Effect of temperature on the sorption isotherm and vapor permeability

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Main content

● Background

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● Conclusions
The sorption isotherm and the water vapor permeability are among the most important hygrothermal properties of porous building materials.
Classic test methods

- The sorption isotherm: the static gravimetric test
- Water vapor permeability: the cup test
Test temperature?

- The sorption isotherm:
  ISO 12571: 23 °C
  ASTM C1498: 23 °C

- The water vapor permeability:
  ISO 12572: 23/38 °C
  ASTM E96: 21-32 °C, 32 °C is recommended
As a result...

- Most tests are performed at a single temperature;
- Controversies over the influence of temperature.
Methods

- Material: autoclaved aerated concrete

References:
ISO 12571 (sorption isotherms) and ISO 12572 (permeability)

Sample sizes:
$4 \times 4 \times 2 \, \text{cm}^3$ (sorption isotherms) and $D=12\, \text{cm}, \, T=3\, \text{cm}$ (permeability)

RH control: 8 RHs (sorption isotherms) and 3 RH pairs (permeability)

Temperature: 15, 25 and 35 °C
Desorption curve

- **15 °C**
- **25 °C**
- **35 °C**

EMC (kg/kg, %) vs. RH (%)
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### Permeability

![Permeability Graph](image)

- **15 °C**
- **25 °C**
- **35 °C**

**Permeability**

\[ \text{Permeability}(\times 10^{-4} \text{ g/m\cdot h\cdot Pa}) \]

**Moisture content**

\[ \text{Moisture content}(\text{kg/kg, %}) \]
Fitting functions

**Sorption isotherms:**

\[ u = k_1 \ln(\varphi + 1) + k_2 \ln(100 - \varphi) + k_3 \exp(\varphi) - k_2 \ln 100 - k_3 \]

**Vapor permeability:**

\[ \mu = k_1 + k_2 u^{k_3} \]
Residual plot-adsorption fitting

- 15 °C
- 25 °C
- 35 °C

Residuals ( % kg/kg )

RH( % )

0 20 40 60 80 100
Residual plot-permeability fitting

- **Residuals (x10^-5 g/(m·h·Pa))**
- **Moisture content (kg/kg)**

- **15 °C**
- **25 °C**
- **35 °C**

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Mean deviation from the overall fitting curve

\[ D_{fit}^{overall} = \frac{1}{j} \sum_j \left[ \frac{1}{i} \sum_i (x_{ij} - x_{pj}^{overall}) \right] \]

- **Adsorption**
  - 15°C
  - 25°C
  - 35°C

- **Desorption**

- **Vapor transmission**

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Enlarged deviations in the overall fitting

\[
D_{\text{fit,abs}} = \frac{1}{j} \sum_j \left( \frac{1}{i} \sum_i \left| x_{ij} - x_{pj} \right| \right)
\]

\[
D_{\text{overall}}^{\text{fit,abs}} = \frac{1}{j} \sum_j \left( \frac{1}{i} \sum_i \left| x_{ij} - x_{pj}^{\text{overall}} \right| \right)
\]
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![Graph showing vapor transmission results](image-url)

- **Adsorption**
  - Single
  - Overall
  - Difference

- **Desorption**
  - Single
  - Overall
  - Difference

- **Vapor transmission**
  - Single
  - Overall
  - Difference
Experimental errors

\[ D_{\text{group.abs}} = \frac{1}{j} \sum_j \left( \frac{1}{i} \sum_i \left| x_{ij} - \bar{x}_j \right| \right) \]
Conclusions

- By neglecting the influence of temperature and fitting all data points obtained at different temperatures into an overall curve, deviations of measured results from fitting curves are enlarged. However, for both sorption isotherms and vapor permeability, these enlargements are much smaller than our experimental errors.

- The pattern of temperature’s influence can be analyzed by the mean deviation from the overall fitting curve. However, no systematical pattern can be observed on either sorption isotherms or on vapor permeability.
Thanks for your attention!