Hysteresis and Temperature Dependency of Moisture Sorption

– New Measurements

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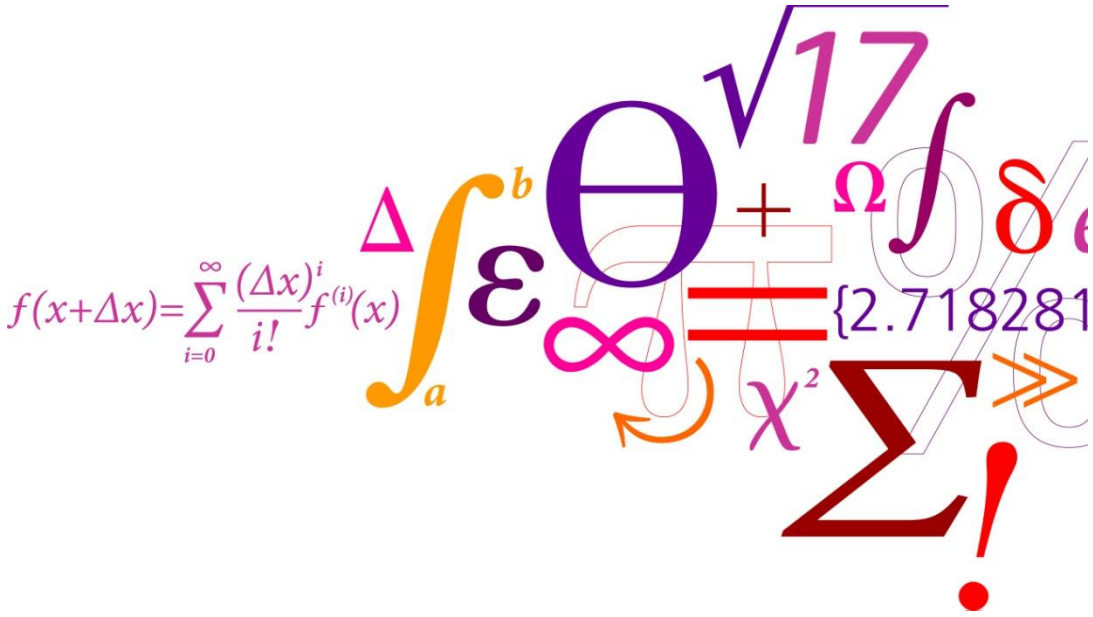


DTU Civil Engineering
Department of Civil Engineering

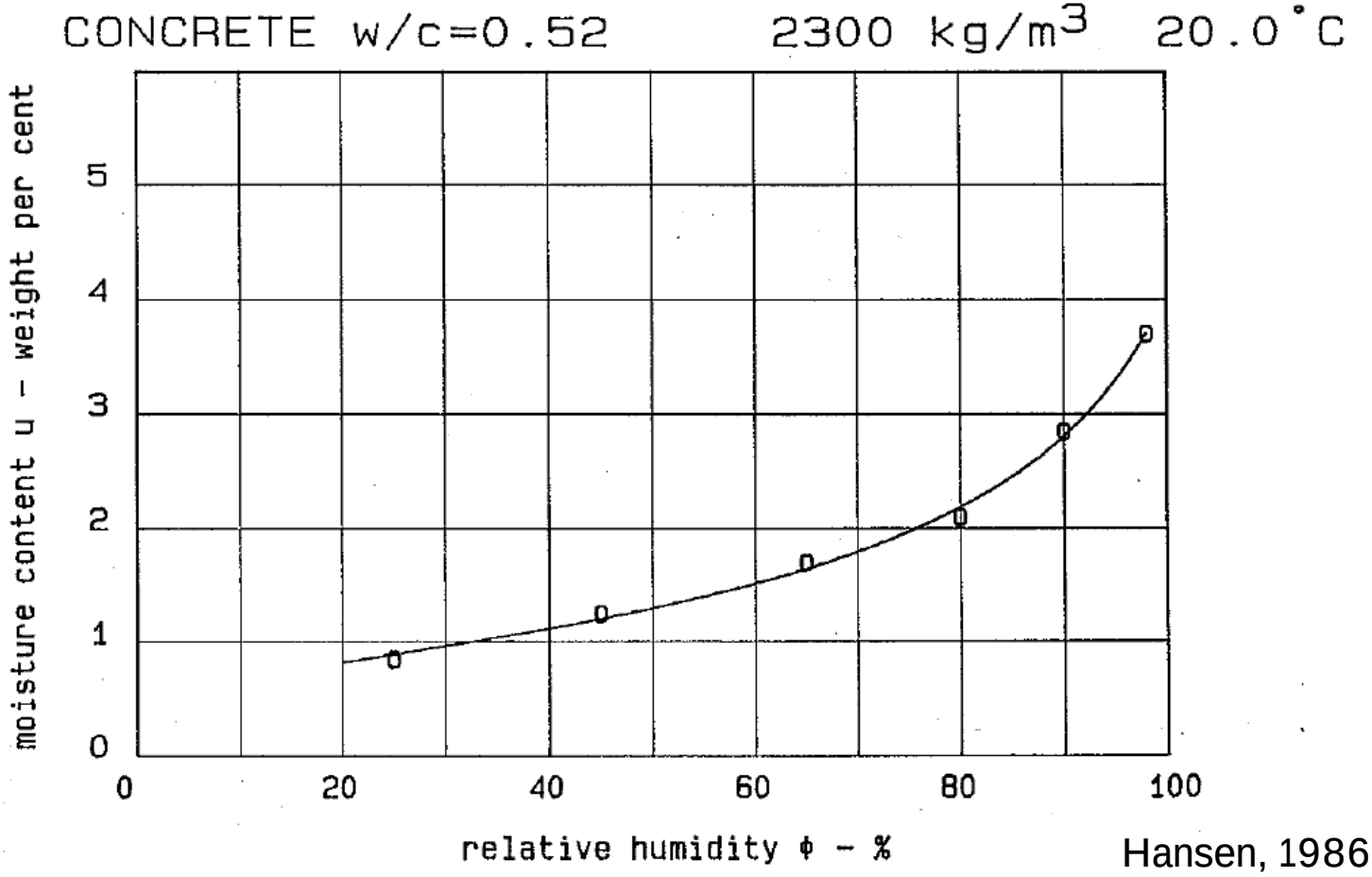
Hysteresis and temperature effect

- Moisture sorption of building materials exhibit hysteresis in the way the equilibrium curves develop between adsorption and desorption
- Sorption curves are also somewhat temperature dependent

These two facts are still most often neglected in models for combined heat and moisture transport in materials.

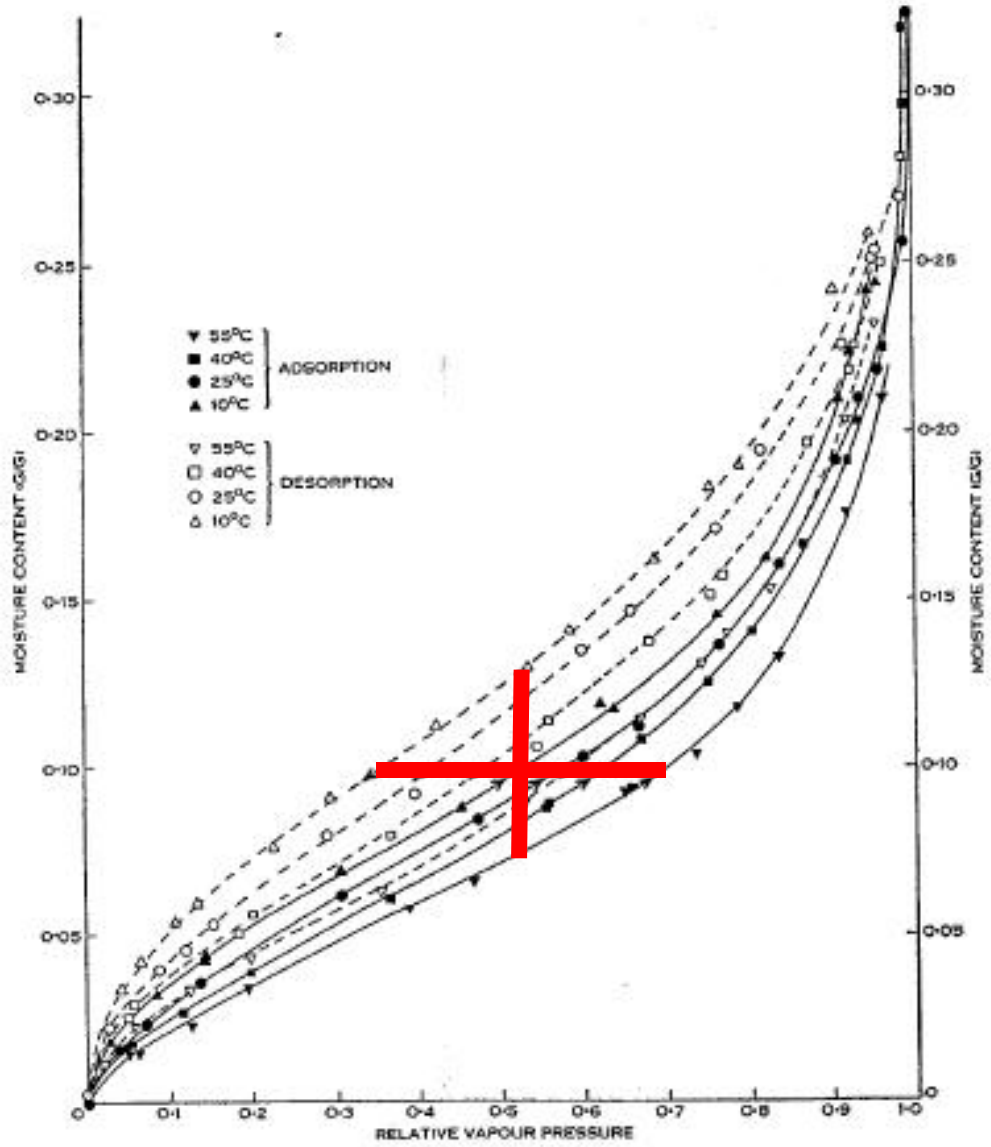
There is need for further elaboration of the importance of these issues, and provision of background data

Sorption curve for concrete as one unique curve



Hansen, 1986

Kelsey, 1957

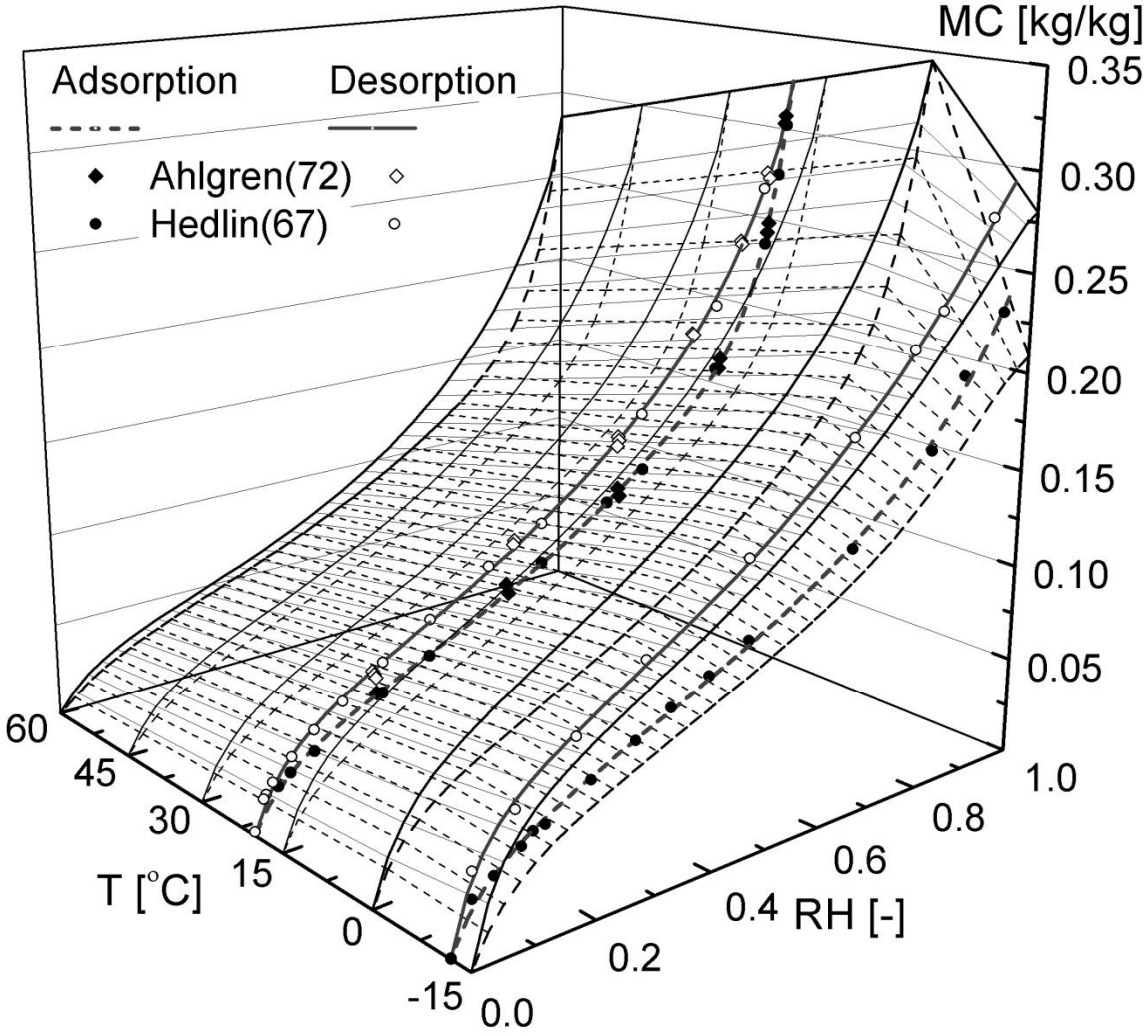

55°C
40°C
25°C
10°C
ADSORPTION
55°C
40°C
25°C
10°C
DESORPTION
MOISTURE CONTENT G/G
MOISTURE CONTENT G/G
0·30
0·25
0·20
0·15
0·10
0·05
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
RELATIVE VAPOUR PRESSURE

Sorption Space (φ, T, u)

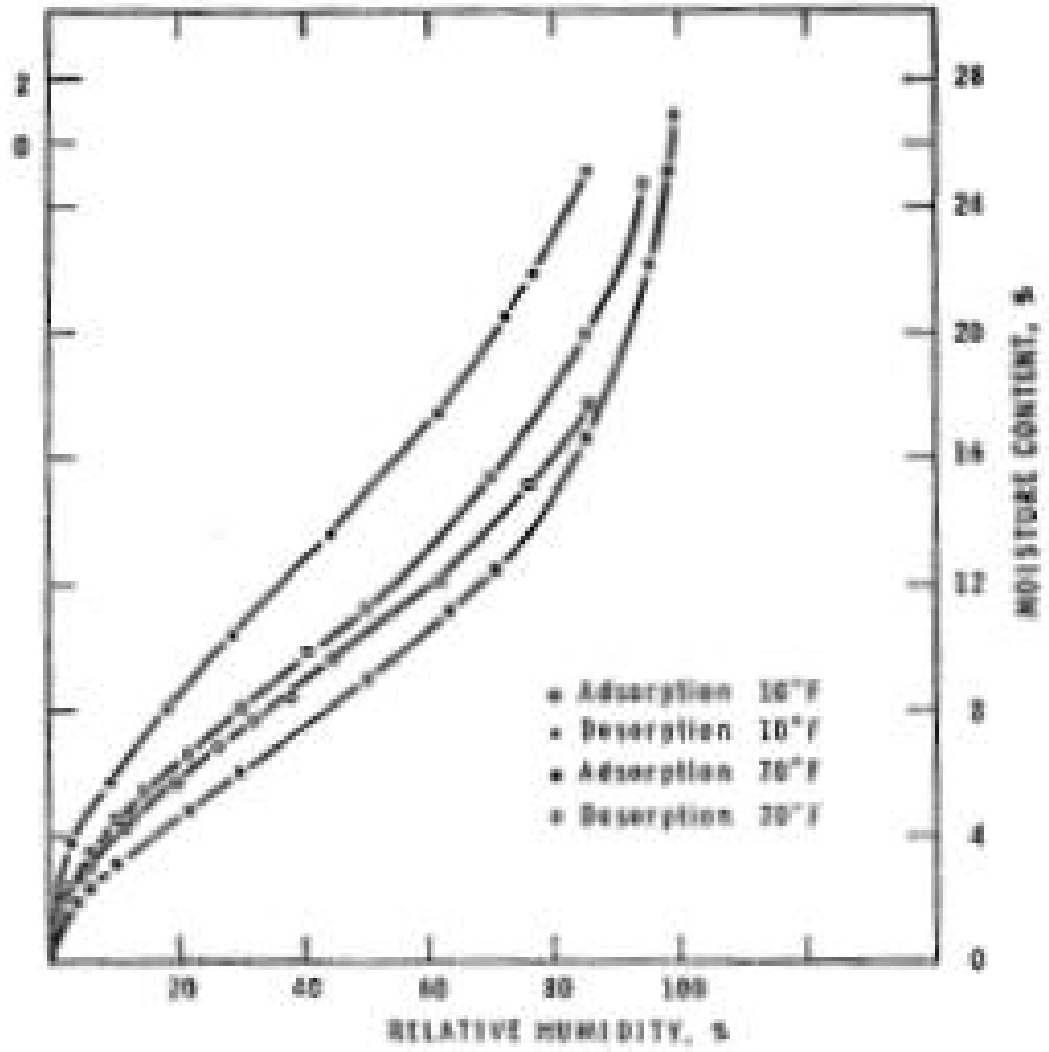
(Norway Spruce)

Sorption characteristics can be represented as a body in the three-dimensional space, defined by axes for relative humidity, temperature, and moisture content.

The body is confined between a lower surface for adsorption, and an upper surface for desorption.



Hedlin, 1967


28
24
20
16
12
8
4
0
MOISTURE CONTENT, %
Adsorption 10°F
Desorption 10°F
Adsorption 70°F
Desorption 70°F
20
40
60
80
100
RELATIVE HUMIDITY, %

New measurements

- The paper contributes to the knowledge base by presenting new measurements of hysteresis and temperature dependency of the moisture sorption characteristics of three different porous building materials
- Scanning curves are measured for all three materials where periods with adsorption and desorption interrupt each other intermittently
- For one of the materials, aerated concrete, the sorption curves are determined at three different temperatures

Equipment

Desiccator with small jars

Sorption balance (DVS)

Salts used in desiccators and their equilibrium relative humidity (at 23°C)

Salt	Equilibrium RH
MgCl	33 %
$Mg(NO_3)_2$	53 %
NH_4Cl	79 %
KNO_3	94 %

Exposure of samples subjected to hysteretic relative humidity exposure

Adsorption tests
$Dry_{105°C}$ – 94%
$Dry_{105°C}$ – 79%
$Dry_{105°C}$ – 53%
$Dry_{105°C}$ – 33%

Adsorption tests were followed by desorption scans
Desorption tests were followed by adsorption scans

Materials

Three hygroscopic materials were used for testing:

Cement paste

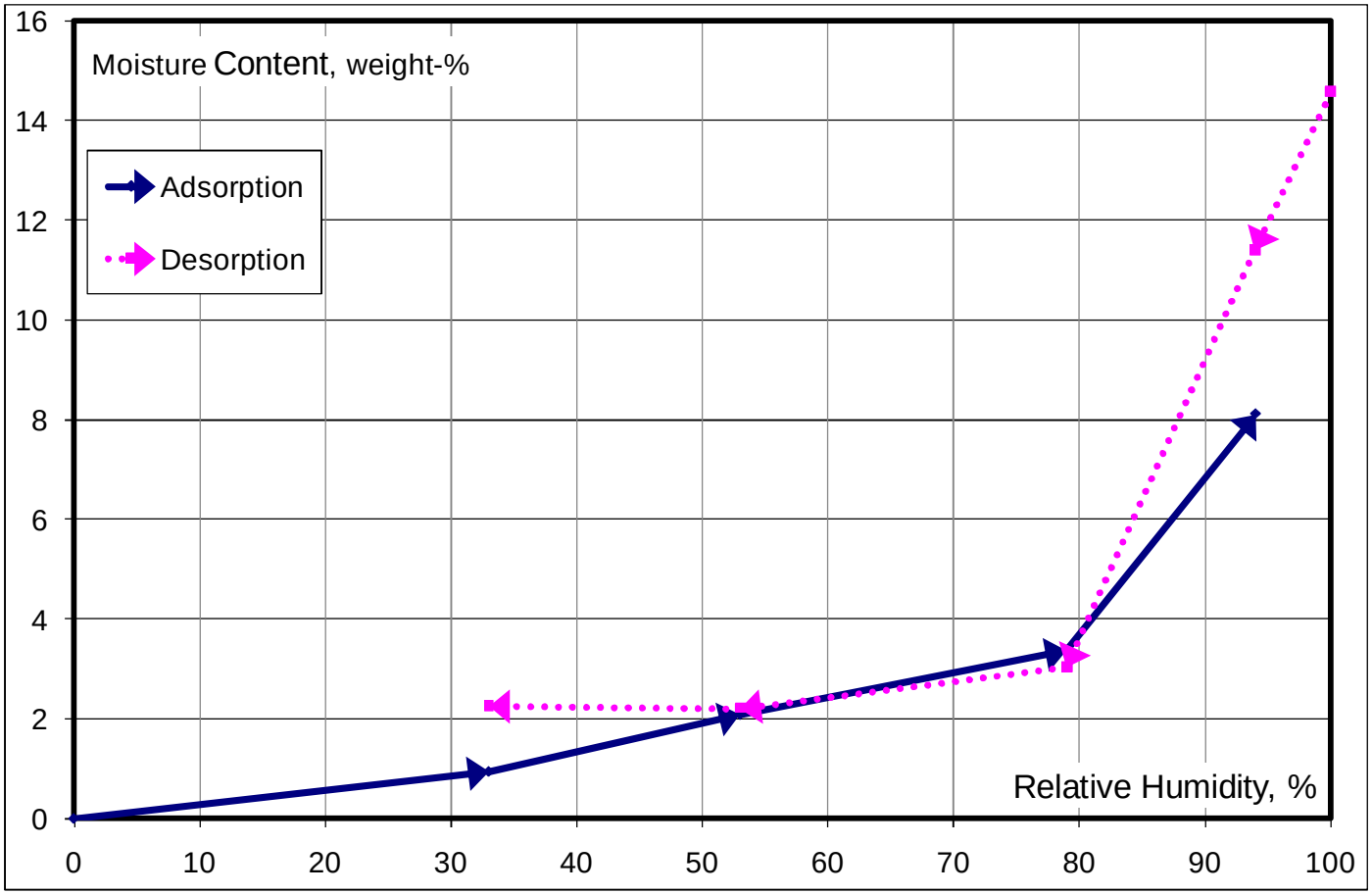
- Water-cement ratio: 0.5
- The cement paste is six years old and well carbonated since it has been stored in air

Aerated concrete

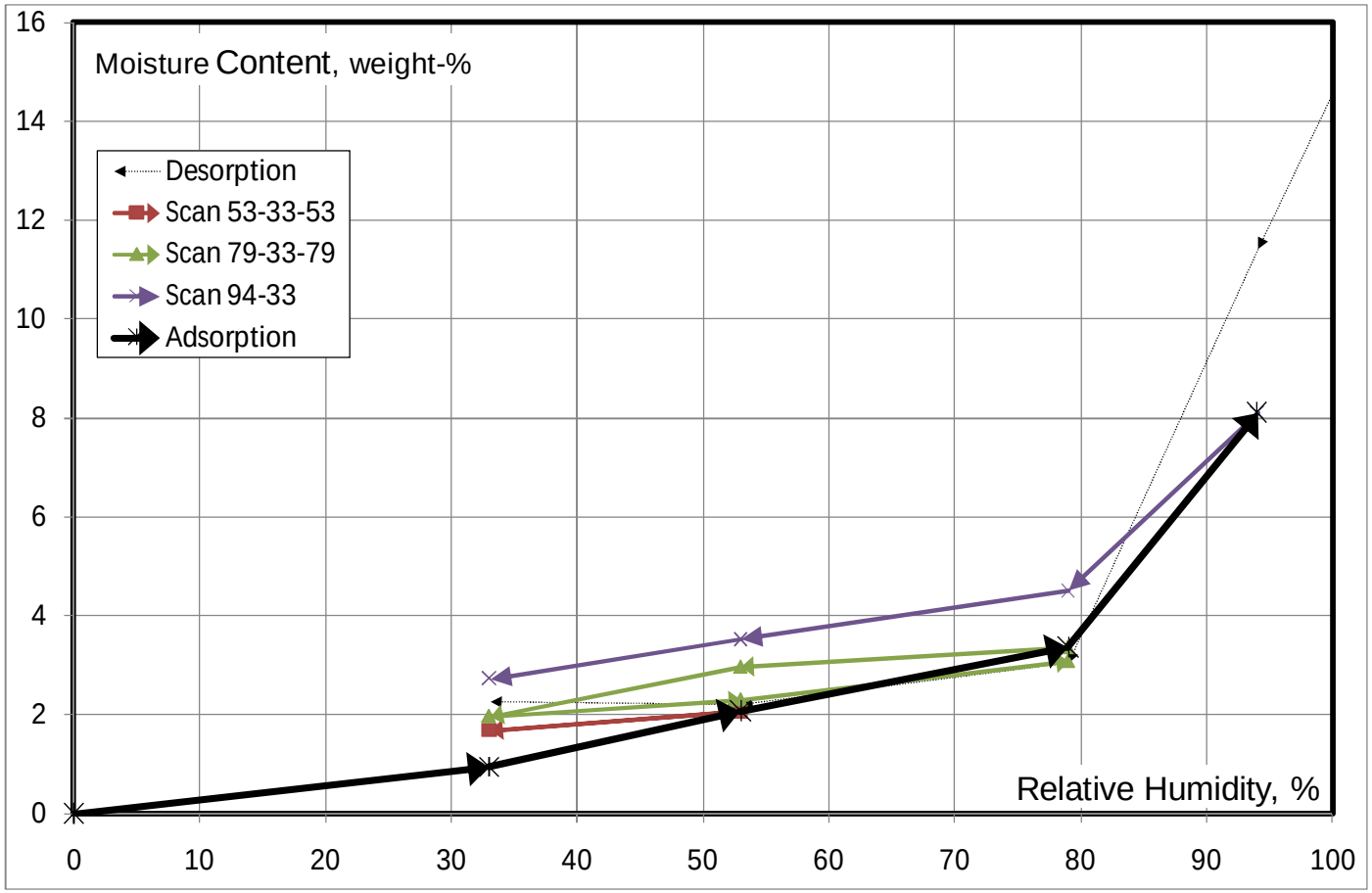
- A light-weight product from H+H Celcon. Density: 380 kg/m^3

Spruce

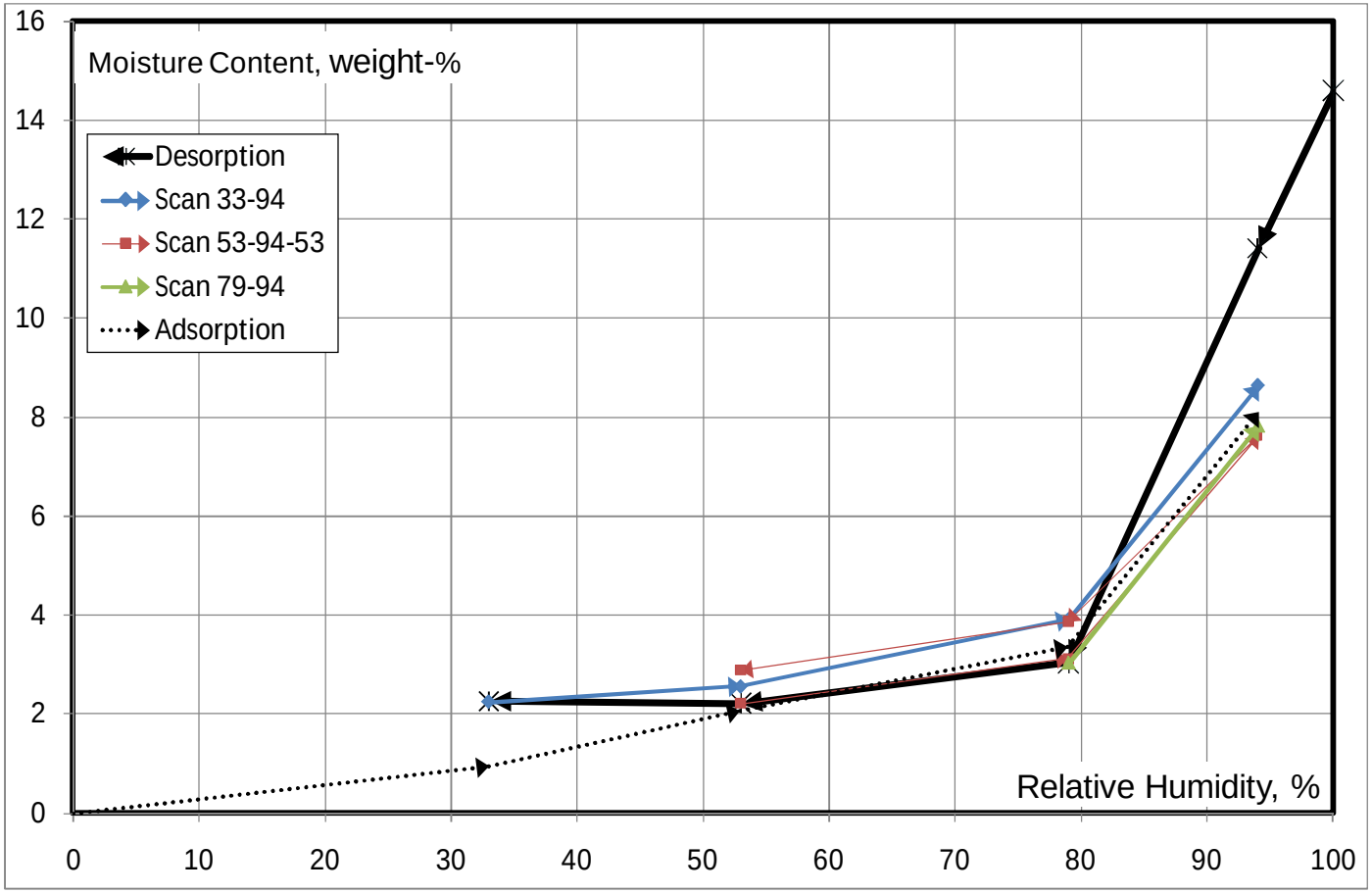
Cement Paste – Adsorption and desorption curves



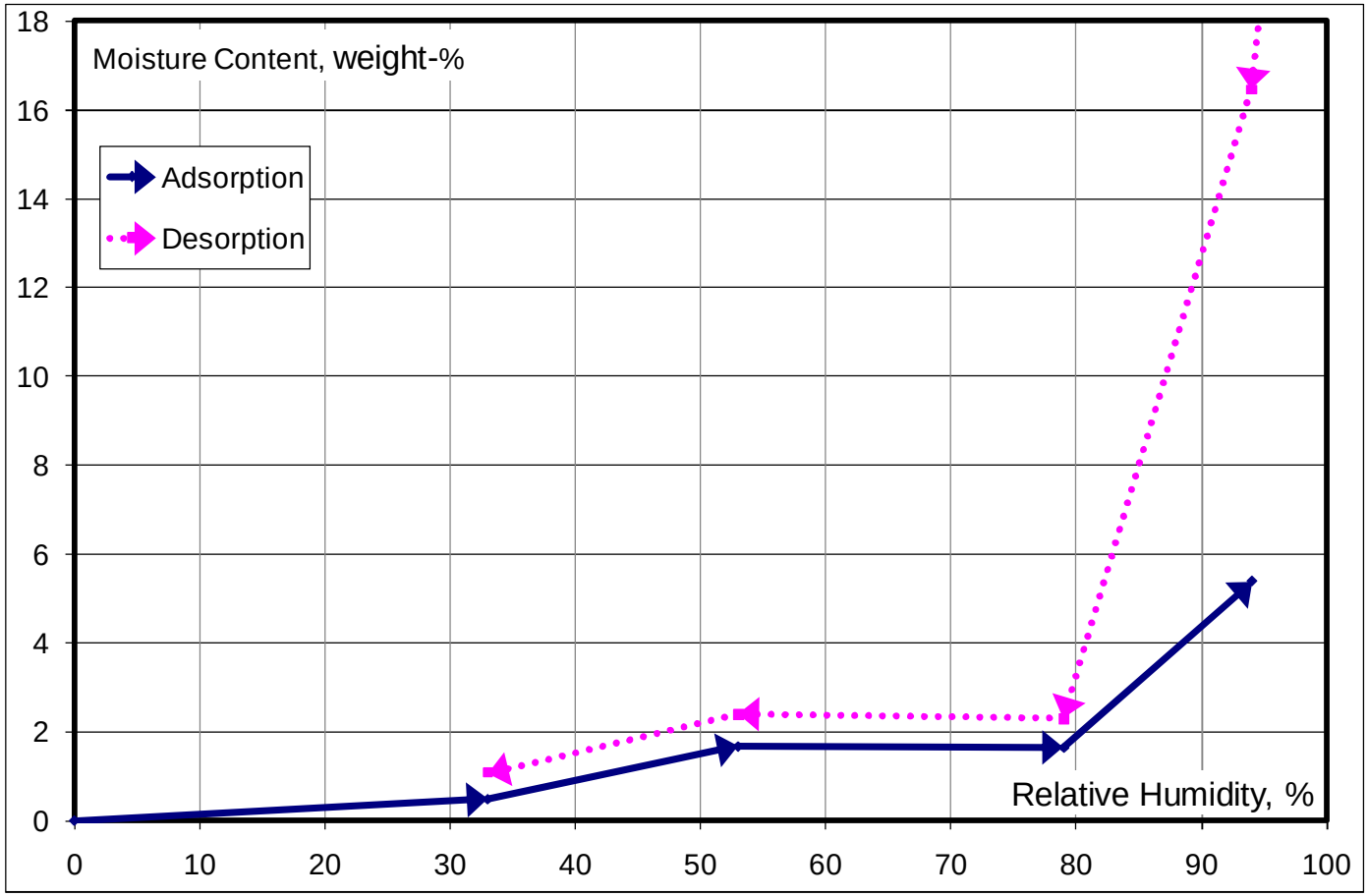
Cement Paste – Adsorption with subsequent desorption scans



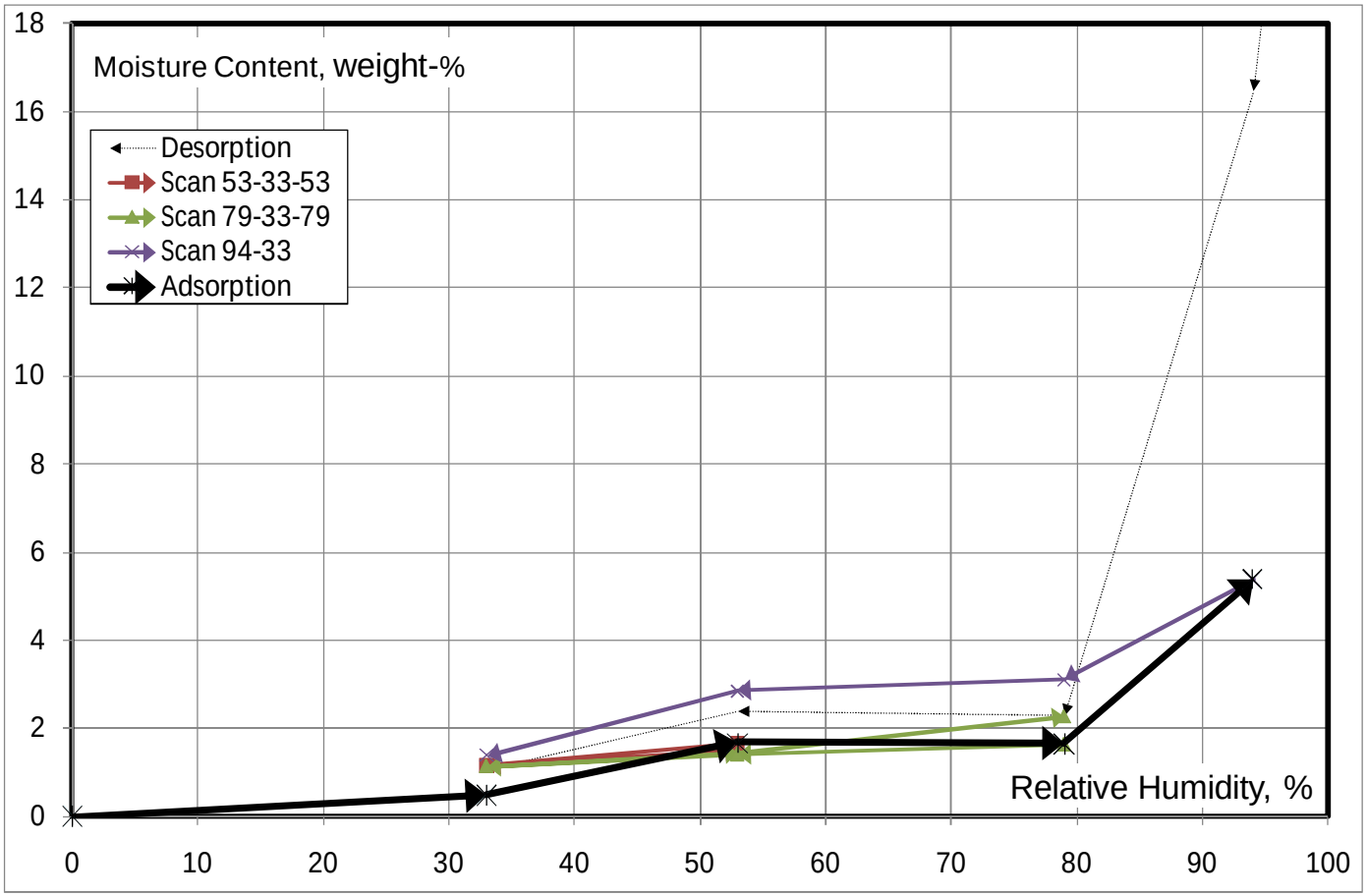
Cement Paste –
Desorption with subsequent adsorption scans



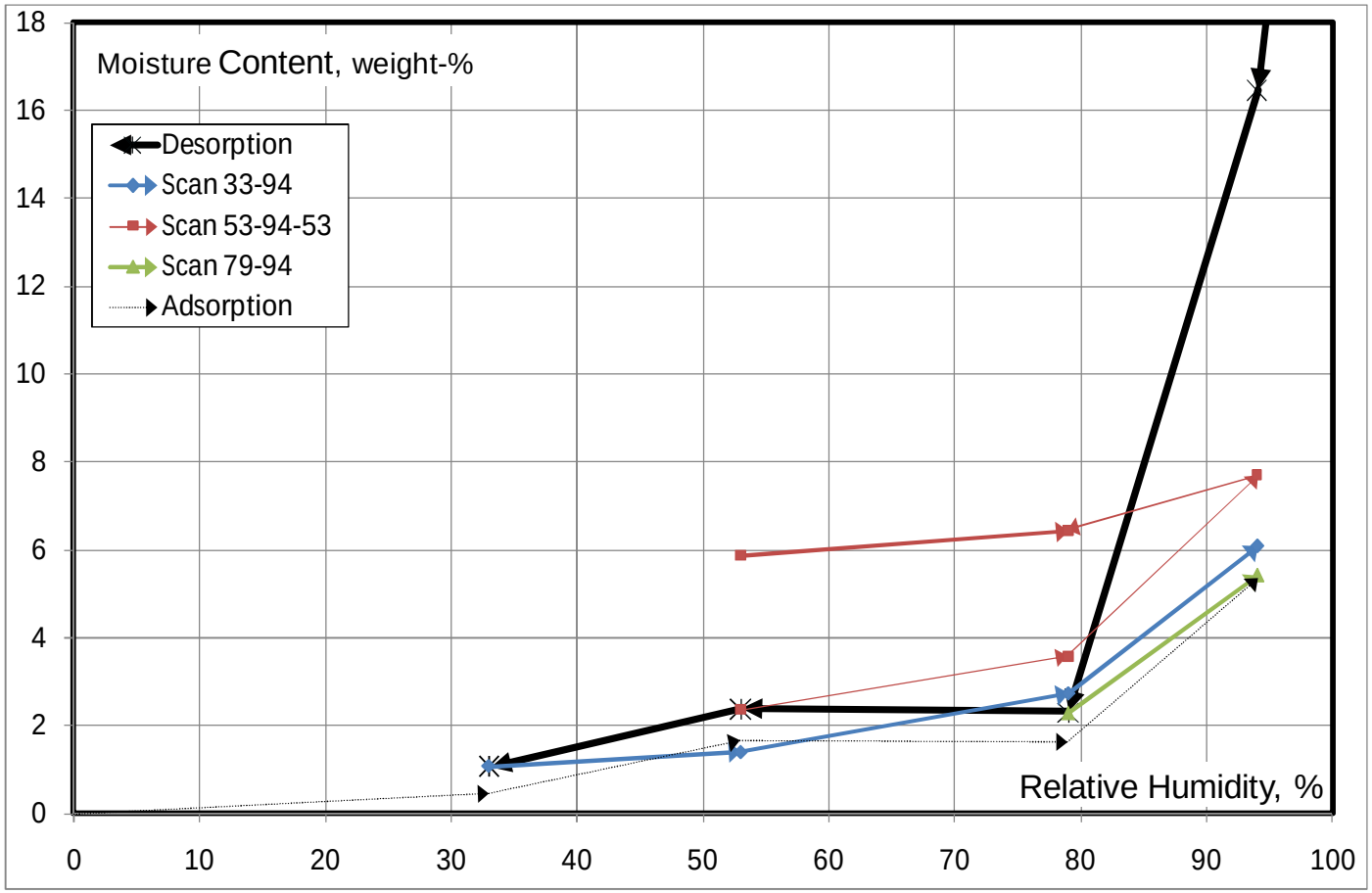
Aerated Concrete – Adsorption and desorption curves



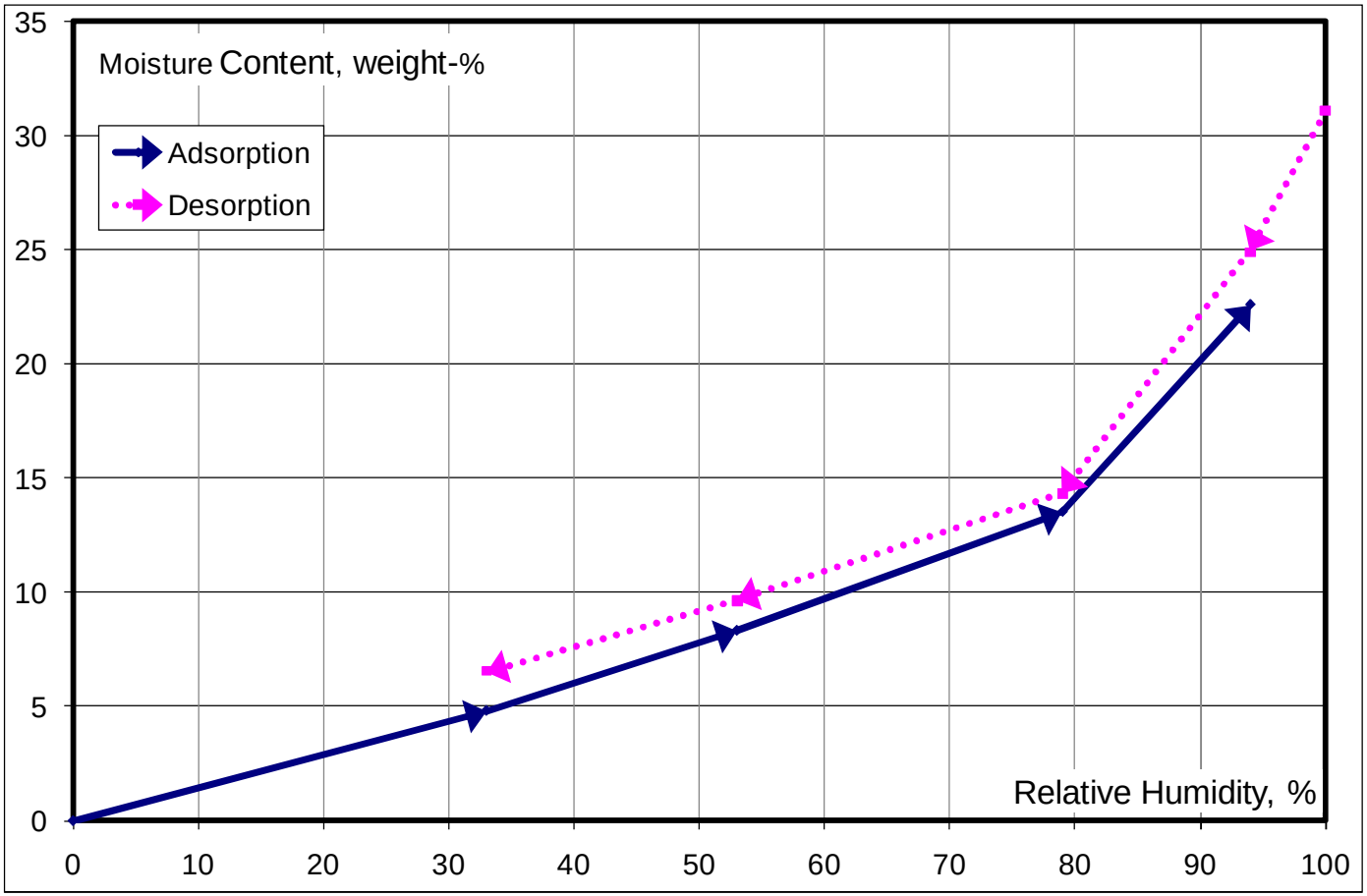
Aerated Concrete – Adsorption with subsequent desorption scans



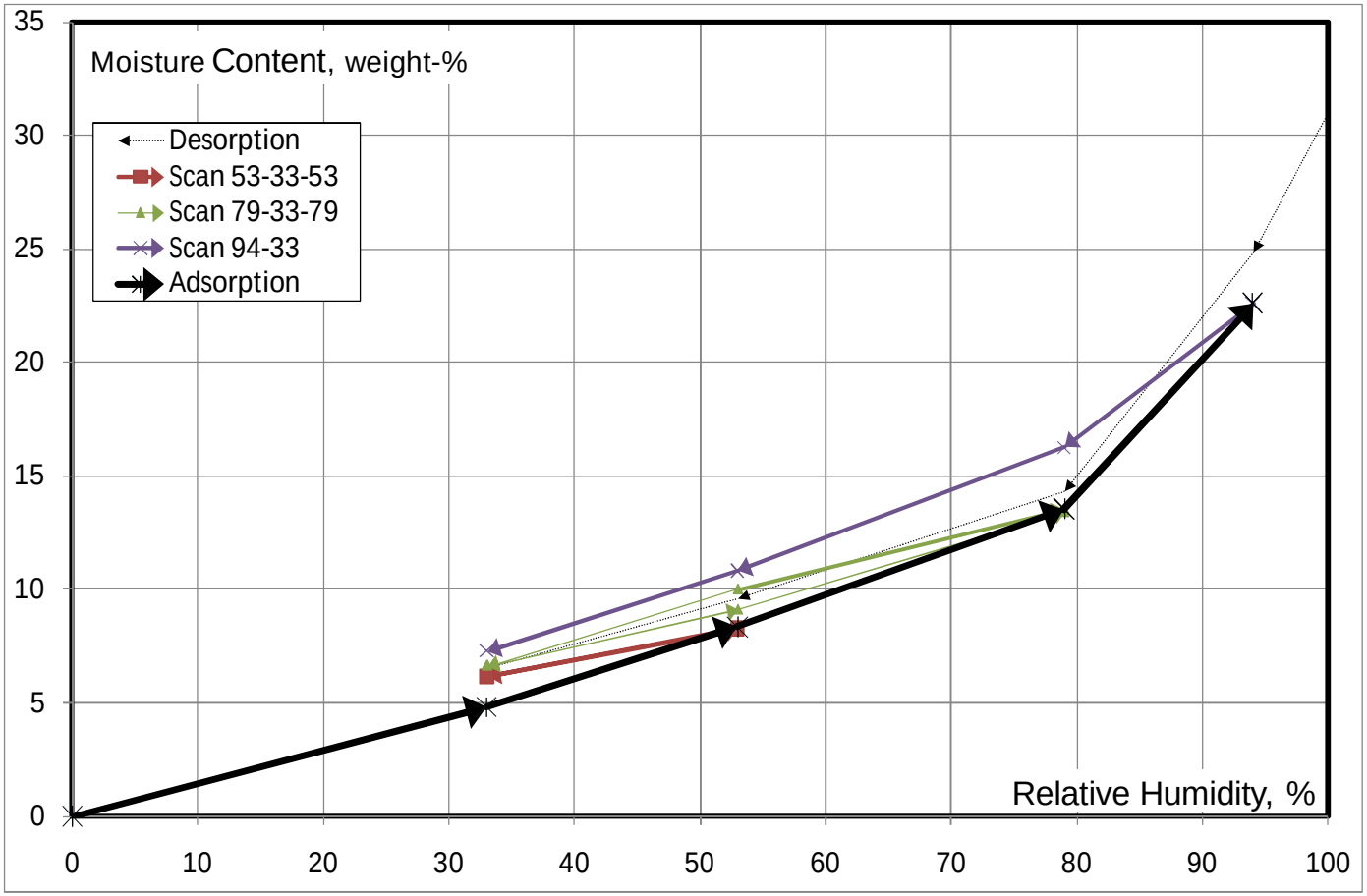
Aerated Concrete – Desorption with subsequent adsorption scans



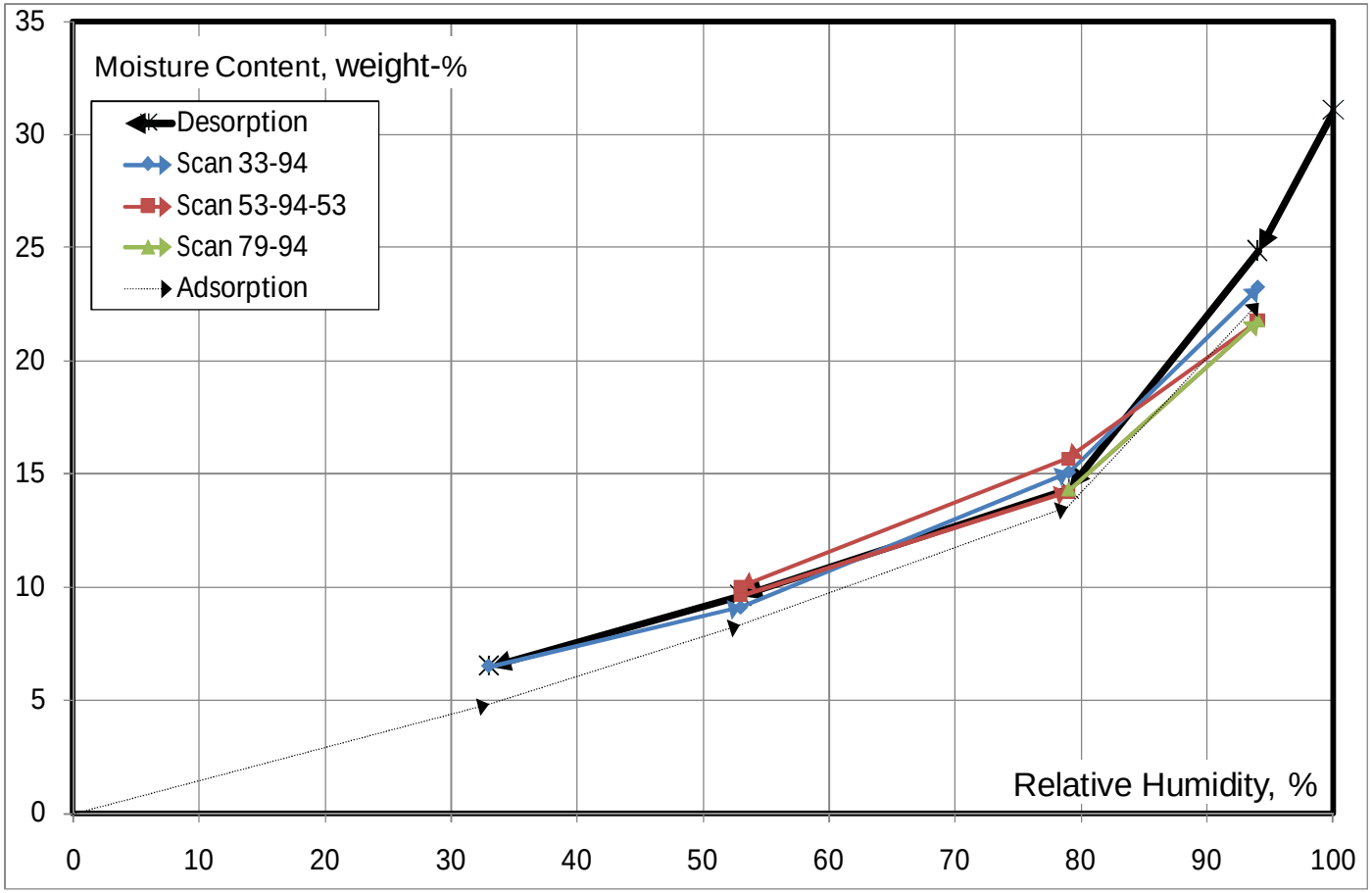
Spruce –
Adsorption and desorption curves



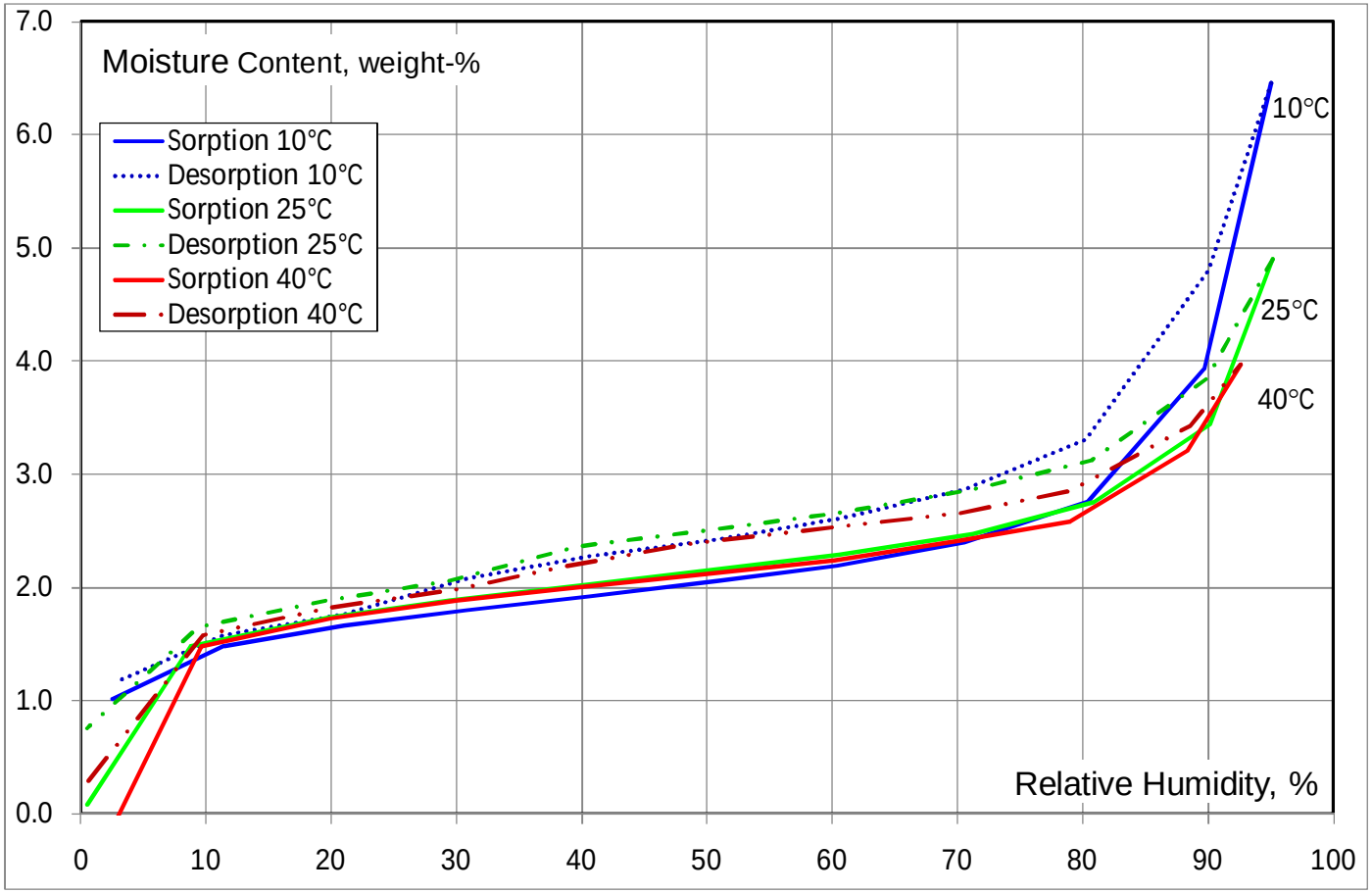
Spruce –
Adsorption with subsequent desorption scans



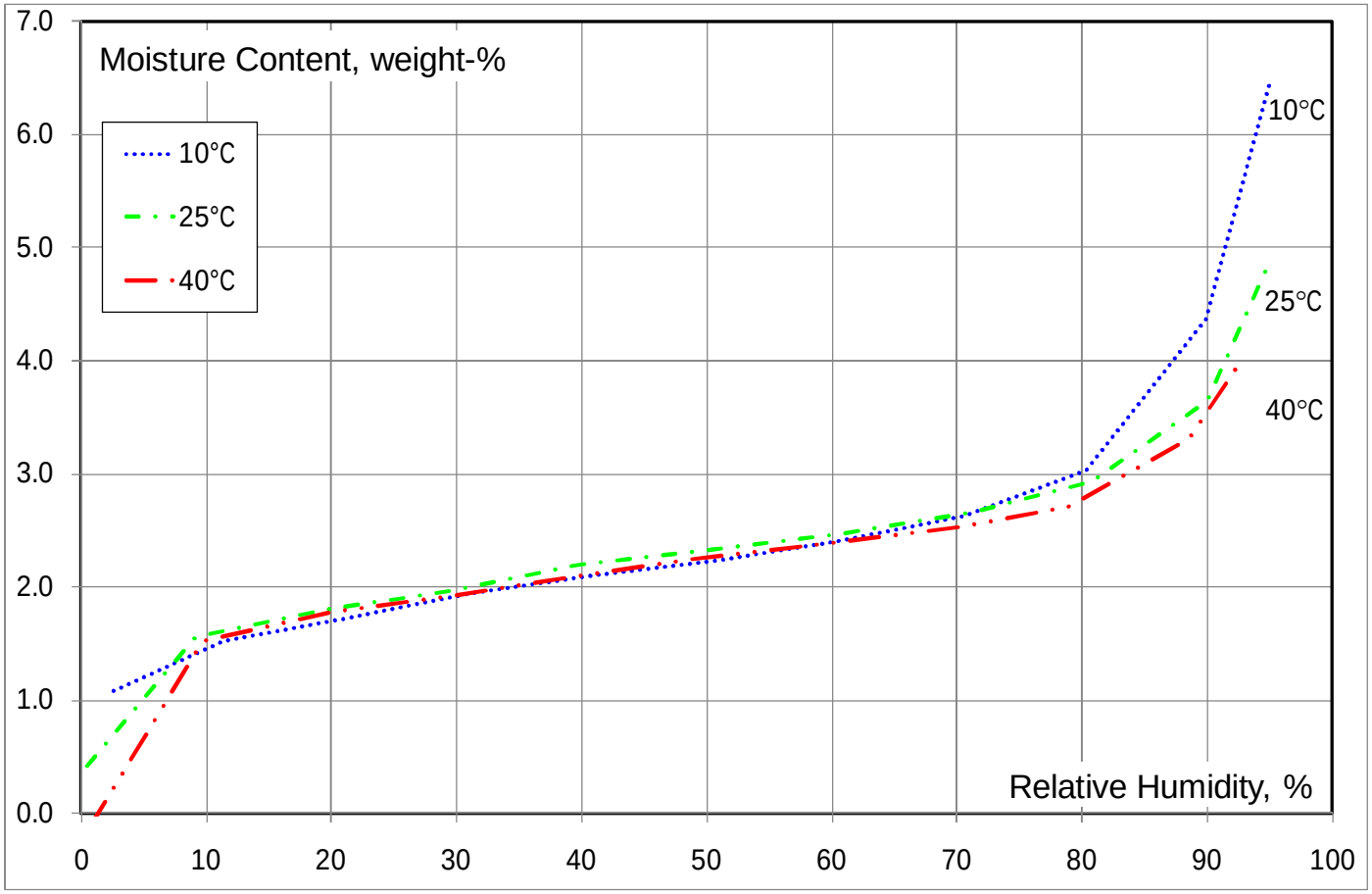
Spruce –
Desorption with subsequent adsorption scans



Aerated Concrete – Adsorption and desorption curves at different temperatures (DVS - sorption balance)



Aerated Concrete –
Mean sorption curves at different temperatures



Conclusions

- New experimental data have been produced regarding hysteresis and temperature dependency for three different hygroscopic materials
- Further investigations of this kind may be worth pursuing
- The automatic sorption balance apparatus appears to be a useful instrument in such investigations