Basic building physics for museums

Poul Klenz Larsen, The National Museum of Denmark
Temperature control

Little thermal stability on daily cycle

Heat radiation warms up the interior during the day

Solid steel
1 cm thickness

30 °C
Temperature control

... and cool it during night

Little thermal capacity

10 °C
Humidity control

The structure is water thight

The surface is impermeable to water vapour

No humidity buffer capacity
Humidity control

Water vapour comes with air infiltration

Air Exchange Rate \( \text{AER} \approx 0 \text{ h}^{-1} \)

No humidity buffer capacity

30-100 %RH
Temperature control

Little temperature stability

Heat radiation is counterbalanced by mechanical cooling
Temperature control

Little thermal insulation

Heat loss is counterbalanced by heating
Humidity control
Little humidity stability
The RH was controlled by humidification / dehumidification

Double textile skin
Climate control

The ’building envelope’ was very leaky

Poor climate control – large energy consumption

Double textile skin
Temperature control
Solar heating through the glass roof
Heat absorption in walls

Solid concrete

23 °C
60 %RH
Temperature control

Heat loss is large in winter

Solid concrete

0 °C

90% RH
Temperature and humidity buffering

Harmonic cycles

37%

1%
Periodical penetration depth (37%) for a 24 hours harmonic swing

- Wood: 0.07
- Light weight concrete: 0.09
- Brick: 0.11
- Concrete: 0.15
- Mineral wool: 0.16
- Granite: 0.21
- Steel: 0.65
Temperature control
Walls and roof must be 4 m thick to even out annual variation

Solid concrete
10 - 12 °C
90% RH
Temperature control

Solar heating of the ground in summer

23 °C
60 %RH
Temperature control

Floor heating with ground heat pump in winter

15 °C
40 %RH
Temperature control

Heat loss through solid masonry is large

25 °C

40 %RH
Temperature control

Thermal insulation to reduce heat loss
Humidity control

Conservation heating moderates RH on an annual cycle

Humidity buffer in walls on a daily cycle

40-60 % RH
Humidity buffer
Humidity buffer

Thermal capacity