Low energy climate control in museums and galleries

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Human needs are different than objects' needs.

- heat
- light
- air
- humidity
Museum buildings are often complicated structures
A submarine transformed into a museum
The interior is impermeable to water vapour
Temperature control

Little thermal stability on daily cycle

Heat radiation warms up the interior during the day

30 °C
Temperature control

... and cool it during night

10 °C
Humidity control

The structure is water thight

The surface is impermable to water vapour
Humidity control

Water vapour flow is little

Air Exchange Rate \( \text{AER} \sim 0 \text{ h}^{-1} \)
Imperial War Museum, Manchester, UK
Temperature control
Heat radiation is counterbalanced by mechanical cooling
Temperature control

Heat loss is counterbalanced by heating
Temporary exhibition of iron age warship
The balloon is held up by pressurized air
Humidity control

The RH was controlled by humidification / dehumidification
Large RH fluctuations due to temperature variation
The ballon collapsed during a power failure
Museum of Rudolf Tegner – a solid concrete building
The building has no climate control and only natural light.
Temperature control summer
Solar heating through the glass roof
Heat absorption in walls and floor

25 °C
60 %RH
Temperature control winter

Heat loss through roof and walls
Heat gain from ground
The “stone house” for a collection of minerals
The gallery has

- a heavy structure to give thermal stability and thermal insulation to reduce heat loss

- a ground heat pump with floor heating for moderate winter heating

- tall space to reduce need for ventilation

- small windows to reduce solar heating but allow natural lighting
Temperature control

Solar heating of the building and the ground in summer
Ground heat pump with floor heating
Temperature control

Floor heating with ground heat pump in winter

Thermal insulation to reduce heat loss
Temperature 13 – 25 °C = conservation heating
Relative humidity 40 – 75 % RH
Brandhorst Museum, München
Concrete structure with insulation and tile cladding
Heating (and cooling) in floor and walls
Humidity control independent of temperature
Ventilation controlled by CO2 level
Natural light through ceiling + LED
Conclusion

Heavy structure to moderate daily temperature variation imposed by people and lighting

Radiant heating (and cooling) in floor or walls.

Separate temperature control and humidity control

Reduce need for humidity control by adjusting temperature setpoint to seasonal variation

If possible use air tight display cases with humidity buffer.

Tall spaces for reduced ventilation need.

Natural lighting combined with LED