Module 3.5

Calculation of U-value
Concrete slab on ground floor.
Learning Outcomes

• On successful completion of this module learners will be able to
  
- Describe the procedure for the calculation of U-values for slab-on-ground floors.
Forward.

• This document uses extracts from, and makes references to, EN ISO 13370: 2007 Thermal performance of buildings – Heat transfer via the ground – Calculation method.
• The content of this document is not a substitute for the standard. To properly apply the standard one must have the complete document.
• Standards available from www.iso.org.
U-value for floors and basements in contact with the ground.

• EN ISO 13370 : 2007 deals with U-value calculations for floors and basements, with three dimensional heat flow in the ground below buildings.

U-value for floors and basements in contact with the ground.

• Types of floors in contact with the ground, as identified by I.S. EN ISO 13370 : 2007.
  a) Slab-on-ground floor.
  b) Suspended floor.
  c) Heated basement.
  d) Unheated basement.
  e) Partly heated basement.
U-value for floors and basements in contact with the ground.

• Slab on ground floor.
  Floor with a concrete slab directly on the ground over its whole area, with the floor at or near external ground level.

• See diagram next slide.
U-value for floors and basements in contact with the ground.

Key
1. floor slab
2. ground

$w$ thickness of external walls

Figure 1 — Schematic diagram of slab-on-ground floor
U-value for floors and basements in contact with the ground.

• Suspended floor.
  Construction in which the lowest floor is held off the ground, resulting in an air space between the floor and the ground.

• See diagram on next slide.
U-value for floors and basements in contact with the ground.

**Key**

1. **floor slab**

- **h**: height of floor surface above outside ground level
- **$R_f$**: thermal resistance of floor construction
- **$R_g$**: effective thermal resistance of ground

**Figure 2 — Schematic diagram of suspended floor**
U-value for floors and basements in contact with the ground.

- Basement.
  A usable part of a building that is partly or entirely below ground level.
- See diagram on next slide.
- This can be further subdivided into
  i) Heated basement.
  ii) Unheated basement.
  iii) Partly heated basement.
U-value for floors and basements in contact with the ground

Key
1 floor slab

$R_f$ thermal resistance of floor construction
$R_w$ thermal resistance of walls of the basement, including all layers
$w$ thickness of external walls
$z$ depth of basement floor below ground level

Figure 3 — Schematic diagram of building with heated basement
U-value for slab on ground floor.

- For basic calculations of U-value the following conditions should apply:
  - The floor slab is uninsulated, or
  - The floor slab is evenly insulated (above, below or within the concrete slab) over its whole area.

- If the floor slab has horizontal and/or vertical edge insulation, then the U-value must be corrected using procedures described in Annex B of I.S. EN ISO 13370.
Equations.

• Characteristic dimension of the floor $B'$.

$$B' = \frac{A}{0.5P}$$

where

$A =$ Area of the heated floor in contact with the ground. Units = m$^2$.

$P =$ Perimeter of the floor which is exposed to the external environment, and/or unheated spaces attached to the dwelling such as attached garages of storage areas.

Units = m

• See sample sketch and calculations on next two slides.
Example – continued.

EVENLY INSULATED
100mm
Lambda=0.023W/mK
Example - continued.

• Calculate the characteristic dimension of the floor $B'$ using - $B' = A / 0.5\ P$.

• $B' = (6\text{m} \times 10\text{m}) / (0.5 \times (6\text{m} + 10\text{m} + 6\text{m}))$

  Note: The 10m wall between this dwelling and the heated dwelling attached, is not included as part of the exposed perimeter.

• $B' = 60 / 11$

• $B' = 5.45$
Equations - continued.

- Equivalent thickness \( d_t \).

\[
d_t = w + \lambda_g (R_{si} + R_f + R_{se})
\]

where

- \( w \) = The full thickness of the wall, including all layers. Units = m.
- \( \lambda_g \) = Thermal conductivity of unfrozen ground, see ISO 13370 Table 1 or Annex G. Units = W/mK.
- \( R_{si} \) = Resistance surface internal. Units m\(^2\)K/W.
- \( R_f \) = Resistance of floor. Units m\(^2\)K/W.
- \( R_{se} \) = Resistance surface external. Units m\(^2\)K/W.
Equations - continued.

- If \( d_t < B' \) then calculate U-value from
  \[
  U = \frac{2\lambda_g}{\pi B' + d_t} \ln \left( \frac{\pi B'}{d_t} + 1 \right)
  \]

- If \( d_t \geq B' \) then calculate U-value from
  \[
  U = \frac{\lambda_g}{(0.457 x B') + d_t}
  \]
Example – U-value calculation
slab on ground floor

• The next slide shows a sketch of a semi-detached dwelling.
• The floor of this dwelling is a slab on ground floor.
• The floor is evenly insulated with 100mm of insulation with $\lambda = 0.023$ W/mK.
• This example calculates the U-value for this construction.
Example – continued.

EVENLY INSULATED
100mm
Lambda=0.023 W/mK
Example - continued.

- Calculate the characteristic dimension of the floor \( B' \) using \( B' = A / 0.5 P \).

\[
B' = \frac{6 \text{m} \times 10 \text{m}}{0.5 \times (6 \text{m} + 10 \text{m} + 6 \text{m})}
\]

Note: The 10m wall between this dwelling and the heated dwelling attached, is not included as part of the exposed perimeter.

\[
B' = \frac{60}{11} = 5.45
\]
Example - continued.

- Calculate the equivalent thickness $d_t$.

\[ d_t = w + \lambda_g (R_{si} + R_f + R_{se}) \]

\[ d_t = 0.3m + 2.0 (0.17 + (0.100/0.023) + 0.04) \]

\[ d_t = 9.42 \]

Notes:

- $\lambda_g = 2.0$ W/mK is a default value from EN ISO 13370 if the soil type under the floor is not specified. If soil types is known see Tables in EN ISO 13370.

- $R_{si}$ and $R_{se}$ from EN ISO 6946
Example - continued.

Notes – continued.

\[ R_f = \frac{d}{\lambda} = \text{thickness of insulation \hspace{1cm} m} \]

\[ \text{thermal conductivity of insulation \hspace{1cm} W/mK} \]

• When calculating \( R_f \), the thermal resistance of the dense concrete slab and any thin floor coverings may be neglected.

• Any hardcore or filling below the concrete slab is assumed to have the same thermal conductivity as the ground and so its thermal resistance should not be included.
Example - continued.

• Decision?
  If \( d_t < B' \) then use first equation.
  or if \( d_t \geq B' \) then use second equation.

• From previous calculations
  \( d_t = 9.42 \) and \( B' = 5.45 \)

• Conclusion – use the second equation of

\[
U = \frac{\lambda_g}{(0.457xB') + d_t}
\]
Example - continued.

- Since $d_t \geq B'$ then calculate U-value from

\[
U = \frac{\lambda_g}{(0.457 \times B') + d_t}
\]

\[
U = \frac{2.0}{(0.457 \times 5.45) + 9.42}
\]

\[
U = \frac{2.0}{11.91}
\]

\[
U = 0.17 \text{ W} / \text{m}^2 \text{ K}
\]

U = Thermal transmittance of this floor.
Module summary.

- The procedures for calculation of U-value for floors and basements, with three dimensional heat flow in the ground below buildings, are described in an EN standard.

- Task.

  Which EN standards describes the calculation of U-values for floors.
Module summary - continued.

- The EN standard defines five different types of floors.
- Task.
  List the five different types of floors.
  Describe a slab on ground floor.
  Describe a suspended floor.
  Describe a basement.
Module summary – continued.

• The area $A$ is used in the calculation of the U-value of the floor.

• Task.
  How is this area calculated?
  Is the floor area of unheated rooms included?
Module summary – continued.

• The exposed perimeter $P$ is used in the calculation of the U-value of the floor.
• Task.
  How is this perimeter calculated?
  Is the perimeter with heated rooms included?
Module summary – continued.

• The term \( w \) is used when calculating the U-value for a floor.

• Task.
  What does the term \( w \) represent?
  What are the units of \( w \), i.e. mm or m?
Module summary – continued.

• $\lambda_g$ = Thermal conductivity of unfrozen ground.

• Task.

What default value should be used if the soil type under the floor is not known.

If the soil type under the floor is known, where can alternative values of $\lambda_g$ be found.
Module summary – continued.

• $R_{si}$ and $R_{se}$ are used in the calculation of the U-value of a floor.

• Task.

What does the term $R_{si}$ represent?
What does the term $R_{se}$ represent?
In which I.S. EN standard can these values be found?
Module summary – continued.

• $R_f$ is used in the calculation of the U-value of a floor.

• Task.
  
  What does the term $R_f$ represent?
  
  Which two items can be used to calculate $R_f$?
  
  The resistance of which two items can be neglected when calculating $R_f$?
Module summary – continued.

- U-value = thermal transmittance of the construction.

Task.
What are the units of U-value?
Acknowledgements:

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References:

- EN ISO 13370: 2007
  Thermal performance of buildings – Heat transfer via the ground – Calculation method.
- EN ISO 6946 : 2007
  Building components and building elements - Thermal resistance and thermal transmittance - Calculation method