Design of concrete structures according Eurocodes - practice 1

I. Common technique of Design of concrete structures - short introduction
II. Structural model of a structure and structural elements
III. Loads

I. Common technique of Design of concrete structures – short introduction

1. In first step during the design of concrete structure it is necessary to identify Structural model (geometry) of a structure of its individual structural elements. It means, that is necessary to find idealization of the structure for following static or mechanic calculation. The most important part of it is to identify individual members of a complex structure and assign it’s effective span length and conditions of support.

2. In second step is necessary to identify Loads (actions) impact on the structure or of its individual structural elements. It means, that is absolutely necessary to find all actions (loads, forces, temperature changes etc.), which can act on the structure during its service life.

3. Next step is to identify effects of the loads by structural analysis using the methods of statics a structural mechanics. There are following main effects:
   - so called force effects: normal (axial) forces - marking N, shear forces V (former marking Q), flexural moments M and torsion moments T.
   - forced deformations like flexure, settlements of the supports, cracks in concrete etc.


II. Structural model of a structure and structural elements

As we know from the introduction, the task of structural model analysis is to identify individual members of a complex structure and assign its effective span length and conditions of support. Division of structures into individual members serves for simplification of structural analysis. The most frequent basic and simple types of members are: girders, columns, slabs, and walls (+ arches and shells).

II. 1. Basic structural elements

Girder is a beam member with span \( l \geq 3 \ h \), where \( h \) is the height of girder’s cross-section. Otherwise is this member classified as a wall.

Column is a member with the height of cross-section \( h \leq 4b \) where \( b \) is the width of the cross-section. In the same time the span of the column \( l \) has to be \( l \geq 3h \).

Slab is a member with planar dimensions at least five times greater then its thickness (=height of the slab \( h_s \)). If the supporting structure is linear (e.g. wall) and the ratio of the planar slab dimensions \( \leq 2 \), the slab can be designed as “one-way slab”. It means as a slab with one bearing direction. Only one bearing direction exists also if two parallel margins are not supported.

Both girders and columns are beam members; the difference between them is in the way of the dominant stressing. Similarly for slabs and walls, which both are planar members.

II. 2. Conditions of support

Another important part of structural model analysis is determination of conditions of support. There are some basic different types of the support (as we know from the statics): fixed end, hinged (shifting, non-shifting) etc. By concrete structures are the real conditions of support usually „something between“ these, from the statics point of view clean, conditions. But as a simplification we usually consider the nearest clean type of the support.
The most important fact for finding these simplifications is the ability of a member rotate in its support. If rotation is restrained the support is taken as a fixed end, if not - as a hinge. In various codes there are usually sets of hints how to decide about rotational restraint – see following text and figure P1-1. For example by slabs is the support taken as fixed end if the height of the bond ring \( h \) is not greater then \( 2 h_6 \) (height of the slab) - see fig. P1-1. case f).

II. 3. Effective span of girders and slabs in buildings according EN1992-1

The effective span, \( l_{\text{eff}} \), of a member should be calculated as follows:

\[
l_{\text{eff}} = l_n + a_1 + a_2
\]

where:

\( l_n \) is the clear distance between the faces of the supports;

values for \( a_1 \) and \( a_2 \), at each end of the span, may be determined from the appropriate \( a_i \) values in figure P-1.1 where \( t \) is the width of the supporting element as shown.

II. 4. Important possible assumption for structural analysis:

(1) Linear analysis of elements based on the theory of elasticity may be used for both the serviceability and ultimate limit states.

(2) For the determination of the load/action effects, linear analysis may be carried out assuming:

i) uncracked cross sections,

ii) linear stress-strain relationships and

iii) mean values of the elastic modulus.

Note: The above written EN 1992-1 provisions are provided mainly for member (beams, slabs) analysis. For frame analysis (subject L31 in the summer term) some of these simplifications may be used where appropriate.

(3) Continuous slabs and beams may generally be analyzed on the assumption that the supports provide no rotational restraint.

(4) Where a beam or slab is monolithic with its supports, the critical design moment at the support should be taken as that at the face of the support (reduction to the face). The design moment and reaction transferred to the supporting element (e.g. column, wall, etc.) should be taken as the greater of the elastic or redistributed values.

(5) Regardless of the method of structural analysis used, where a beam or slab is continuous over a support which may be considered to provide no restraint to rotation (e.g. over walls - see fig. P-1.1 b)), the design support moment, calculated on the basis of a span equal to the centre-to-centre distance between supports, may be reduced by an amount \( \Delta_{\text{Ed}} M \) as follows:

\[
\Delta_{\text{Ed}} M = F_{\text{Ed, sup}} \cdot t/8
\]

where:

\( F_{\text{Ed, sup}} \) is the design support reaction,

\( t \) is the breadth of the support (see Figure P1-1 case b)).

Note: The moment at the face of the support should not be less than 0.65 that of the full fixed end moment.

III. Loads and actions

Load (loading) is English-speaking countries (ESC) and their technical literature defined as a phenomenon (set of actions) that causes the change in the state of deformation, state of stress and/or a change of the position of the structure and components on which it acts. In the En 1990 is approximately equal wide definition used for the term "action" – see following article:

Action (marking \( F \)) is
b) Set of imposed deformations or accelerations caused for example, by temperature changes, moisture variation, uneven settlement or earthquakes (indirect action).

From this text flows in the same time that the term “load” is in the EN 1990 considered a little bit more limited - for primarily force actions. In this text like as in Eurocodes both term will be used. Mentioned difference between regular ESC English and terminology used in Eurocodes is relatively frequent. In important cases appropriate notices will be given.

III. 1. Classification of load

Load is usually classified according various criteria according actual purpose of classification. Classification according variability in time:

- **Permanent load** \( G, g \). (Dead load (ESC), zatížení stálé) This is a load with constant quantity, layout and orientation (all this conditions must be fulfilled) during the whole service life of the corresponding structure. Permanent load usually is: self weight of the supporting structure and of all permanent parts of construction, permanently acting press of ground etc.

- **Variable load** \( Q, q \). (Live load (ESC), proměnné zatížení). This is a group of all non-permanent actions. These actions can change their quantity, layout and orientation during the service life of the corresponding structure.

- **Quasipermanent load** (long term live load, quasistálé), which is in principle variable load with character close to permanent load. For example build in machinery, fluids and powdery materials in reservoirs etc.

- **Accidental load** \( A \) (mimořádné zatížení) e.g. explosions, impacts of vehicles or aeroplanes, earthquake.

EN 1991 uses parallel to this division into:

- **Self weight** (vlastní hmotnost nosné konstrukce).
- **Imposed loads** (induced load (ESC), užitné zatížení), Imposed loads shall be classified as variable free actions, unless otherwise specified in EN 1991.) Imposed loads on buildings are those arising from occupancy. Values given in this Section, include:
  - normal use by persons;
  - furniture and moveable objects (e.g. moveable partitions, storage, the contents of containers);
  - vehicles;
  - anticipating rare events, such as concentrations of persons or of furniture, or the
  - moving or stacking of objects which may occur during reorganization or redecoration.

Loads can be once more divided according their origin into:

- **Imposed load** – see text above.
- **Self weight** – see text above.
- **Climatic or environmental load:** action of wind and snow (widely all actions of environment - e.g. corrosion)
- **Indirect actions:** e.g. settlement of support, temperature influence, shrinking etc.
- **Assemblage actions:** These are the specific actions induced due the assemblage of construction.

Loads can be also divided according kind of their physical action:

- **Single load** (force) (unit = kN)
- **Areal load** (uniform or not uniform) (unit = kN . m\(^2\))
- **Linear load** (uniform or not uniform) (unit = kN . m\(^{-1}\)) – don’t mix the last two ones!
Time histories of different loads action are displayed on following figure with ESC terminology!

III. 2. Basic parameters of loading

**Characteristic value**
The fundamental parameter of loading (action) is its characteristic value $F_k$. (Another are time variability, direction and orientation and others already mentioned ones.) The characteristic value of load/action is its main representative value. Characteristic values of actions are specified:

1. The characteristic value $F_k$ of an action is its main representative value and shall be specified:
   - as a **mean value**, an upper or lower value, or a **nominal value** (which does not refer to a known statistical distribution);
   - in the project documentation, provided that consistency is achieved with methods given in EN 1991.

2. 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; this consideration will be used in the basic courses of concrete members and structures.
   - if the variability of $G$ cannot be considered as small, two values shall be used: an upper value $G_{k,\text{sup}}$ and a lower value $G_{k,\text{inf}}$.

3. The variability of $G$ may be neglected if $G$ does not vary significantly*) during the design working life of the structure and its coefficient of variation is small. $G_k$ should then be taken equal to the mean value. In such structures the **self-weight of the structure may be represented by a single characteristic value and be calculated on the basis of the nominal dimensions and mean unit masses.**

*) **NOTE**: coefficient of variation can be in the range of 0.05 to 0.10 depending on the type of structure.

4. In cases when the structure is very sensitive to variations in $G$ (e.g. some types of prestressed concrete structures), two values should be used even if the coefficient of variation is small. Then $G_{k,\text{inf}}$ is the 5% fractile and $G_{k,\text{sup}}$ is the 95% fractile of the statistical distribution for $G$, which may be assumed to be Gaussian.

5. For **variable actions**, the characteristic value ($Q_k$) shall correspond to either:
   - an upper value with an intended probability of not being exceeded or a lower value with an intended probability of being achieved, during some specific reference period.
- a nominal value, which may be specified in cases where a statistical distribution is not known.

**Other representative values of variable actions**

Other representative values of a variable action shall be as follows:

a) **The combination value**, represented as a product \( \psi_0 Q_k \), used for the verification of ultimate limit states and irreversible serviceability limit states. Values of \( \psi_0 \), \( \psi_1 \) and \( \psi_2 \) are given in the chart P1-5. The coefficient \( \psi_0 = 1 \) if only one variable load (action) is present.

b) **The frequent value**, represented as a product \( \psi_1 Q_k \), used for the verification of ultimate limit states involving accidental actions and for verifications of reversible serviceability limit states.

c) **The quasi-permanent value**, represented as a product \( \psi_2 Q_k \), used for the verification of ultimate limit states involving accidental actions and for the verification of reversible serviceability limit states. Quasi-permanent values are also used for the calculation of long-term effects.

**NOTE:** For loads on building floors, the quasi-permanent value is usually chosen so that the proportion of the time it is exceeded is 0.50 of the reference period. The quasi-permanent value can alternatively be determined as the value averaged over a chosen period of time. In the case of wind actions or road traffic loads, the quasi-permanent value is generally taken as zero.

**Lecturer notice:** Cases b) and c) will be not actual in the L30 subject.

**Design values of loads/actions**

For design of structures are used so-called “design values” of loads/actions (also of geometrical data and resistance of used materials). Design values have to be on the “safe side” and therefore usually respects more possible risks when compared to characteristic or representative values.

The design value \( F_d \) of a common action (load) \( F \) can be expressed in general terms as:

\[
F_d = \gamma_1 F_{\text{rep}}
\]

with

\[
F_{\text{rep}} = \psi F_k
\]

where:

- \( F_k \) is the characteristic value of the action.
- \( F_{\text{rep}} \) is the relevant representative value of the action.
- \( \gamma_1 \) is a partial factor for the action, which takes account of the possibility of unfavorable deviations of the action values from the representative values. \( \gamma_1 \) will be represented by \( \gamma_0 \) or \( \gamma_0 \) – see table P1-4.
- \( \psi \) is either 1.00 or \( \psi_0 \) or \( \psi_1 \) or \( \psi_2 \). These are factors for combination value of a variable action, which are relevant for different limit states and combination models see text above.

**III. 3. Design values of loads/actions effects**

With help of structural analysis and its methods the effect of load/actions can be identified. It means force effects e.g. normal forces, shear forces, flexural moments etc or deformations.

For computation of this design values of loads/actions and design values of geometrical data have to be used. For common load/action effect \( E_d \) hold true (simplified):

\[
E_d = E \{ \gamma_{r,i} F_{\text{rep},i} ; a_d \} \quad i \geq 1
\]

Where new symbol:

- \( a_d \) is the design value of the geometrical data – see article IV. 1.

**III. 4. Combinations of actions**

The regular situation by design of structures is that there is more then one possible load (type of load)/action which acts on investigated structure. Therefore is necessary to combine these actions together. If more then one variable load is present, there is relatively low probability.
that variable all loads will act in the same time in their full magnitude. This fact is expressed with help of \( \psi \) factors, which reduces the magnitude of accompanying loads. In one alternative case is a permanent load reduced with factor \( \xi \). Which combination rule = formula will be used depends on the task of computation. For usual **ultimate limit states** (ULS) (mezní stavy únosnosti) following formulas are recommended:

\[
\begin{align*}
\sum_{j=1}^n \gamma_{Q,j} G_{k,j} & \cdot \psi_{0,j} \cdot O_{k,j} \ 	ext{ Formula 6.10 (recommended for ULS EQU)} \\
\sum_{j=1}^n \gamma_{Q,j} G_{k,j} & \cdot \psi_{0,j} \cdot O_{k,j} \ 	ext{ Formula 6.10a} \\
\sum_{j=1}^n \xi \gamma_{Q,j} G_{k,j} & \cdot \psi_{0,j} \cdot O_{k,j} \ 	ext{ Formula 6.10b}
\end{align*}
\]

Greater effect is taken into account!

Usage of couple of formulas 6.10a and 6.10b is recommended for design according ultimate limit state STR/GEO = usual case in practice! More about ULS in lectures!

Where:

- "+" implies "to be combined with"
- \( \Sigma \) implies "the combined effect of"
- \( \gamma_{Q,j} \) is a partial factor for the **permanent load/action** \( G_{j} \), which takes account of the possibility of unfavorable deviations of the action values from the representative values. See table P1-4.
- \( \gamma_{Q,1} \) is a partial factor for the **leading (hlavní) variable load/action**, which takes account of the possibility of unfavorable deviations of the action values from the representative values. See tables P1-4a,b,c.
- \( \psi_{0} \) is factor for combination value of an **accompanying (vedlejší) variable action**. See table P1-5.
- \( \xi \) is factor for combination value of a **permanent action**. See table P1-4a.
- \( O_{k,1} \) Characteristic value of the leading variable action \( I \).
- \( O_{k,i} \) Characteristic value of the accompanying variable action \( i \).

Configuration of loads/actions in design situation has to respect the **most unfavorable** (but physically really possible) conditions for investigated part of the structure!!! In simple or simplified cases the combination of loads is their plain addition only.

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**Design values of geometrical data**

Design values of geometrical data such as dimensions of members that are used to assess action effects and/or resistances are usually represented by their nominal values:

\[ a_d = a_{nom} \]

Nominal values for member dimensions are usually **sectional dimensions** of a member from project and calculated **effective spans**.

Where the effects of deviations in geometrical data are significant for the reliability of the structure must be taken in account — more in EN 1990 and EN 1992.

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**Design situations (návrhové situace)**

There is usually more then one type of load, which acts on the structure. Moreover type and magnitude of these loads may differ in different stage of structure’s existence. Therefore structures are primarily designed for one or more design situations. In the EC are defined following design situations:

- **persistent design situations**, which refer to the conditions of normal use;
b) transient design situations, which refer to temporary conditions applicable to
investigated structure, e.g. during execution or repair;

c) accidental design situations, which refer to exceptional conditions applicable to
the structure or to its exposure, e.g. to fire, explosion, impact (car crash, aircraft
crash) or the consequences of localized failure;

d) seismic design situations, which refer to conditions applicable to the structure
when subjected to seismic events.

In this basic course of concrete structures theory we will come out from persistent design
situations only.

EXAMPLE:
Table P1-4a: Design values of actions and their combination based on formulas 6.10a and 6.10b (for STR/GEO) !!recommended!!

<table>
<thead>
<tr>
<th>Persistent and transient design situations</th>
<th>Permanent actions</th>
<th>Leading (hlavní) variable action</th>
<th>Accompanying variable actions (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination formula</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfavourable</td>
<td>Favourable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**6.10a**
\[
\gamma_{ij, sup} G_{kj, sup} \quad \gamma_{ij, inf} G_{kj, inf} \quad \gamma_{Q, i} \psi_{0, i} Q_{k, i} \quad \gamma_{Q, i} \psi_{0, i} Q_{k, i}
\]

**6.10b**
\[
\xi \gamma_{ij, sup} G_{kj, sup} \quad \gamma_{ij, inf} G_{kj, inf} \quad \gamma_{Q, i} Q_{k, i} \quad \gamma_{Q, i} \psi_{0, i} Q_{k, i}
\]

**Important:** max from load combination calculated according 6.10a and 6.10b is taken!

(*) Variable actions are those considered in table P1-5

Notice: In basic courses L30 and L31 for unfavourable action \( G_{kj, sup} \) - simplified marking \( G_{kj} \) will be used.

Recommended values:
\[
\xi = 0,85 \Rightarrow \xi \gamma_{ij, sup} = 0,85 \cdot 1,35 = 1,15
\]
\[
\gamma_{ij, sup} = 1,35 \quad \text{where unfavourable}
\]
\[
\gamma_{ij, inf} = 1,00 \quad \text{where favourable}
\]
\[
\gamma_{Q, i} = 1,50 \quad \text{where unfavourable (0,0 where favourable!)}
\]
\[
\gamma_{Q, i} = 1,50 \quad \text{where unfavourable (0,0 where favourable!)}
\]

For values of \( \psi_0 \) see table P1-5.

**NOTE:** The characteristic values of all permanent actions from one source are multiplied by if the total resulting action effect is unfavourable and \( G_{kj, inf} \) if the total resulting effect is unfavourable and \( G_{kj, inf} \) if the total resulting materials are involved.

Table P1-4b: Design values of actions and their combination based on formula 6.10 (for STR/GEO) -- ! not economical ⇒ not recommended !!

<table>
<thead>
<tr>
<th>Persistent and transient design situations</th>
<th>Permanent actions</th>
<th>Leading (hlavní) variable action</th>
<th>Accompanying (vedlejší) variable actions (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination formula</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfavourable</td>
<td>Favourable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**6.10**
\[
\gamma_{ij, sup} G_{kj, sup} \quad \gamma_{ij, inf} G_{kj, inf} \quad \gamma_{Q, i} Q_{k, i} \quad \gamma_{Q, i} \psi_{0, i} Q_{k, i}
\]

(*) Variable actions are those considered in table P1-5

Notice: In basic courses L30 and L31 for unfavourable action \( G_{kj, sup} \) - simplified marking \( G_{kj} \) will be used.

Recommended values:
\[
\gamma_{ij, sup} = 1,35 \quad \text{where unfavourable}
\]
\[
\gamma_{ij, inf} = 1,00 \quad \text{where favourable}
\]
\[
\gamma_{Q, i} = 1,50 \quad \text{where unfavourable (0 where favourable!)}
\]
\[
\gamma_{Q, i} = 1,50 \quad \text{where unfavourable (0 where favourable!)}
\]

For values of \( \psi_0 \) see table P1-5.

Rev. 2004/2005
Table P1-4c: Design values of actions and their combination based on formula 6.10 (for EQU)

<table>
<thead>
<tr>
<th>Persistent and transient design situations</th>
<th>Permanent actions</th>
<th>Leading (hlavní) variable action</th>
<th>Accompanying (vedlejší) variable actions (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination formula</td>
<td>Unfavourable</td>
<td>Favourable</td>
<td>Others</td>
</tr>
<tr>
<td></td>
<td>$\gamma_{cj, sup} G_{kj, sup}$</td>
<td>$\gamma_{cj, inf} G_{kj, inf}$</td>
<td>$\gamma_{Q_i} Q_{k, l}$</td>
</tr>
<tr>
<td></td>
<td>$\gamma_{Q_i} Q_{0, l}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Variable actions are those considered in table P1-5
Notice: In basic courses L30 and L31 for unfavourable action $G_{kj, sup}$ - simplified marking $G_{kj}$ will be used.

Recommended values:
- $\gamma_{cj, sup} = 1,10$ where unfavourable
- $\gamma_{cj, inf} = 0,90$ where favourable
- $\gamma_{Q_i} = 1,50$ where unfavourable ($0,0$ where favourable!)
- $\gamma_{Q_i} = 1,50$ where unfavourable ($0,0$ where favourable!)

For values of $\psi_0$ see table P1-5.

Table P1-5: Recommended values of $\psi$ factors for buildings
Notice: different factors $\psi_0$, $\psi_1$, $\psi_2$ are used for different design situations and different limit states.

<table>
<thead>
<tr>
<th>Action</th>
<th>$\psi_0$</th>
<th>$\psi_1$</th>
<th>$\psi_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imposed loads in buildings, category (see EN 1991-1-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category A: domestic, residential areas</td>
<td>0,7</td>
<td>0,5</td>
<td>0,3</td>
</tr>
<tr>
<td>Category B: office areas</td>
<td>0,7</td>
<td>0,5</td>
<td>0,3</td>
</tr>
<tr>
<td>Category C: congregation areas</td>
<td>0,7</td>
<td>0,7</td>
<td>0,6</td>
</tr>
<tr>
<td>Category D: shopping areas</td>
<td>0,7</td>
<td>0,7</td>
<td>0,6</td>
</tr>
<tr>
<td>Category E: storage areas</td>
<td>1,0</td>
<td>0,9</td>
<td>0,8</td>
</tr>
<tr>
<td>Category F: traffic area, vehicle weight $\leq$ 30kN</td>
<td>0,7</td>
<td>0,7</td>
<td>0,6</td>
</tr>
<tr>
<td>Category G: traffic area, $30kN &lt;$ vehicle weight $\leq$ 160kN</td>
<td>0,7</td>
<td>0,5</td>
<td>0,3</td>
</tr>
<tr>
<td>Category H: roofs</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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 $H \leq 1000$ 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 $\psi$ values may be set by the National annex.
* For countries not mentioned below, see relevant local conditions.
<table>
<thead>
<tr>
<th>Materials</th>
<th>Density $\gamma$ [kN/m³]</th>
<th>Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete (normal weight plain and underreinforced)</td>
<td>24</td>
<td>+1 kN/m³ for unhardened concrete</td>
</tr>
<tr>
<td>Reinforced and pre-stressed normal weight concrete</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Lightweight: density class LC 1,0 to LC 2,0 (according class</td>
<td>9 to 20</td>
<td></td>
</tr>
<tr>
<td><strong>Mortars an plasters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement mortar</td>
<td>19 to 23</td>
<td>Underlined values are recommended</td>
</tr>
<tr>
<td>Gypsum mortar</td>
<td>12 to 18</td>
<td></td>
</tr>
<tr>
<td>Lime-cement mortar</td>
<td>18 to 20</td>
<td></td>
</tr>
<tr>
<td>Lime mortar or plaster</td>
<td>12 to 18</td>
<td></td>
</tr>
<tr>
<td><strong>Masonry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnt bricks P7 to P20 (no hollows) – lime mortar</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Burnt bricks P7 to P25 (no hollows) – lime -cement mortar</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Burnt bricks CD with hollows</td>
<td>12 to 13,5</td>
<td>See producer’s manual</td>
</tr>
<tr>
<td>Burnt bricks with hollows – different type and producer</td>
<td>12 to 15</td>
<td></td>
</tr>
<tr>
<td><strong>Pavement, leveling layers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stoned pavement</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Teraco pavement</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Asphalt</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Asphalt-concrete</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Cement screed</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td><strong>Wood</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine, spruce, fir, lime wood, alder, aspen</td>
<td>5 to 6</td>
<td></td>
</tr>
<tr>
<td>Larch</td>
<td>6,5 to 8</td>
<td></td>
</tr>
<tr>
<td>Oak, beech, birch, ash tree</td>
<td>7 to 8</td>
<td></td>
</tr>
<tr>
<td>Particleboard</td>
<td>7,5</td>
<td></td>
</tr>
<tr>
<td>Cement bonded particleboard</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Sololit</td>
<td>8,5</td>
<td></td>
</tr>
<tr>
<td>Softwood plywood</td>
<td>5,0</td>
<td></td>
</tr>
<tr>
<td>Birch plywood</td>
<td>7,0</td>
<td></td>
</tr>
<tr>
<td><strong>Infill</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (dry)</td>
<td>15 to 16</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td>15 to 16</td>
<td></td>
</tr>
<tr>
<td>Crushed bricks</td>
<td>12 to 13</td>
<td></td>
</tr>
<tr>
<td>“Keramzit” – not blended</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>– Fine granularity</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>– Coarse granularity</td>
<td>4,5 to 5,5</td>
<td></td>
</tr>
<tr>
<td>“Perlit” EP100 – EP200</td>
<td>1 to 2</td>
<td></td>
</tr>
<tr>
<td><strong>Insulation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polystyren</td>
<td>0,2 to 1,5</td>
<td></td>
</tr>
<tr>
<td>Insulating mattress</td>
<td>1,5 to 2,5</td>
<td></td>
</tr>
<tr>
<td>Tar paper</td>
<td>0,003 to 0,005 kN/m²</td>
<td></td>
</tr>
<tr>
<td>Asphalt roofing felt</td>
<td>0,014 to 0,027 kN/m²</td>
<td></td>
</tr>
<tr>
<td>Asphalt roofing felt “IPA”</td>
<td>0,045 to 0,047 kN/m²</td>
<td></td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>78,5</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass in sheets</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
## Table P1-3: Imposed loads in buildings and their parts acc. ČSN EN 1991-1-1

<table>
<thead>
<tr>
<th>Categories of loaded areas</th>
<th>( q_k ) [kN/m²]</th>
<th>( Q_k ) [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Floors</td>
<td>1,5</td>
<td>1,5</td>
</tr>
<tr>
<td>- Stairs</td>
<td>3,0</td>
<td>3,0</td>
</tr>
<tr>
<td>- Balconies</td>
<td>3,0</td>
<td>3,0</td>
</tr>
<tr>
<td><strong>Category B</strong></td>
<td>2,5</td>
<td>4,0</td>
</tr>
<tr>
<td><strong>Category C</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- C1</td>
<td>3,0</td>
<td>3,0</td>
</tr>
<tr>
<td>- C2</td>
<td>4,0</td>
<td>4,0</td>
</tr>
<tr>
<td>- C3</td>
<td>5,0</td>
<td>4,0</td>
</tr>
<tr>
<td>- C4</td>
<td>5,0</td>
<td>7,0</td>
</tr>
<tr>
<td>- C5</td>
<td>5,0</td>
<td>4,5</td>
</tr>
<tr>
<td><strong>Category D</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- D1</td>
<td>5,0</td>
<td>5,0</td>
</tr>
<tr>
<td>- D2</td>
<td>5,0</td>
<td>7,0</td>
</tr>
<tr>
<td><strong>Stores and industry structures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category E1 – areas for storage</td>
<td>7,5</td>
<td>7,0</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Values for \( q_k \) and \( Q_k \) according national annex (NA) of ČSN EN 1991-1-1 are given in Table P1-3 above. Where a range is given in this table, the value may be set by the National annex. The recommended values, intended for separate application, are underlined. \( q_k \) is intended for determination of general effects and \( Q_k \) for local effects. The National annex may define different conditions of use of this Table.
2. Where necessary \( q_k \) and \( Q_k \) should be increased in the design depending on the accurate knowledge about the structure and its utilization.
3. For local verifications a concentrated load \( Q_k \) acting alone should be taken into account.
4. For concentrated loads from storage racks or from lifting equipment, \( Q_k \) should be determined for the individual case – more ČSN EN 1991-1-1.
5. Where floors are subjected to multiple uses, they shall be designed for the most unfavorable category of loading which produces the highest effects of actions (e.g. forces or deflection) in the member under consideration.
6. Provided that a floor allows a lateral distribution of loads, the self-weight of movable partitions (screens) may be taken into account by a uniformly distributed load \( q_k \) which should be added to the imposed loads of floors obtained from Table P1-3. This defined uniformly distributed load is dependent on the self-weight of the partitions as follows:
   - for movable partitions with a self-weight ≤ 1,0 kN/m wall length: \( q_k = 0,5 \) kN/m²;
   - for movable partitions with a self-weight ≤ 2,0 kN/m wall length: \( q_k = 0,8 \) kN/m²;
   - for movable partitions with a self-weight ≤ 3,0 kN/m wall length: \( q_k = 1,2 \) kN/m².
Heavier partitions should be considered in the design taking account of:
   - the locations and directions of the partitions;
   - the structural form of the floors.
Table P1-2: Categories of use

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific Use</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Areas for domestic and residential activities</td>
<td>Rooms in residential buildings and houses; bedrooms and wards in hospitals; bedrooms in hotels and hostels kitchens and toilets.</td>
</tr>
<tr>
<td>B</td>
<td>Office areas</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Areas where people may congregate (with the exception of areas defined under category A, B, and D¹)</td>
<td>C1: Areas with tables, etc. e.g. areas in schools, cafés, restaurants, dining halls, reading rooms, receptions. C2: Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms. C3: Areas without obstacles for moving people, e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals, railway station forecourts. C4: Areas with possible physical activities, e.g. dance halls, gymnastic rooms, stages. C5: Areas susceptible to large crowds, e.g. in buildings for public events like concert halls, sports halls including stands, terraces and access areas and railway platforms.</td>
</tr>
<tr>
<td>D</td>
<td>Shopping areas</td>
<td>D1: Areas in general retail shops D2: Areas in department stores</td>
</tr>
</tbody>
</table>

¹) Attention is drawn to 6.3.1.1(2), in particular for C4 and C5. See EN 1990 when dynamic effects need to be considered. For Category E, see Table 6.3

NOTE 1 Depending on their anticipated uses, areas likely to be categorised as C2, C3, C4 may be categorised as C5 by decision of the client and/or National annex.

NOTE 2 The National annex may provide sub categories to A, B, C1 to C5, D1 and D2

NOTE 3 See 6.3.2 for storage or industrial activity

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific use</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Areas susceptible to accumulation of goods, including access areas</td>
<td>Areas for storage use including storage of books and other documents.</td>
</tr>
<tr>
<td>E2</td>
<td>Industrial use</td>
<td></td>
</tr>
</tbody>
</table>
Guidelines for determination of effective span and support cond.

(a) Non-continuous members

(b) Continuous members

(c) Supports considered fully restrained

(d) Bearing provided

(e) Cantilever

(f) Conditions of support