Module 3.3

Calculation of U-value
Simple construction without thermal bridging

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Learning Outcomes

- On successful completion of this module learners will be able to
- Describe the procedure for the calculation of U-values for simple constructions without thermal bridging.

Forward.

- This document uses extracts from, and makes references to, EN ISO 6946 : 2007

  Building components and building elements - Thermal resistance and thermal transmittance - 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.

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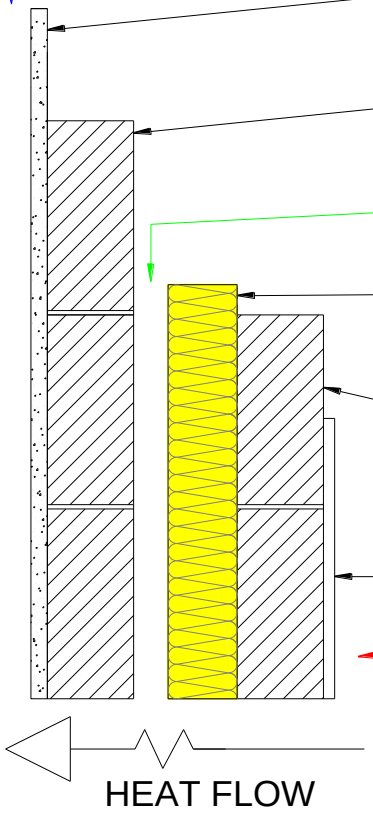
Sample U-value calculation – simple construction

PARTIALLY FILLED CAVITY



Rse - RESISTANCE of Surface External
See ISO 6946 : 2007 Table 1.

19mm EXTERNAL RENDER
(THERMAL CONDUCTIVITY=0.57 W/m K)

100mm DENSE CONCRETE BLOCK
(THERMAL CONDUCTIVITY=1.33 W/m K)

40mm AIR CAVITY (Unventilated)
Resistance see ISO 6946 : 2007 Table 2

80mm THERMAL INSULATION
(THERMAL CONDUCTIVITY=0.025 W/m K)

100mm DENSE CONCRETE BLOCK
(THERMAL CONDUCTIVITY=1.33 W/m K)

13mm LIGHTWEIGHT PLASTER
(THERMAL CONDUCTIVITY=0.18 W/m K)

Rsi - RESISTANCE of Surface Internal
See ISO 6946 : 2007 Table 1

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- continued.

- U-value = thermal transmittance,
- For a simple construction the U-value is equal to the inverse of the sum of the thermal resistances of each layer.
- U-value =

$$\frac{1}{\text{sum of thermal resistance of each layer}}$$

- U-value =

$$\frac{1}{R_{se} + R_{render} + R_{block} + R_{air} + R_{insulatn} + R_{block} + R_{plaster} + R_{si}}$$

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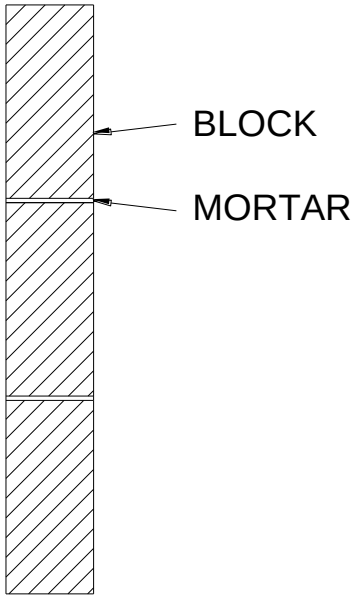
Consideration of mortar joints

- In this simple construction all of the layers are considered to be sufficiently homogeneous

  (for the purposes of thermal calculations).

  Strictly speaking, the mortar joints between the concrete blocks could be taken as a different resistance material.



Consideration of mortar joints – continued.

- The joints may be considered the same as the brick, however, if the difference in thermal resistance between bridging material and the bridged material is less than 0.1 m^2K/W.
  (Reference: I.S. EN ISO 6946 : 2007)
- For normal mortar this means that the joints can be disregarded (considered same as brick) when the thermal conductivity of the masonry units is greater than 0.5 W/m·K and the thickness of blocks or bricks is not more than 105 mm. (Reference: BRE 443 Section 4.2)

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Consideration of cavity wall ties.

The effect of wall ties can be neglected
a) in an un-insulated cavity,
b) between masonary leaf and timber studs.
c) If the thermal conductivity of the tie, or part of it, is less than 1 W/m·K, i.e. plastic wall ties.

d) Where the adjustment in the U-value is less than 3% of the original. (Reference I.S. EN ISO 6946 and BRE 443)

- Otherwise the effect of wall ties needs to be considered following I.S. EN ISO 6946 Annex D
- <u>For this example the effect of wall ties are neglected</u>.

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Sources for thermal resistance.

Values for thermal resistance can be found as follows,

- For surface layers and air layers
  - Rsi – Table 1 of EN ISO 6946
  - Rse – Table 1 of EN ISO 6946
  - Ra – Table 2 of EN ISO 6946.
- For layers of solid material
  - Thermal resistance $R = d / \lambda$
  - where d = thickness (depth) of material layer
    - λ = thermal conductivity of the material
  - Example for a 100mm thick concrete block.
  - Thermal resistance $R = d / \lambda$
  - where d = thickness (depth) = 0.100m
    - λ = thermal conductivity = 1.33 W/mK
    - $R = 0.075\ m^2\ K / W$

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Sum of thermal resistance for all layers for this sample calculation.

Layer / Surface	Thickness (d) (m)	Conductivity (λ) (W / m K)	Resistance (R=d/λ) (m^2 K / W)
External surface (Rse)	- - -	- - -	0.040
External render	0.019	0.57	0.033
Concrete block	0.100	1.33	0.075
Air cavity (Ra)	- - -	- - -	0.180
Insulation	0.080	0.025	3.200
Concrete block	0.100	1.33	0.075
Plaster (lightweight)	0.013	0.18	0.072
Internal surface (Rsi)	- - -	- - -	0.130
Total Resistance	- - -	- - -	3.805

Note: Values of Rse, Ra and Rsi taken from I.S. EN ISO 6946 Table 1 and Table 2.
Thermal conductivity values used are indicative only.
Certified values should be used, if available.

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- U-value =

$$\frac{1}{\text{sum of thermal resistance of each layer}}$$

- U-value = thermal transmittance
  = 1 / 3.805

- U-value = 0.26 W / m^2K

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Module summary.

- In a simple construction all of the layers are considered to be sufficiently homogeneous (for the purposes of thermal calculations).

  In such a case the thermal conductivity of the bridging material must be similar to the thermal conductivity of the bridged material.

- Task.

  For mortar joints to be considered the same as block or brick, what is the maximum allowable difference in thermal conductivity between the mortar and the brick .

  What are the units associated with thermal conductivity

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Module summary - continued.

- Wall ties are used in brick of block work construction. Depending on what they are made of, wall ties may lead to additional heat loss from buildings.

- Task.

  When can the effect of heat loss due to wall ties be ignored.

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Module summary - continued.

- In a simple construction all of the layers are considered to be sufficiently homogeneous

  (for the purpose of thermal calculations).

- Task.

  State the formula for the calculation of U-value under these conditions.

  What are the units associated with U-value.

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Acknowledgements:

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References:

- International standards.
- EN ISO 6946 : 2007

  Building components and building elements - Thermal resistance and thermal transmittance - Calculation method.

- National standards.
- BRE 443 : 2006 – Convention for U-value calculations. ISBN 1 86081 924 9