CEILING STRUCTURES BS – 06, 07
Building physics basics

- ČSN 730540-2:2011 – U values
- Basic calculation to for exterior wall – fit recommended values!

<table>
<thead>
<tr>
<th>Popis konstrukce</th>
<th>Požadované hodnoty $U_{n,20}$</th>
<th>Doporučené hodnoty $U_{rec,20}$</th>
<th>Doporučené hodnoty pro pasivní budovy $U_{pas,20}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stěna vnější</td>
<td>0,30</td>
<td>těžká: 0,25</td>
<td>0,18 až 0,12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lehká: 0,20</td>
<td></td>
</tr>
<tr>
<td>Střecha strmá se sklonem nad 45°</td>
<td>0,30</td>
<td>0,20</td>
<td>0,18 až 0,12</td>
</tr>
<tr>
<td>Střecha plochá a šikmá se sklonem do 45° včetně</td>
<td>0,24</td>
<td>0,16</td>
<td>0,15 až 0,10</td>
</tr>
<tr>
<td>Podlaha a stěna vytápěného prostoru přílež.</td>
<td>0,45</td>
<td>0,30</td>
<td>0,22 až 0,15</td>
</tr>
<tr>
<td>k zemině 5.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Výplň otvoru ve vnější stěně a strmé střeše, z vytápěného prostoru do venkovního prostředí, kromě dveří</td>
<td>1,5 2)</td>
<td>1,2</td>
<td>0,8 až 0,6</td>
</tr>
<tr>
<td>Šikmá výplň otvoru se sklonem do 45°, z vytápěného prostoru do venkovního prostředí</td>
<td>1,4 7)</td>
<td>1,1</td>
<td>0,9</td>
</tr>
<tr>
<td>Dveřní výplň otvoru z vytápěného prostoru do venkovního prostředí (včetně rámu)</td>
<td>1,7</td>
<td>1,2</td>
<td>0,9</td>
</tr>
</tbody>
</table>
Building physics basics

- ČSN 730540-2:2011

- $R \ [m^2K/W]$ – thermal resistance
- $\lambda \ [\text{lambda}] \ [W/(m.K)]$ – coefficient of thermal conductivity
- $U \ [W/(m^2K)]$ – heat transfer coefficient
- $R_{se,si}$ – thermal resistance to heat transfer (surface)

- $R = d/ \lambda$
- $U = 1/(R_{se}+R+R_{si})$

- $R_{si} \sim 0,13 \ m^2K/W$ (for single casing wall)
- $R_{se} \sim 0,04 \ m^2K/W$ (for single casing wall)
Horizontal Structures, Basic function, Requirements

- **Acoustics function and requirements**
  - airborne sound transmission loss  42 – 67 dB
  - impact sound transmission loss  48 – 68 dB

- **Thermal function and requirements**
  - heat transfer coefficient $U$
  - decrease of touch floor temperature
  - thermal stability of room
  - limitation of heat bridges

Values of heat transfer coefficient $U_N$

<table>
<thead>
<tr>
<th>Floor structures</th>
<th>Req.</th>
<th>Recom.</th>
</tr>
</thead>
<tbody>
<tr>
<td>floor structures under/above unheated space</td>
<td>0.24</td>
<td>0.16</td>
</tr>
<tr>
<td>lightweight structure</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>heavy structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element Type</td>
<td>Max. Span</td>
<td>Recommended Dimensions</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>One-directional deck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinned joint</td>
<td>up to 3m</td>
<td>( d = \frac{l}{20} + \frac{25}{25} )</td>
</tr>
<tr>
<td>Stiff joint</td>
<td>4.5 - 6m</td>
<td>( d = \frac{l}{30} + \frac{33}{33} )</td>
</tr>
<tr>
<td>Cantilever</td>
<td>( \frac{l}{3} + \frac{l}{l_1} )</td>
<td>( d_1 = 50 ) mm</td>
</tr>
<tr>
<td>Pinned joint</td>
<td>4.5 x 4.5 m, 5 x 5 m, ( l_x : l_y \leq 1 : 2 )</td>
<td>( d = \frac{1}{75} (x + l_y) )</td>
</tr>
<tr>
<td>Two-directional deck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinned joint</td>
<td>6 x 6 m, 9 x 9 m, ( l_x : l_y \leq 1 : 2 )</td>
<td>( d = \frac{l}{40} + \frac{45}{45} )</td>
</tr>
<tr>
<td>Stiff joint</td>
<td></td>
<td>( d = \frac{l}{90} ) ( \frac{x + l_y}{x + l_y} ) ( + \frac{105}{105} ) ( \frac{x + l_y}{x + l_y} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Max. Span</th>
<th>Recommended Dimensions</th>
<th>Minimal Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinned joint</td>
<td>6 - 7 m, special cases over 9m, recom. distance: 1.2 - 3.0 m</td>
<td>( h = \frac{l}{10} + \frac{17}{17} )</td>
<td>( h = \frac{b + h}{2} + \frac{3}{3} )</td>
</tr>
<tr>
<td>Stiff joint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantilever</td>
<td>( \frac{h}{3} )</td>
<td>( b = \frac{h}{3} + \frac{10}{10} )</td>
<td>( b = \frac{h}{2} + \frac{3}{3} )</td>
</tr>
<tr>
<td>Girder (high loaded truss)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low load:</td>
<td></td>
<td>( h = \frac{l}{25} ) ( \frac{30}{30} )</td>
<td>( b = 60 - 120 ) mm</td>
</tr>
<tr>
<td>High load:</td>
<td></td>
<td>( h = \frac{l}{20} + \frac{25}{25} )</td>
<td>( b = 60 - 120 ) mm</td>
</tr>
<tr>
<td>Beam floor structures with fillers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CEILING STRUCTURES

- monolithic reinforced concrete
- monolithic RC with „lost formwork“
- prefabricated reinforced concrete
- composite reinforced concrete

formwork drawing

drawing layout of a precast structure
EXEMPLE – formwork drawing in the scale 1:50

- Represents a real shape of a concrete structure with basic dimensions
- View into the finished formwork just before pouring concrete in it
Vertical structures (load bearing walls) finished and formwork
Formwork assembly started
Formwork bottom finished
Reinforcement cladding
Pouring of concrete
Formwork disassembly
Formwork disassembly
LAYOUT OF PRECAST CEILING STRUCTURE

• location of elements
• dimensions and shapes of constructions
• locations, dimensions and shapes of openings
• type of construction (element type)
• specification of used material
HOW TO DRAW CEILING STRUCTURES AND TYPE OF LINES

• visible lines and edges – thin continuous line,

• invisible (hidden) – thin dashed line,

• bearing structures (walls&columns) outlines – thick continuous,

How to draw opening in ceiling structures

• openings – by old Czech building code

• openings – by new Czech building code
DRAWING CONDITIONS OF CEILING STRUCTURES

- Drawing of plan of floor construction - types of lines
  - outlines of vertical bearing structures of all "depicting floor" (i.e. walls, pilasters, columns but not partition!) and also vertical structures which are not upright loaded by floor structure (i.e. stairs walls, outer walls etc.)
  - visible edges of formwork, visible edges of floor elements, v.e. of floor conduits, v.e. of floor openings etc.
  - hidden edges of formwork, hidden edges of floor elements and h.e. of floor conduits, h.e. of floor openings etc.
  - modular lines
  - outlines of structures which are going over the surface of horizontal structure (for example: attic)

- Partial cross-section - thick solid line
  - graphical indication

- Dimensioning - modular lines
  - vertical bearing structure
  - sizes of elements and their length of bearing
  - openings and their position
  - rims, thermal insulation
  - partial cross-section

- Indication - of floor elements - horizontal members
  - vertical members

- Table of specification

EXAMPLE OF PLAN AND DOWENSWEPT SECTION OF CEILING STRUCTURE
CEILING STRUCTURES

- Outline of vertical bearing structures of all "sagging floors" (i.e., walls, pillars, columns, but not partition) and also vertical structures which are put upright loaded by floor structure (i.e., stairs walls, outer walls etc.)
- Visible edges of floor elements, floor conduits, floor openings etc.
- Hidden edges of floor elements and openings
- Modular lines

Partial cross-section - thick solid line
- Graphical indication

Dimensioning - modular lines
- Vertical bearing structure
- Sizes of elements and their length of bearing
- Openings and their position
- Rims, thermal insulation
- Partial cross-section

Indication - of floor elements - horizontal members
- Vertical members

Table of specification
Elements signs

Each element (wall, column, floor slab) has their own sign made from a big letter and number i.e. C1, W3 etc.

• vertical elements’ signs are in a square: C1, column no.1
• horizontal elements’ signs are in a circle: S2 ... slab no.2
• the area of slabs is signed with a diagonal crossing
• the element reinforcement orientation is symbolised by arrows
EXEMPLE plan of mounted ceiling structure
EXEMPLE – MONOLITHIC CEILING STRUCTURE
EXEMPLE – MONOLITHIC CEILING STRUCTURE
LEGENDA MATERIÁLŮ:
- ZELEZOBETON C30/37
- ZELEZOBETON C30/37

LEGENDA PRVKŮ:
- D1 KŘÍŽEM PNUTÁ ŽB DESKA TL.: 180mm
- D2 JEDNOMĚRNĚ PNUTÁ ŽB DESKA TL.: 180mm
- D3 JEDNOMĚRNĚ PNUTÁ ŽB DESKA TL.: 155mm
- D4 JEDNOMĚRNĚ PNUTÁ ŽB DESKA TL.: 145mm
- P1 ŽB PRŮVLAK H=650mm; B=300mm
- S ŽB SLOUP 300x300mm
- ST ŽB STĚNA TL.: 300mm

LEGENDA PŘEKLADŮ:
- P1 ŽB PŘEKLAD 300x4500mm
- P2 ŽB PŘEKLAD 300x1800mm
- P3 ŽB PŘEKLAD 300x1550mm
- P4 ŽB PŘEKLAD 300x1400mm

POZNÁMKA: KÓTOVÁNO V MILNOMETRECH, VÝŠKOVÉ KOTY V METRECH
EXEMPLE OF PLAN AND DOWENSWEPT SECTION OF CEILING STRUCTURE
EXAMPLE OF PLAN AND DOWENSWEPT SECTION OF MONOLITHIC CEILING STRUCTURES
CEILING STRUCTURES

- monolithic RC with „lost formwork“
Floor structures

- prefabricated reinforced concrete

Precast RC beam floors - placed side by side
Floor structures

- prefabricated reinforced concrete

Precast RC floors from panels

Floor structures

- prefabricated ceramic-concrete

Precast RC floors from panels

Floor structures

- prefabricated reinforced concrete

Precast RC floors from panels

prestressed hollow panels

http://www.spiroll.cz
Floor structures

• composite reinforced concrete

Composite RC floors from ribs and fillers

http://www.wienerberger.cz/
Floor structures

• composite reinforced concrete

Composite RC slab floors

Excercise alternative
drawing of layout of precast structure (scale 1:50)
Signs for elements

Each element (wall, column, floor slab ...) has its own sign made from big letter and number i.e. C1, W3 etc.

• vertical elements’ signs are in a square: $\boxed{C1}$ ... column no. 1
• horizontal elements’ signs are in a circle: $\bigcirc S2$ ... slab no. 2
Example

panel prefabricated with openings
Example 2

Commercial building
Example of plan and section of mounted ceiling structure
Example of concrete finished in mounted ceiling structure
STRUCTURAL DESIGN: LOAD BEARING SYSTEM, MATERIALS

LBS IS COMPOSED OF VERTICAL AND HORIZONTAL STRUCTURES:

- VERTICAL STRUCTURES: BEARING WALLS, BEARING COLUMNS VIA LECTURE 2.
- HORIZONTAL STRUCTURES: CEILING, FLOORS, ROOFS

Lecturer: Ing. Malila Noori, Ph. D.
Precast RC floors made of panels
- solid panels
  max. recommended span: 4.2 m

- hollow panels
  max. recommended span: 6.6 m
- precast ceramic-concrete floor panels
  max. recommended span: 6 m

- prestressed hollow panels
  max. recommended span: 12 m

- prestressed rib panels
  max. recommended span: 24 m
Composite Reinforced Concrete Floor Structures
Composite RC floors made of ribs and fillers
max. recommended span: 4.8 – 7.8 m

Composite RC slab floors
max. recommended span: 7.6 m
Steel and Composite Steel and Concrete Floor Structures

Steel Floor Structures

Beam structure

Slab structure
Steel castellated girders

Steel floor using truss girders
Steel floor using rolled-steel joists with hollow brick slabs - type HURDIS
Steel floor made of rolled-steel joists and RC slabs

monolithic slabs  prefab slabs

location of RC slabs relation to steel girder

Floor with composite beams
Reinforced Concrete Floor Structures

Monolithic Reinforced Concrete Floor Structures

Joist structures

max. recommended span: 6 – 7 m (exceptionally 9 m and more)
joist axial distance 1,2 – 3,0 m

Slab structures
One-way spanning slabs
- simply supported slab: max. recommended span: 3 m
- slabs with fixed or continuous supports: max. recommended span: 4.5 – 6 m

Two-way spanning slab (max. ratio $l_1 / l_2 = 1 / 1.5$)
- simply supported slabs: max. recommended span: 4.5 x 4.5 up to 5.5 m
- slab with fixed supports: max. recommended span: 6 x 6 m (up to 9 x 9 m)
Monolithic RC floor structures with „lost formwork“ made of ceramic fillers
max. recommended span: 6 – 7 m (exceptionally 9 m and more)
Prefabricated Reinforced Concrete Floor Structures

Precast RC beam floors
-the floor consists of a number of beams placed side by side

Precast RC rib and filler floors
Floors from glue laminated and nailed beams and truss girder
max. recommended span: 6 – 8 m (exceptionally 12 m and more)

fig.: Glue laminated beams

fig.: Nailed beams

fig.: Truss girders
STEEL CONCRETE LINTEL

INDIVIDUAL LINTEL

CONTINUOUS LINTEL

CONTINUOUS LINTEL WITH WREATHS

EXAMPLES OF CERAMIC MOUNTED LINTEL
**FIG. 3 - EXAMPLE OF PLAN AND DOWNSHED T SECTION OF CEILING STRUCTURES**

<table>
<thead>
<tr>
<th>typ prvku</th>
<th>maximální doporučený roz pon</th>
<th>rozměry doporučené</th>
<th>rozměry minimální</th>
</tr>
</thead>
<tbody>
<tr>
<td>prosté (klobové) uložení</td>
<td>do 3 m</td>
<td>d = $\frac{l}{20} \frac{1}{25}$</td>
<td></td>
</tr>
<tr>
<td>velkotě a spojitá</td>
<td>4,5 - 6 m</td>
<td>d = $\frac{l}{30} \frac{1}{35}$</td>
<td>l = teoret. rozpětí desky d₁ = 30 mm</td>
</tr>
<tr>
<td>deska jednosměrně pnutá</td>
<td>4,5 x 4,5 m až 6 x 6 m l₁, l₂ = max. 1:2</td>
<td>d = $\frac{l}{30} \frac{1}{35}$</td>
<td>h₁ = 100 mm</td>
</tr>
<tr>
<td>deska ozubená</td>
<td>8 x 6 m až 9 x 9 m l₁, l₂ = max. 1:2</td>
<td>d = $\frac{l}{40} \frac{1}{45}$</td>
<td>l₁ &lt; l₂</td>
</tr>
<tr>
<td>prosté uložení</td>
<td>d = $\frac{l}{30}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>velkotě a spojitá</td>
<td>d = $\frac{l}{20}$</td>
<td>l₁ &lt; l₂</td>
<td></td>
</tr>
</tbody>
</table>

**Poznámka:** Velkotě uvedené rozměry prvků jsou orientační pro předběžný návrh a jejich skutečné dimenze je třeba navrhnout přesným statickým výpočtem.

**FIG. 3 - EXAMPLE OF PLAN AND DOWNSHED T SECTION OF CEILING STRUCTURES**

<table>
<thead>
<tr>
<th>typ prvku</th>
<th>maximální doporučený roz pon</th>
<th>rozměry doporučené</th>
<th>rozměry minimální</th>
</tr>
</thead>
<tbody>
<tr>
<td>tém</td>
<td>6 - 7 m speciálně 8 m a více</td>
<td>d = $\frac{l}{10} \frac{1}{12}$</td>
<td>h = $\frac{l}{30} \frac{1}{23}$</td>
</tr>
<tr>
<td>tém</td>
<td>6 - 7 m speciálně 8 m a více</td>
<td>b = 60-120 mm</td>
<td></td>
</tr>
<tr>
<td>tém</td>
<td>6 - 7 m speciálně 8 m a více</td>
<td>l₁ = světlý k rozpon a = 0,3-0,5 m</td>
<td></td>
</tr>
<tr>
<td>tém</td>
<td>6 - 7 m speciálně 8 m a více</td>
<td>b = 60-120 mm</td>
<td></td>
</tr>
</tbody>
</table>

**Poznámka:** Velkotě uvedené rozměry prvků jsou orientační pro předběžný návrh a jejich skutečné dimenze je třeba navrhnout přesným statickým výpočtem.
OVERHEAD TRACK
CONSTRUCTION
DRAWING

UKÁZKA VÝKRESU SESTAVY STROPNÍCH DÍLCŮ (1:50)  B5.1a

PREFA MONOLITICKÝ STROP
Z NOSNIKŮ A VLOŽEK

MONTOVANÝ STROP
Z ŽB PANELŮ

3,150

KÓTA VZDÁLENOSTI STĚN

SOUČÁSTÍ VÝKRESU JE SPECIFIKACE DÍLCŮ (VIZ
UKÁZKA VARIANTY ZJEDNODUŠENÉHO ZOBRAZENÍ)

SOUČÁSTÍ PŮDORYSU JSOU SVISLÉ ŘEZY, A TO
SKLOPENÉ DO PŮDORYSU (VIZ STROP Z PANELŮ),
NEBO KRESLENÉ MIMO PŮDORYS (VIZ STROP
Z NOSNIKŮ A VLOŽEK)
EXAMPLES OF PLAN AND SECTION OF CEILING STRUCTURES

PLAN AND SECTION OF DIFFERENT KIND OF CEILING STRUCTURES
EXAMPLE OF SLABS WITH DIFFERENT WAYS

- One-way slab is supported on two sides by beams or bearing walls; beams, in turn, may be supported by girders or columns.
- One-way slabs are used for light to moderate loads over relatively short spans.
- Slabs may be used for deflection and shear resistance.

- Two-way slabs are supported on four sides by beams; slabs should be as nearly square as possible.
- Two-way slabs with beams are used for long spans and heavier loads, or when a high resistance to lateral forces is required. Two-way slabs, however, are usually made without beams.
- See below.

- Joists may be flared at the beam supports for greater shear resistance.

- One-way joist slabs are used for longer spans and heavier loads than practical for one-way solid slabs, but not suitable for large concentrated loads.

- Joists tend to an economical alternative to conventional beams; they have the same depth as the joists but a broader span.
EXAMPLE OF SLABS WITH DIFFERENT WAYS

- Two-way waffle slabs are used for long spans and heavy loads.
- For maximum efficiency, keys should be as near square as possible.
- Waffle slabs can be efficiently cantilevered in two directions, up to 1/3 of the main span.
- Casters under slab often left exposed.

- Two-way flat plates are similar to two-way slabs but have no drop panels.
- Flat plates are suitable for moderate loads.
- They are simple to form, and permit some flexibility in column placement.

- Two-way slab is supported by columns without beams.
- Drop panels under column caps reinforce slab at column supports.
- Reinforcing steel is arranged to handle varying stresses within a slab of uniform thickness; this also applies to flat plates below.
FIG. 16 Samples of floors of prefabricated elements

PANEL FLOORS

PANEL POD

<table>
<thead>
<tr>
<th>L (mm)</th>
<th>B (mm)</th>
<th>H (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5990</td>
<td>550</td>
<td>235</td>
</tr>
<tr>
<td>+ 6296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>step 300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PANEL K-P7T (BEAM FLOOR)

<table>
<thead>
<tr>
<th>L (mm)</th>
<th>B (mm)</th>
<th>H (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2090</td>
<td>290</td>
<td>140</td>
</tr>
<tr>
<td>+ 4780</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4480</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>+ 5300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>step 300</td>
<td>210</td>
<td></td>
</tr>
</tbody>
</table>
SAMPLE OF FLOORS OF PREFABRICATED ELEMENTS
EXAMPLE OF BEAM AND CSD HURDIS CEILING STRUCTURES