TEST REPORT

SQM_641_2023

CUSTOMER

Kebe S.A.

PRODUCT NAME

K300

TYPE OF PRODUCT

Masonry unit

TYPE OF TEST

Determination of the thermal design conductivity of the block and of masonry made with it

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Ordering Kebe S.A.
Product placed on the market from Kebe S.A. - 61100 Nea Santa - Kilkis - GREECE
Data related to the sample examined Masonry unit
Sample origin sampled and provided from the Customer
Manufacturing plant Kebe S.A. - 61100 Nea Santa - Kilkis - GREECE

Estimate prot. 23436/lab of 09/01/2023
Order confirmation email of 09/01/2023
Receipt of the samples -
Test execution September 2023
Laboratory and location of test execution Certimac - via Ravegnana, 186 - Faenza (RA)

Report issued 09/22/2023
Revision n° 00

Test executed by: Eng. Mattia Morganti
Report drafted by: Eng. Mattia Morganti
Approval: Technical director Eng. L. Laghi

This test report is part of a file in PDF format digitally signed by Luca Laghi

Chief Technical Officer
(Eng. Luca Laghi)

1. Object of the test

The following test report describes the determination of thermal design values of a masonry brick. The calculations were performed by means of a Finite Element Model implemented in Ansys 18.2 (Ref. 2-b), applied to a planar cross section (unit length), perpendicular to the holes axis and parallel to the thermal flux. In this calculation, the input data have been modified taking into account the effect of humidity as indicated by the technical standard in Ref. 2-a.

2. Reference standards and documents

The tests have been executed according to the methods defined in the following documentations and reference standards:

a. EN ISO 10456:2007. Building materials and products - Hygrothermal properties -Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007)
b. CertiMaC calibration report 040219-C-17/Rev01. Calibration of a two-dimensional model for the calculation of the equivalent thermal conductivity of a masonry unit.
c. EN 6946:2008. Building components and building elements – Thermal resistance and thermal transmittance – Calculation method.
d. Test report SQM_640_2023, 09/22/2023 - Determination of the equivalent thermal conductivity of the block K300 and of masonry made with it.

3. Input data

The technical drawing of the block and the thermal conductivity of fired clay were supplied by the client (Figure 1). All input data used for the calculation are shown in Tables 1 and 2.

Figure 1. Geometry of the block

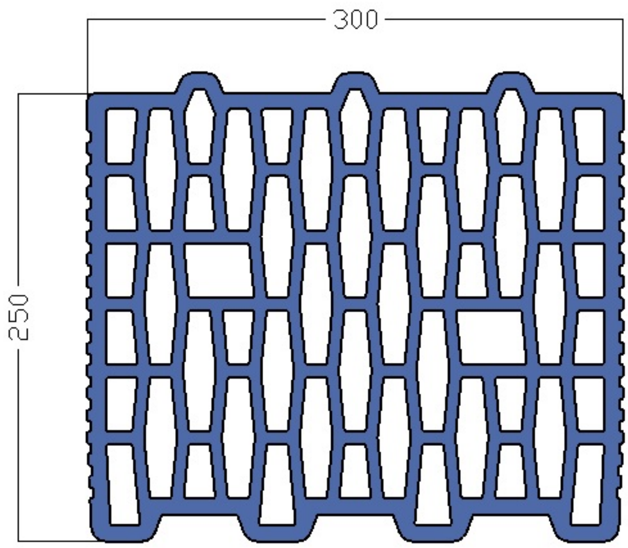

Table 1. Input data

Physical quantity	Nominal value	Ref.
Material thermal conductivity $\lambda_{10,dry,mat}$	0.401 W/mK	Provided by the Customer
Equivalent thermal conductivity of voids	Test Report K300	Ref. 2-d

Table 2. Input data of the masonry

Masonry n. 1	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer
External plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer

Masonry n. 2	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer
External plaster	Thickness = 25 mm λ_{mortar} = 0.08 W/mK	Provided by the Customer

Masonry n. 3	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Not present	Provided by the Customer
External plaster	Not present	Provided by the Customer

4. Determination of the thermal design values

Thermal design values of the masonry are determined as defined by the standards at Ref. 2-a and 2-c, increasing the thermal conductivity of the materials in relation to the moisture content, using the following conversion coefficient (moisture content volume by volume):

$$F_m = e^{f_\psi(\psi_2 - \psi_1)}$$

The standard sets as operating conditions a temperature of 23 °C and a relative humidity of 80% (precautionary hypothesis), which is related to the test condition at 10 °C, dry.

4. Results

Table 3 shows the results of the Finite Elements Analysis performed with design thermal values at Ref. 2-a.

Table 3. FEM results

Heat flow [W/m]	**Thermal coupling coefficient** L^{2D} [W/mK]	**Thermal transmittance** **U** [W/m²K]	**Total thermal resistance** R_T [m²K/W]	**True thermal resistance of the masonry unit** R_t [m²K/W]	**Equivalent thermal conductivity** $\lambda_{10,dry,unit}$ [W/mK]
2.5178	0.1259	0.5036	1.9859	1.8159	0.1652

5. Determination of thermal values of the masonry

Table 4 shows the thermal values of the masonry, in the three configurations described above, taking into account the effect of humidity.

Table 4. Results of the calculation for the masonry

Masonry n. 1	**Result**
Thermal resistance only of the layer R_t [m²K/W]	1.7549
Equivalent thermal conductivity of the masonry λ_{equ} [W/mK]	0.1994
Thermal resistance of the masonry including superficial thermal resistances R_T (m²K/W)	1.9249
Thermal transmittance **U** (W/m²K)	0.5195

Masonry n. 2	Result
Thermal resistance only of the layer $\mathbf{R_t}$ [m²K/W]	1.9810
Equivalent thermal conductivity of the masonry λ_{equ} [W/mK]	0.1767
Thermal resistance of the masonry including superficial thermal resistances $\mathbf{R_T}$ (m²K/W)	2.1510
Thermal transmittance **U** (W/m²K)	0.4649

Masonry n. 3	Result
Thermal resistance only of the layer $\mathbf{R_t}$ [m²K/W]	1.6966
Equivalent thermal conductivity of the masonry λ_{equ} [W/mK]	0.1768
Thermal resistance of the masonry including superficial thermal resistances $\mathbf{R_T}$ (m²K/W)	1.8666
Thermal transmittance **U** (W/m²K)	0.5357

SUMMARY TABLE OF RESULTS

The tests previously described gave the following results, taking into account the effect of humidity:

Product	Thermal design conductivity λ_{equ} [W/mK]	Thermal design transmittance U [W/m²K]
block K300	**0.1652**	**0.5036**
Masonry n. 1	**0.1994**	**0.5195**
Masonry n. 2	**0.1767**	**0.4649**
Masonry n. 3	**0.1768**	**0.5357**

6. List of distribution

ENEA	Archive	1 copy
Certimac	Archive	1 copy
Kebe S.A.	Archive	1 copy

In charged of technical test execution	In charged of technical report drafting	Technical director Approval
Eng. Mattia Morganti	Eng. Mattia Morganti	Ing. Luca Laghi

-------- End of the Test Report ------

TEST REPORT

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1. Object of the test

The following test report describes the determination of the equivalent thermal values of a masonry brick. The calculations were performed by means of a Finite Element Model implemented in Ansys 18.2 (Ref. 2-b), applied to a planar cross section (unit length), perpendicular to the holes axis and parallel to the thermal flux.

2. Reference standards and documents

The tests have been executed according to the methods defined in the following documentations and reference standards:

a. EN 1745:2012. Masonry and masonry products – Methods for determining thermal properties.
b. CertiMaC calibration report 040219-C-17/Rev01. Calibration of a two-dimensional model for the calculation of the equivalent thermal conductivity of a masonry unit.
c. EN 6946:2008. Building components and building elements – Thermal resistance and thermal transmittance – Calculation method.

3. Input data

The technical drawing of the block and the thermal conductivity of fired clay were supplied by the client (Figure 1). All input data used for the calculation are shown in Table 1.

Figure 1. Geometry of the block

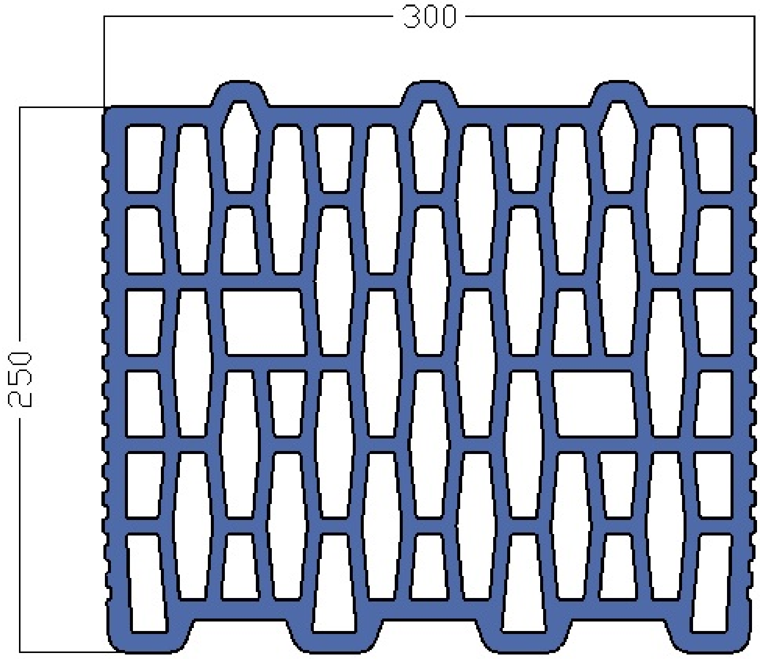
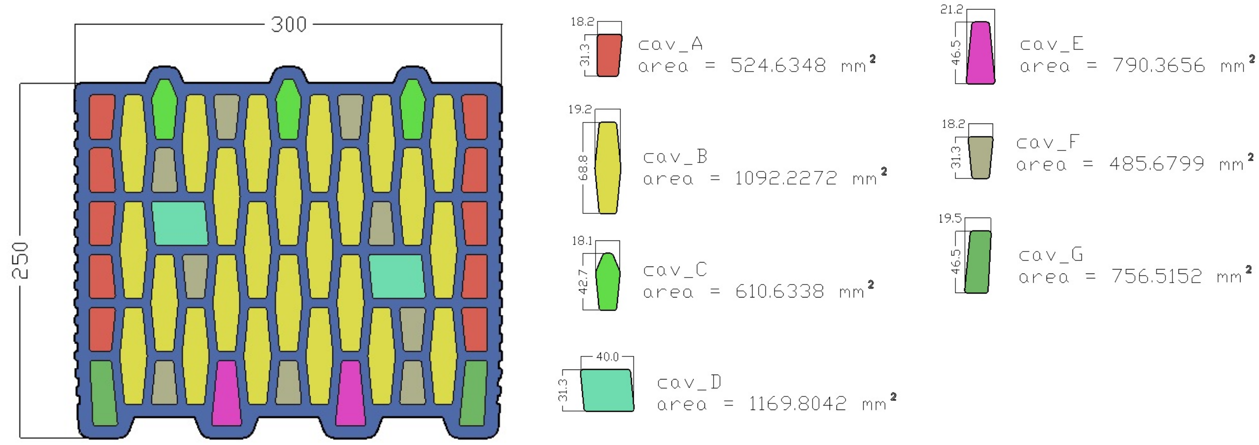


Table 1. Input data

Physical quantity	Nominal value	Ref.
Internal temperature Ti	20 °C = 293.15 K	Ref. 2-a and 2-c
External temperature Te	0 °C = 273.15 K	Ref. 2-a and 2-c
Internal superficial resistance Rsi	0.13 m^2K/W	Ref. 2-a and 2-c
External superficial resistance Rse	0.04 m^2K/W	Ref. 2-a and 2-c
Material thermal conductivity $\lambda_{10,dry,mat}$	0.401 W/mK	Provided by the Customer

Equivalent thermal conductivity values of air voids were determined according to the methodology outlined in Ref. 2-a and 2-c., approximating convective and radiative heat transfer inside the void (Figure 2).

Figure 2. Cross section of the block and air voids data



4. Results

Table 2 shows the results of the Finite Elements Analysis; Figures 3 and 4 graphically show the distribution of the isotherms and the vector state of the heat flow.

Table 2. FEM results

Heat flow [W/m]	**Thermal coupling coefficient** L^{2D} [W/mK]	**Thermal transmittance** **U** [W/m^2K]	**Total thermal resistance** R_T [m^2K/W]	**True thermal resistance of the masonry unit** R_t [m^2K/W]	**Equivalent thermal conductivity** $\lambda_{10,dry,unit}$ [W/mK]
2.4032	0.1202	0.4806	2.0805	1.9105	0.1570

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Figure 3. Distribution of isotherms in the block [°C]

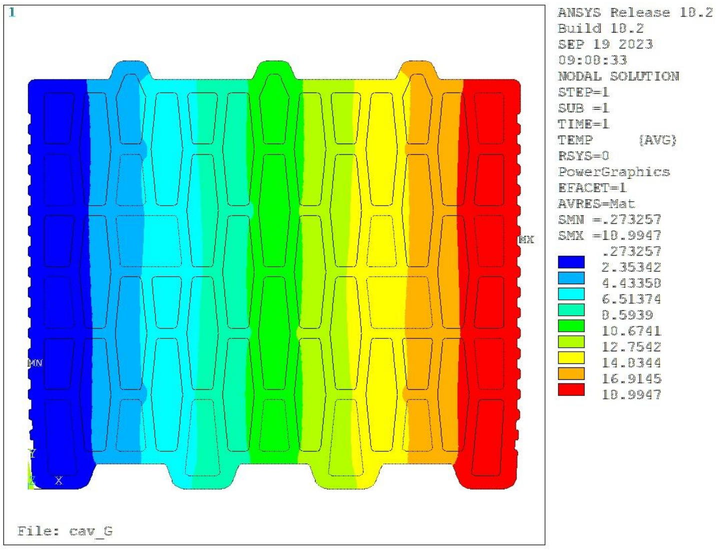
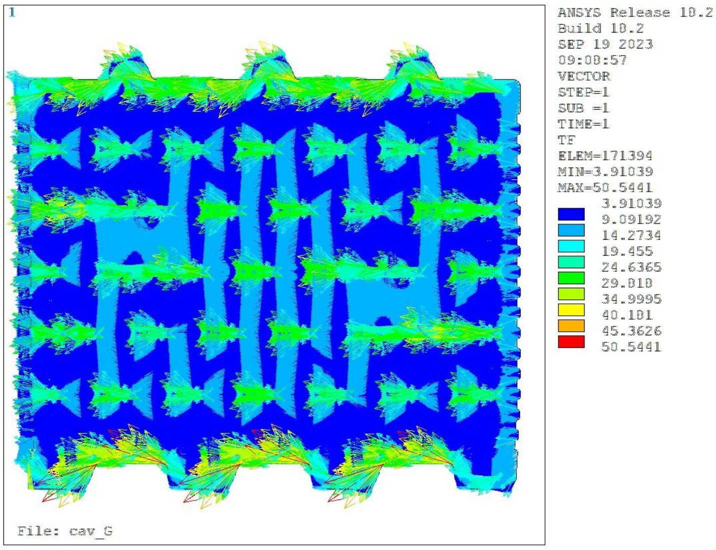


Figure 4. Average heat flow vectors [W/m²]



5. Determination of thermal values of the masonry

Because of the interlocking block geometry, only horizontal mortar joints were considered. For the evaluation of the thermal values of the masonry, three different configurations were studied. The input data for the definition of the configurations are indicated in table 3.

Table 3. Input data of the masonry

Masonry n. 1	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer
External plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer

Masonry n. 2	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Thickness = 25 mm λ_{mortar} = 1.0 W/mK	Provided by the Customer
External plaster	Thickness = 25 mm λ_{mortar} = 0.08 W/mK	Provided by the Customer

Masonry n. 3	Nominal value	Ref.
Horizontal mortar joints	Thickness = 3 mm λ_{mortar} = 0.87 W/mK	Provided by the Customer
Internal plaster	Not present	Provided by the Customer
External plaster	Not present	Provided by the Customer

Tables 4, 5 and 6 show the thermal values of the masonry, in the three configurations described above.

Table 4. Results of the calculation for the masonry no. 1

Physical quantity	Result
Thermal resistance only of the layer **R_t** [m²K/W]	1.8760
Equivalent thermal conductivity of the masonry **λ_{equ}** [W/mK]	0.1866
Thermal resistance of the masonry including superficial thermal resistances **R_T** (m²K/W)	2.0460
Thermal transmittance **U** (W/m²K)	0.4888

Table 5. Results of the calculation for the masonry no. 2

Physical quantity	Result
Thermal resistance only of the layer **R_t** [m²K/W]	2.1635
Equivalent thermal conductivity of the masonry **λ_{equ}** [W/mK]	0.1618
Thermal resistance of the masonry including superficial thermal resistances **R_T** (m²K/W)	2.3335
Thermal transmittance **U** (W/m²K)	0.4285

Table 6. Results of the calculation for the masonry no. 3

Physical quantity	Result
Thermal resistance only of the layer **R_t** [m²K/W]	1.8091
Equivalent thermal conductivity of the masonry **λ_{equ}** [W/mK]	0.1658
Thermal resistance of the masonry including superficial thermal resistances **R_T** [m²K/W]	1.9791
Thermal transmittance **U** [W/m²K]	0.5053

SUMMARY TABLE OF RESULTS

The tests previously described gave the following results:

Product	Equivalent thermal conductivity λ_{equ} [W/mK]	Thermal transmittance U [W/m²K]
block K300	0.1570	0.4806
Masonry no. 1	0.1866	0.4888
Masonry no. 2	0.1618	0.4285
Masonry no. 3	0.1658	0.5053

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