Preliminary Study on the Thermal Mass Characteristics of Stone Building in Crete, Greece

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Thermophysical characteristics of the building envelope determine heat exchange between internal space and the external environment.

Principal thermophysical properties

- **Thermal trasmittance** measures the effectiveness of a material as an insulator.
- **Thermal mass** describes a material's capacity to absorb, store and release heat, how the mass of the building provides thermal inertia against temperature fluctuations.

Legislation

Greek
KENAK October 2010

European
Energy Performance of Building Directive 2010/31/EU

Energy performance - Vernacular architecture

Different local materials

Typology

Form

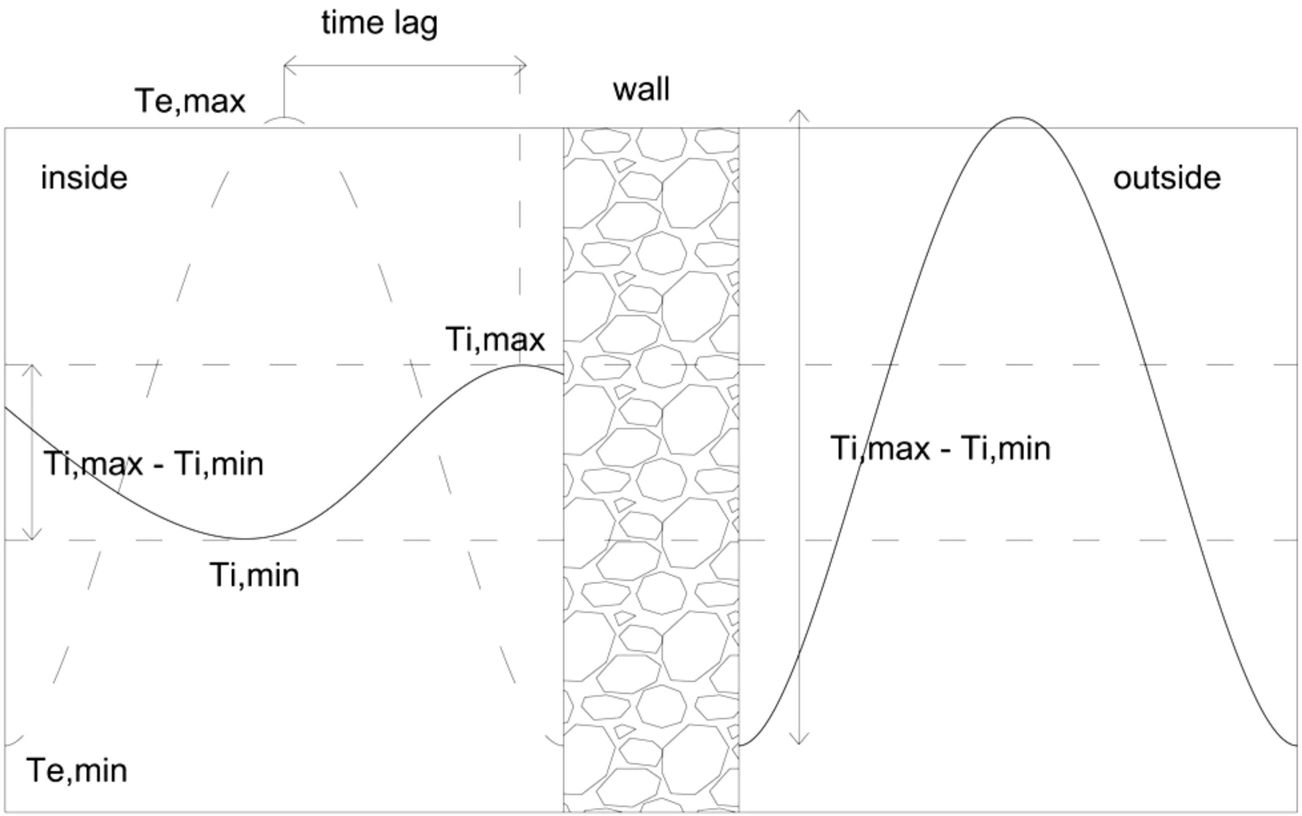
Construction techniques

→ Difficulties determining thermophysical properties

Definition of Thermal Mass Characteristics

Time Lag or Time Shift *φ*, is defined as the time it takes for the heat wave to propagate through a wall from the outer surface to the inner surface.

Decrement factor *f*, is defined as the decreasing ratio of its temperature amplitude during the transient process of a wave penetrating through a solid element

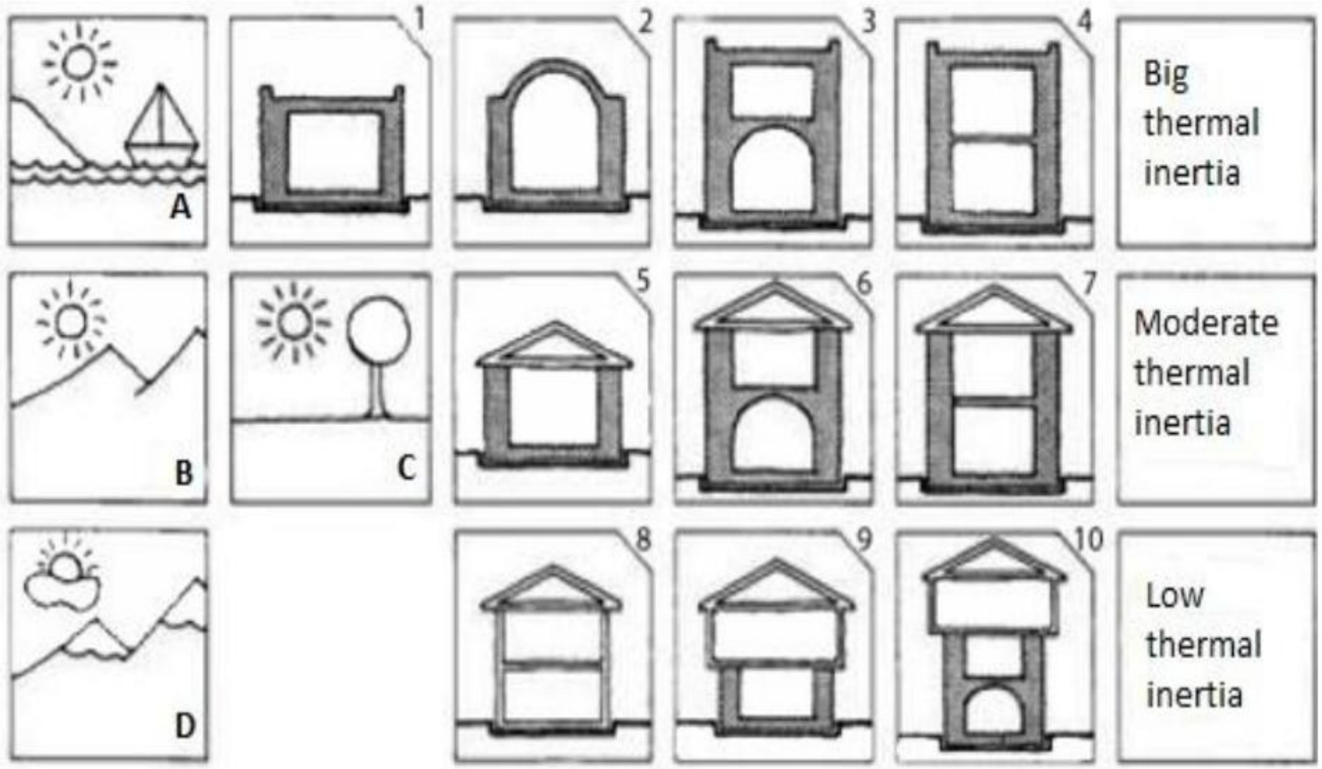


$$\phi = t_{Ti,min} - t_{Te,min}$$

$$\phi = t_{Ti,max} - t_{Te,max}$$

$$f = \frac{Ti,max - Ti,min}{Te,max - Te,min}$$

Climatic Zone



Crete.
Coastal zone
with hot and dry climate
temperate climate

Building construction and climatic zones of Greece

Method

EN ISO 6946:2007

calculation of the thermal resistance and thermal transmittance

$$U = \frac{1}{Rse + \Sigma R + Rsi}$$

EN ISO 13786:2007

calculation of the dynamic thermal behavior, time lag and decrement factor

Data

1) TABLE I. THERMAL PROPERTIES OF LAYERS OF STONE WALL

Thermal properties of layers of stone wall	***Lime plaster***	***Limestone***
λ [W/m·K]	0.87	1.7
ρ [kg/m^3]	1800	2200
c [J/Kg·K]	1000	1000

2) The period of the variations at the surfaces is specified

- One day (86,400 s), daily meteorological variations and temperature setback
- One week (604,800 s), longer term averaging of the building

TABLE II. THERMAL TRANMITTANCE COEFFFICIENT OF STONE WALL

Thickness, d [mm]	*Thermal transmittance co-efficient (U-value)*	
	U-value of the wall with plaster	*U-value of the wall without plaster*
300	2.71	2.89
400	2.34	2.47
500	2.06	2.15
600	1.83	1.91
700	1.66	1.72
800	1.51	1.56
900	1.39	1.43
1000	1.28	1.32

Energy Performance of Building Directive 2010/31/EU ⟶ U-value ≤ 0.60 $W/m^2 \cdot K$

TABLE III. THERMAL PROPERTIES STONE WALL, ONE DAY PERIOD

Thickness, d [mm]	*Thermal properties*		
	Decrement factor, f	*Time lag [h]*	*Thermal admittance $[W/m^2 \cdot K]$*
300	0.30	8.24	5.29
400	0.18	10.84	5.27
500	0.10	13.46	5.26
600	0.06	16.08	5.26
700	0.03	18.70	5.26
800	0.02	21.32	5.26
900	0.01	23.94	5.26
1000	0.01	2.57	5.26

TABLE IV. THERMAL PROPERTIES STONE WALL, ONE WEEK PERIOD

Thickness, d [mm]	*Thermal properties*		
	Decrement factor, f	*Time lag [h]*	*Thermal admittance $[W/m^2 \cdot K]$*
300	0.93	13.75	3.2
400	0.86	20.43	3.25
500	0.77	27.48	3.37
600	0.67	34.63	3.48
700	0.57	41.74	3.55
800	0.48	48.78	3.58
900	0.41	55.76	3.58
1000	0.34	62.71	3.58

Conclusions

- Limestone wall has a high thermal transmittance co-efficient
- Vernacular dwellings have relatively stable indoor thermal conditions
- Low decremnet factor and high time lag
- High thermal mass of the construction
- Energy performance of stone wall building at temperate climate

Thank you.

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