 (1.2 for functional characteristic loads exceeding 3.0 kN/m 2, 1.3 for wind load and 1.4 for functional characteristic loads up to 3.0 kN/m 2 and for snow load). The closest internal forces values according to recommendations of EN 1990 and PN-82/B-02000 are achieved using expression (6.10b) with the value g Q =1.4.

In the practical calculations all components of expressions (6.10), (6.10a) and (6.10b) should be multiplied by coefficients of actions transforming loads into internal forces. In the comparison calculations these coefficients can be assumed to be equal to one.

The comparison of the internal forces according to expressions (6.10), (6.10a) and (6.10b) assuming coefficients of actions transforming loads into internal forces to be equal to one, were given in Fig. 3. From the presented chart it follows that the values S according to PN are closest to the values according to EN 1990 assuming the expression (6.10b) within the range (Q_k/G_k exceeding 0.375 with y $\psi_{0,1}$=0.6 and 0.533 with $\psi_{0,1}$=0.7. Within the range (Q_k/G_k up to 0,375 with $\psi_{0,1}$=0.6 and 0.533 with $\psi_{0,1}$=0.7, in which the expression (6.10a) is binding, the internal forces according to EN 1990 are higher. The highest value of the relation of these forces with $\Sigma Q_k/\Sigma G_k$ =0 is 1.17. The expression ((6.10a) is therefore binding when permanent loads determine the internal forces values, and the expression (6.10b) when variable loads determine the internal forces values. The best solution would be adopting in the National Annex γ_G = 1.15 and γ_Q=1.40 in the case of adopting the expression (6.10b), which in such case would correspond to the expression (6.10). If, however, for the sake of harmonization of the provisions the expression (6.10b) and γ_Q=1.50 were adopted, then the line (2) within the whole range Q_k/G_k would be very close to line (4) with γ_G = 1.15 and γ_Q=1.40. In such case, one could expect that when the expression (6.10b) is applied the internal forces values calculated according to EN 1990 would be, at least grater than the relation of values S according to lines (3) and (4), which are within the range from 1.04 with $?_Q$=1.40 to 1.13 with $?_Q$=1.20. If one takes into consideration, that the load from the walls is perceived as variable load, which should be added to the functional load (resulting in a greater calculation value of combined load since $©_Q$ > $©_G$), then the increase of internal forces could be estimated within the range from 5 to 15%. When applying the expression (6.10a), i.e. in the case of dominating influence of permanent loads, the increase could be estimated about 10%.

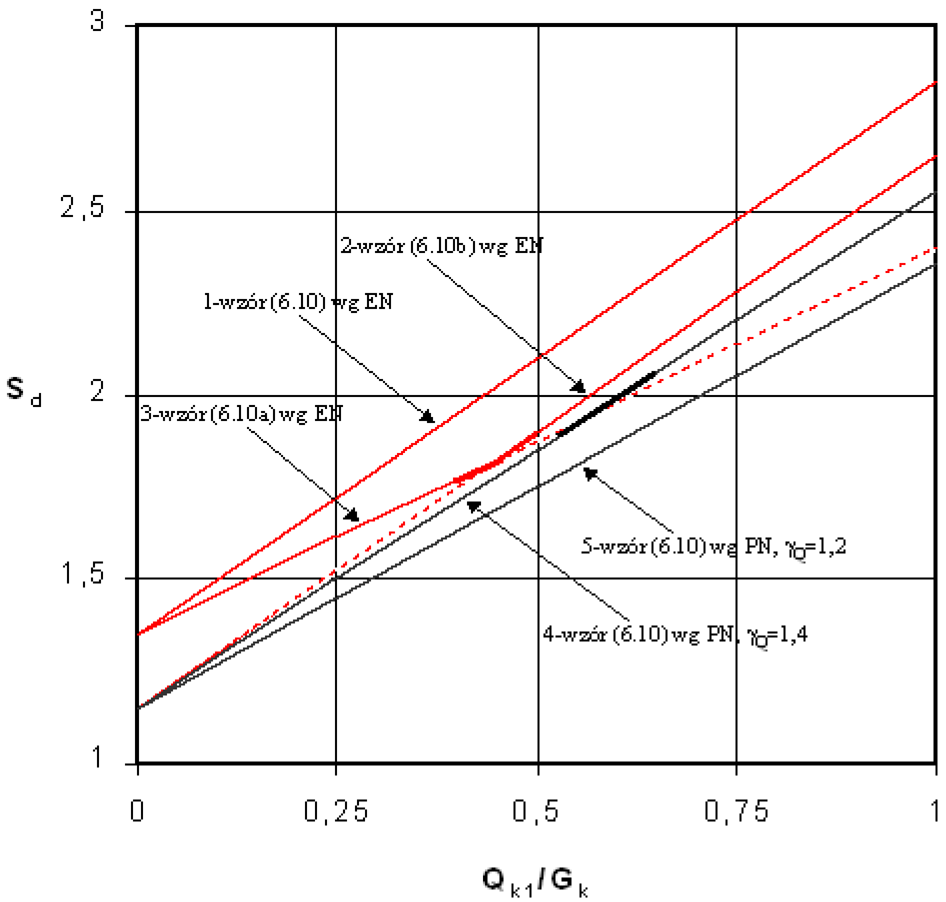


Fig. 3. Comparison of internal forces $S(Q_k/G_k)$ according to expressions (6.10), (6.10a) and (6.10b) assuming influence coefficients transforming loads into internal forces equal to one ($\psi_{0,1} = 0.7$) according to different rules of loads combinations recommended in EN 1990 (EN) and adopted in the current Polish standards (PN)

Summary

The basic differences in provisions of EN 1990 and EN 1990 in relation to the corresponding current Polish standards PN-76/B-03001 and standards from series PN-82/B-02000 include:

- characteristic load values, generally greater or not smaller according to Eurocodes,
- partial safety coefficients values, always greater according to Eurocodes .
- other rules of load combinations,
- lower load combinations coefficients according to EN 1990,
- differentiation of reversible and irreversible functional limiting states.
- introduction in Eurocodes a number of new notions (e.g. representative loads, load categories, calculation situations, etc.).

The application of structure Eurocodes EN 1990 and EN 1991-1-1 with the Polish National Annexes, significantly reduces the differences in values of internal forces in relation to forces determined according to the Polish standards binding up to now. If, following the survey, both Polish Annexes are accepted, then internal forces increase calculated according to EN 1990 and EN 1991-1-1 will be from 5 to several percent. In most cases, this increase will be closer to the bottom limit. Significantly better conformity could be achieved applying in the National Annex the up-to-now (the highest) value of the partial safety coefficient for variable loads, which is equal to 1.4.

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