Condensation

UNE EN ISO 13788

INDEX

1.- OFFICES - SOUTH

1.1.- Brick wall 13

1.1.1.- Condensation analysis results

1.1.1.1.- Surface condensation

f_{Rsi} = 0.929 ³ $f_{Rsi,min}$ = 0.105
The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $j_{si,cr}$ £ 0.8.

1.1.1.2.- Interstitial condensation

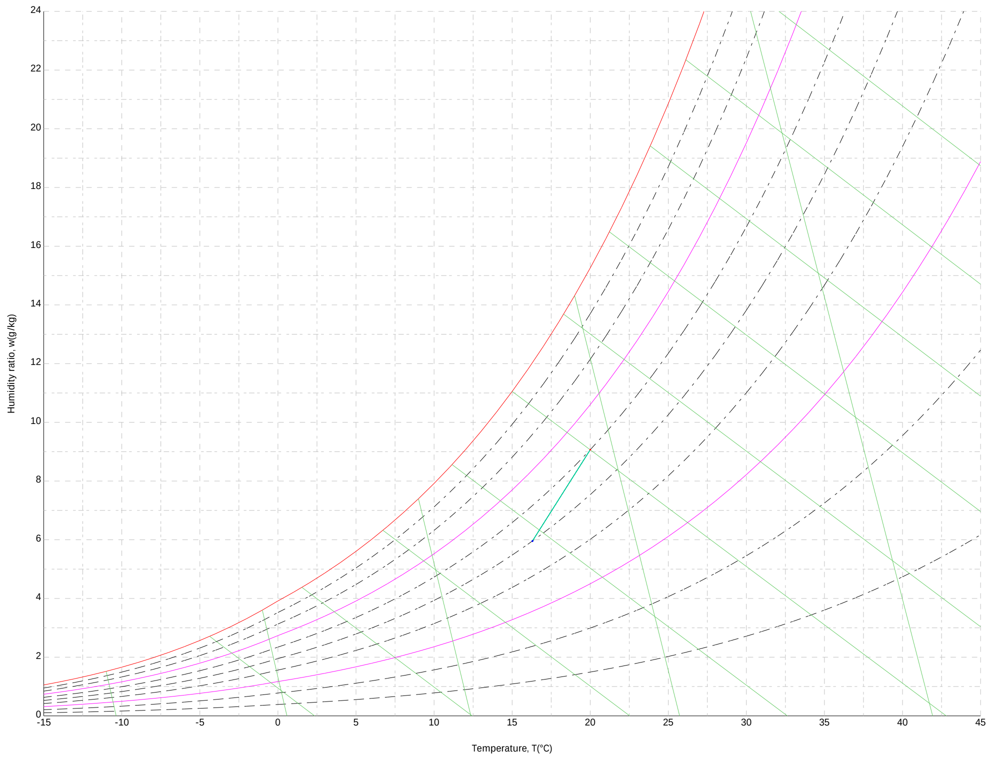
The construction element does not show any sign of interstitial condensation.

1.1.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

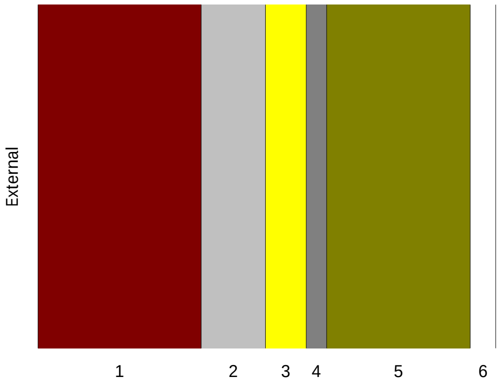
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.1.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

	Brick wall 13	e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.04		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	G03 - 13 mm fiberboard sheathing	1.3	0.068	0.18676	1	0.0127
5	I04 - 89 mm batt insulation	8.9	0.046	1.94348	1	0.0894
6	G01 - 16 mm gyp board	1.6	0.160	0.09938	1	0.0159
R_{si}				0.13		

where:

- *e: Thickness, cm.*
- *l: Thermal conductivity of the material, W/(m·K).*
- *R: Thermal resistance of the material, m²·K/W.*
- *m: Water vapour diffusion resistance factor of the material.*
- *S_d: Equivalent air thickness against the water vapour diffusion, m.*
- *R_{se}: External surface thermal resistance of the element, m²·K/W.*
- *R_{si}: Internal surface thermal resistance of the element, m²·K/W.*

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	28.5
Total thermal resistance, R_T	m²·K/W	3.5391
Total equivalent air thickness, $S_{d,T}$	m	0.26
Thermal transmittance, U	W/(m²·K)	0.283
Internal surface resistance factor, f_{Rsi}	--	0.929

where:

- *E_T: Total thickness of the element, cm.*
- *R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.*
- *S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.*
- *U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).*
- *f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.*

1.1.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.929 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.1.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 13	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.34	1857.335	926.197	49.9	--	--
Interface 1-2	16.46	1871.438	1115.840	59.6	--	--
Interface 2-3	16.62	1890.196	1134.505	60.0	--	--
Interface 3-4	17.53	2003.050	1181.916	59.0	--	--
Interface 4-5	17.73	2027.864	1205.621	59.5	--	--
Interface 5-6	19.76	2302.487	1372.492	59.6	--	--
Internal surface	19.86	2317.363	1402.171	60.5	--	--
Internal air	20.00	2336.951	1402.171	60.0		

where:

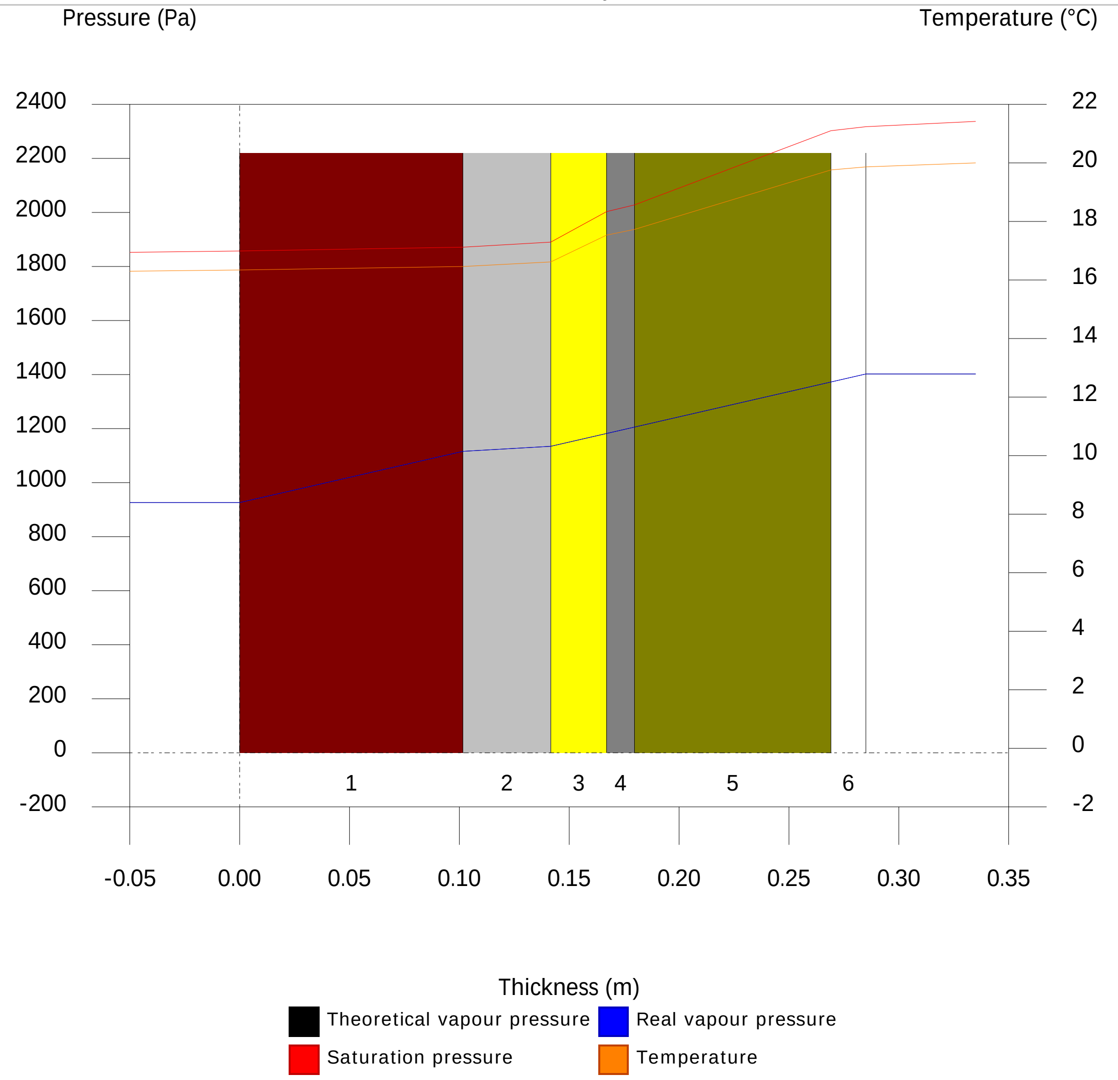
- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*

j :	*Relative humidity, %.*
g_c:	*Condensation flow density, g/(m²·month).*
M_a:	*Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.1.6.- Graphical representation of the foreseen interstitial condensation

January



1.2.- Brick wall 17

1.2.1.- Condensation analysis results

1.2.1.1.- Surface condensation

f_{Rsi} = 0.835 ³ f $_{Rsi,min}$ = 0.105

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}:	*Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.*
$f_{Rsi,min}$:	*Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of j $_{si,cr}$ £ 0.8.*

1.2.1.2.- Interstitial condensation

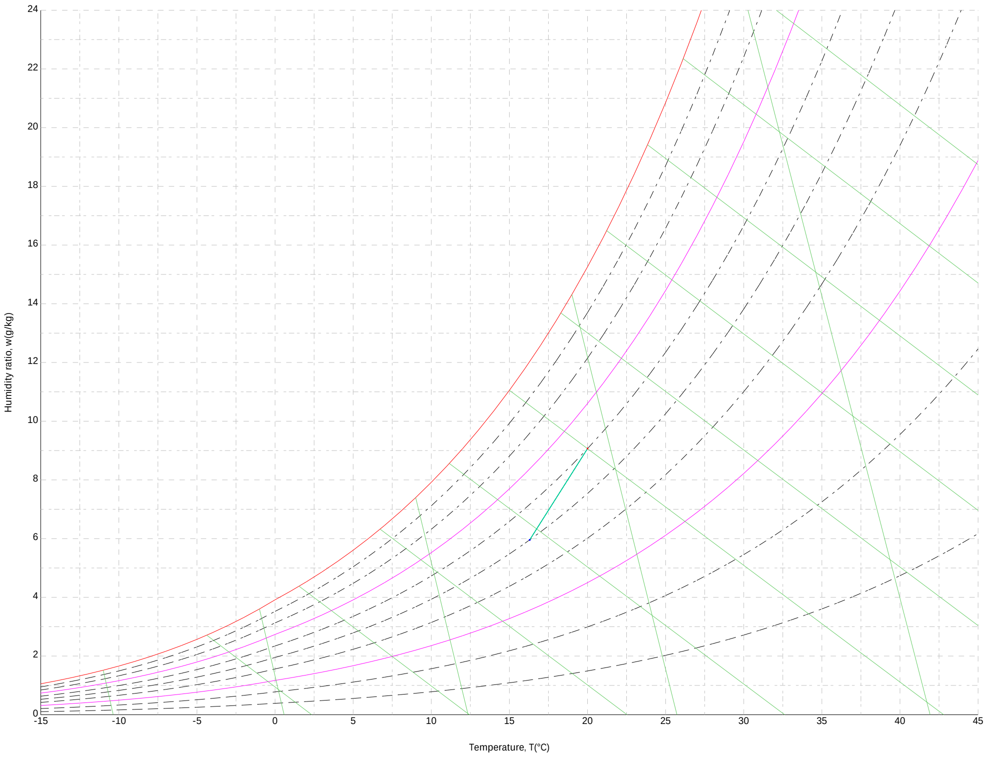
The construction element does not show any sign of interstitial condensation.

1.2.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

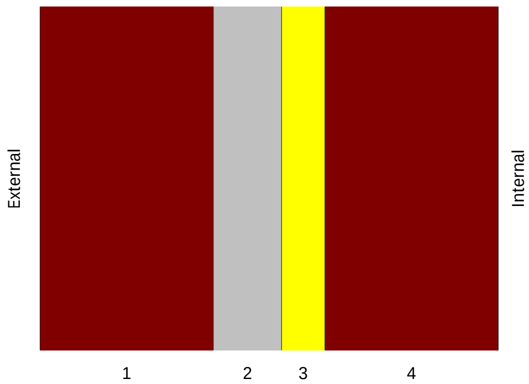
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.2.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides

making up the design model of the construction element are as follows:

Brick wall 17		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.13		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
R_{si}				0.13		

where:

- *e: Thickness, cm.*
- *l: Thermal conductivity of the material, W/(m·K).*
- *R: Thermal resistance of the material, m²·K/W.*
- *m: Water vapour diffusion resistance factor of the material.*
- *S_d: Equivalent air thickness against the water vapour diffusion, m.*
- *R_{se}: External surface thermal resistance of the element, m²·K/W.*
- *R_{si}: Internal surface thermal resistance of the element, m²·K/W.*

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	26.9
Total thermal resistance, R_T	m²·K/W	1.5132
Total equivalent air thickness, $S_{d,T}$	m	0.24
Thermal transmittance, U	W/(m²·K)	0.661
Internal surface resistance factor, f_{Rsi}	--	0.835

where:

- *E_T: Total thickness of the element, cm.*
- *R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.*
- *S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.*
- *U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).*
- *f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.*

1.2.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
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July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.835 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.2.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 17	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.62	1890.248	926.197	49.0	--	--
Interface 1-2	16.90	1923.894	1128.875	58.7	--	--
Interface 2-3	17.26	1969.105	1148.823	58.3	--	--
Interface 3-4	19.40	2252.147	1199.493	53.3	--	--
Internal surface	19.68	2291.362	1402.171	61.2	--	--
Internal air	20.00	2336.951	1402.171	60.0		

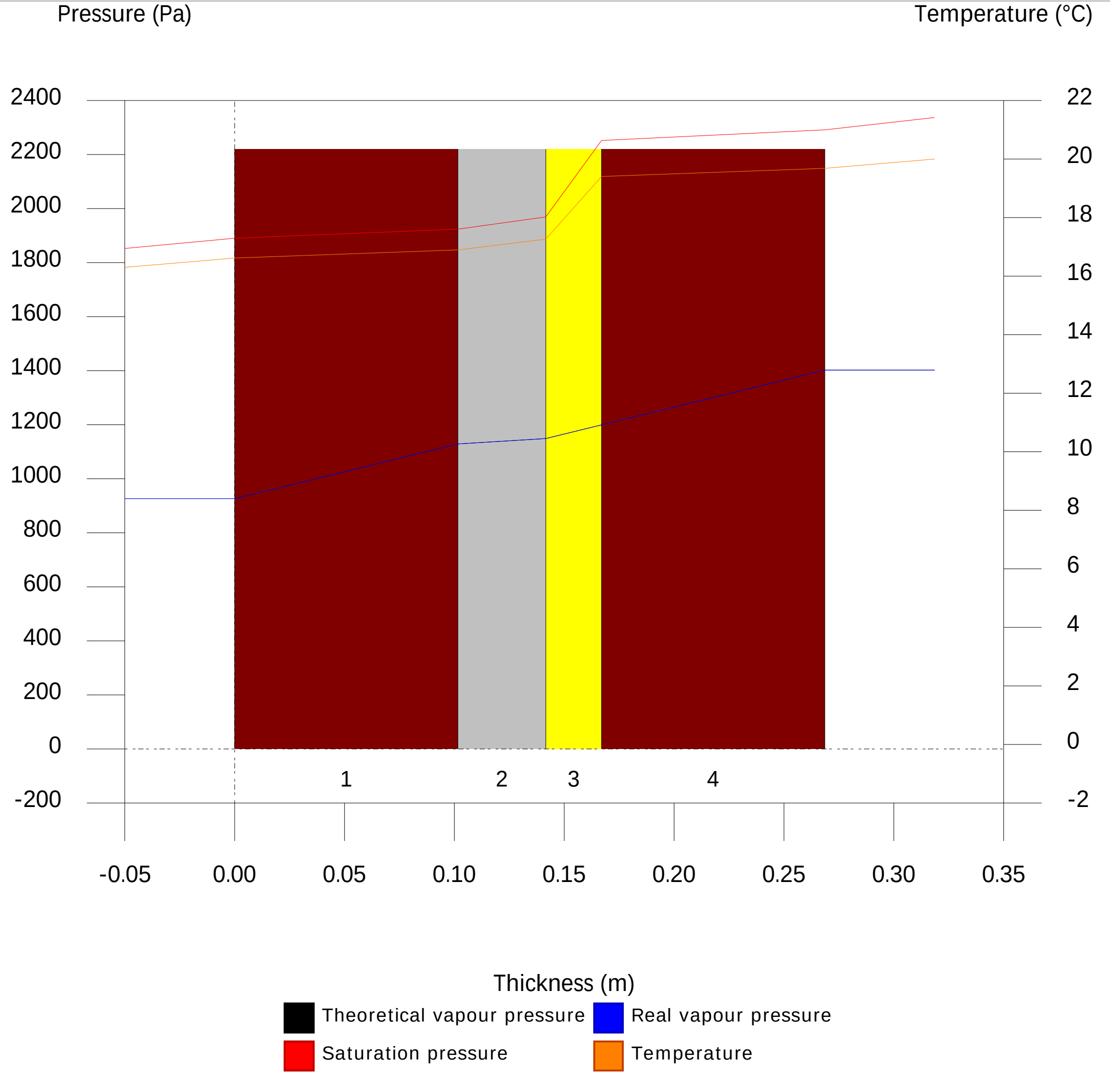
where:

- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*
- j: *Relative humidity, %.*
- g_c: *Condensation flow density, g/(m²·month).*
- M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.2.6.- Graphical representation of the foreseen interstitial condensation

January



1.3.- Isolated partition

1.3.1.- Condensation analysis results

1.3.1.1.- Surface condensation

$f_{Rsi} = 0.903 \geq f_{Rsi,min} = 0.105$

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: *Internal surface resistance factor, calculated as (1 - U·R$_{si}$), where U = 0.390 W/m²·K and R$_{si}$ = 0.25 m²·K/W.*

$f_{Rsi,min}$: *Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $\varphi_{si,cr} \leq$ 0.8.*

1.3.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

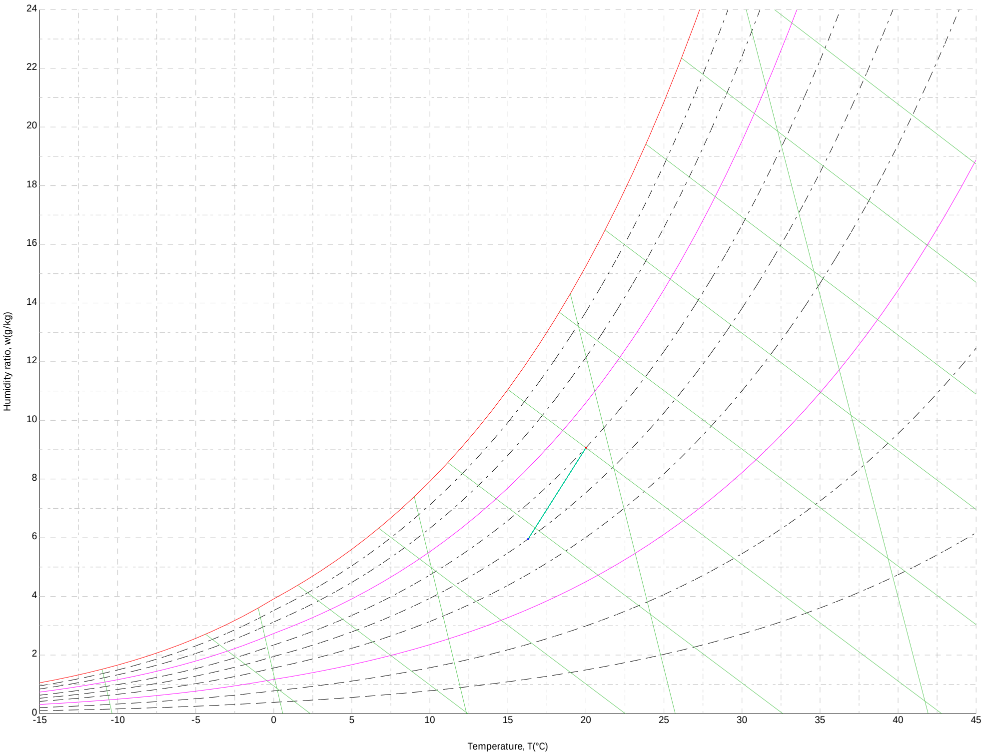
1.3.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

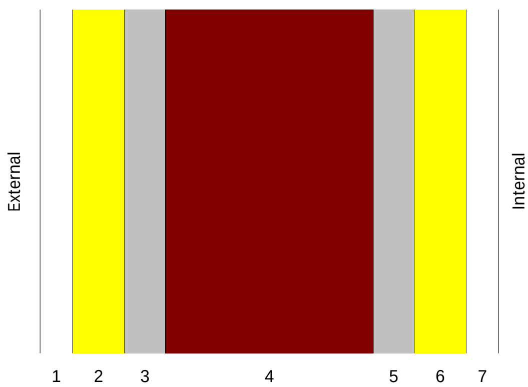
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.3.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

	Isolated partition	e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.13		
1	16 mm gyp board	1.6	0.160	0.09938	1	0.0159
2	25 mm insulation board	2.5	0.030	0.84667	1	0.0254
3	Wall air space resistance	2.0		0.15000		0.01
4	100 mm brick	10.2	0.890	0.11416	1	0.1016
5	Wall air space resistance	2.0		0.15000		0.01
6	25 mm insulation board	2.5	0.030	0.84667	1	0.0254
7	16 mm gyp board	1.6	0.160	0.09938	1	0.0159
R_{si}				0.13		

where:

- *e: Thickness, cm.*
- *l: Thermal conductivity of the material, W/(m·K).*
- *R: Thermal resistance of the material, m²·K/W.*
- *m: Water vapour diffusion resistance factor of the material.*
- *S_d: Equivalent air thickness against the water vapour diffusion, m.*
- *R_{se}: External surface thermal resistance of the element, m²·K/W.*
- *R_{si}: Internal surface thermal resistance of the element, m²·K/W.*

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	22.4
Total thermal resistance, R_T	m²·K/W	2.5662
Total equivalent air thickness, $S_{d,T}$	m	0.20
Thermal transmittance, U	W/(m²·K)	0.390
Internal surface resistance factor, f_{Rsi}	--	0.903

where:

- *E_T: Total thickness of the element, cm.*
- *R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.*
- *S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.*
- *U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).*
- *f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.390 W/m²·K and R_{si} = 0.25 m²·K/W.*

1.3.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.903 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.3.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Isolated partition	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.49	1874.633	926.197	49.4	--	--
Interface 1-2	16.63	1891.790	963.258	50.9	--	--
Interface 2-3	17.85	2043.640	1022.464	50.0	--	--
Interface 3-4	18.07	2071.627	1045.773	50.5	--	--
Interface 4-5	18.23	2093.151	1282.594	61.3	--	--
Interface 5-6	18.45	2121.730	1305.904	61.5	--	--
Interface 6-7	19.67	2289.538	1365.109	59.6	--	--
Internal surface	19.81	2309.975	1402.171	60.7	--	--
Internal air	20.00	2336.951	1402.171	60.0		

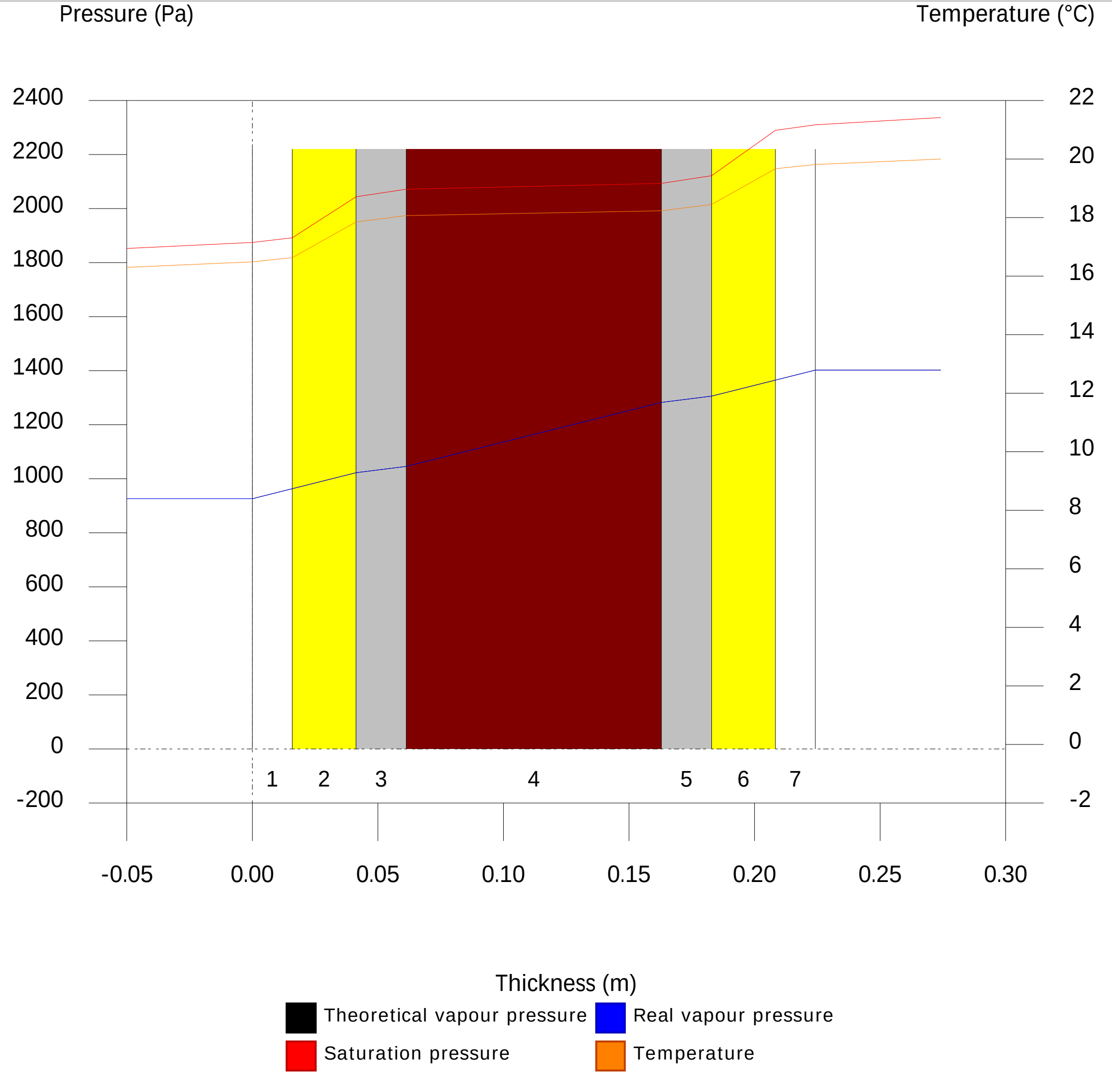
where:

- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*
- j: *Relative humidity, %.*
- g_c: *Condensation flow density, g/(m²·month).*
- M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.3.6.- Graphical representation of the foreseen interstitial condensation

January



1.4.- Concrete roof 19

1.4.1.- Condensation analysis results

1.4.1.1.- Surface condensation

$f_{Rsi} = 0.939 \geq f_{Rsi,min} = 0.105$

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.242 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $\varphi_{si,cr} \leq$ 0.8.

1.4.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

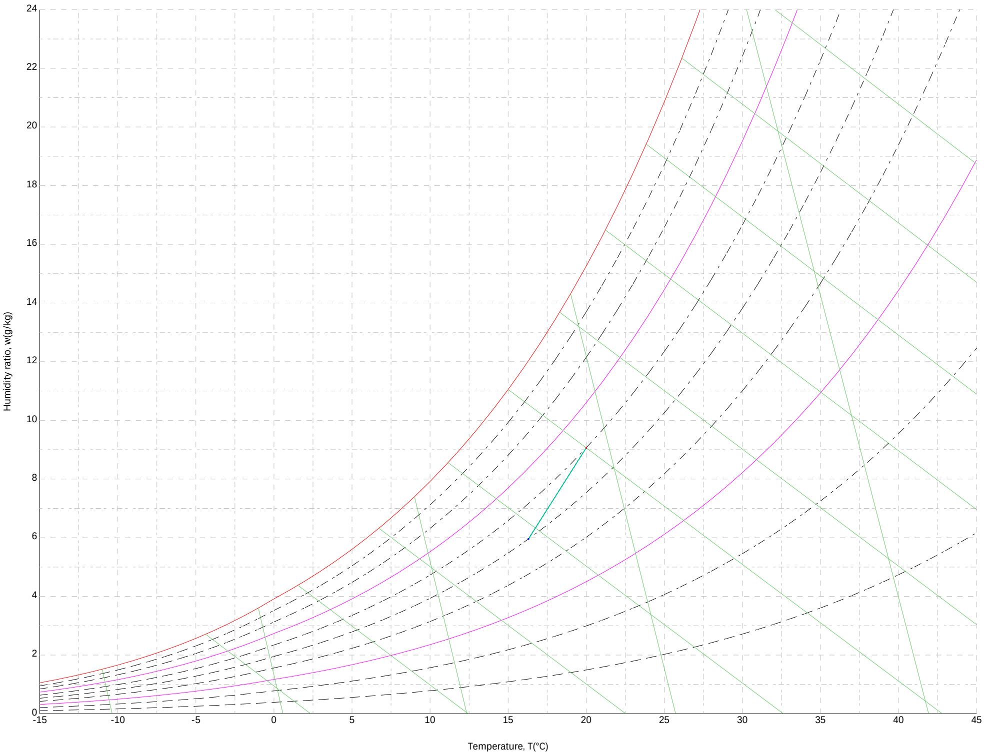
1.4.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

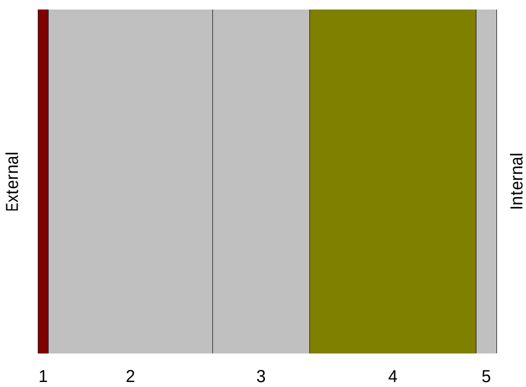
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.4.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

Concrete roof 19		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.04		
1	F13 - Built-up roofing	0.9	0.162	0.05864	1	0.0095
2	M14 - 150 mm heavyweight concrete	15.2	1.947	0.07827	1	0.1524
3	F05 - Ceiling air space resistance	9.0	0.500	0.18000	1	0.09
4	I05 - 154 mm batt insulation	15.4	0.046	3.35652	1	0.1544
5	F16 - Acoustic tile	1.9	0.061	0.31311	1	0.0191
R_{si}				0.10		

where:

e: Thickness, cm.
l: Thermal conductivity of the material, W/(m·K).
R: Thermal resistance of the material, m²·K/W.
m: Water vapour diffusion resistance factor of the material.
S_d: Equivalent air thickness against the water vapour diffusion, m.
R_{se}: External surface thermal resistance of the element, m²·K/W.
R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	42.5
Total thermal resistance, R_T	m²·K/W	4.1266
Total equivalent air thickness, $S_{d,T}$	m	0.43
Thermal transmittance, U	W/(m²·K)	0.242
Internal surface resistance factor, f_{Rsi}	--	0.939

where:

E_T: Total thickness of the element, cm.
R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.
S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.
U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).
f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.242 W/m²·K and R_{si} = 0.25 m²·K/W.

1.4.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.939 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.4.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Concrete roof 19	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.34	1856.631	926.197	49.9	--	--
Interface 1-2	16.39	1862.858	936.826	50.3	--	--
Interface 2-3	16.46	1871.200	1107.344	59.2	--	--
Interface 3-4	16.62	1890.505	1208.044	63.9	--	--
Interface 4-5	19.63	2283.903	1380.800	60.5	--	--
Internal surface	19.91	2324.012	1402.171	60.3	--	--
Internal air	20.00	2336.951	1402.171	60.0		

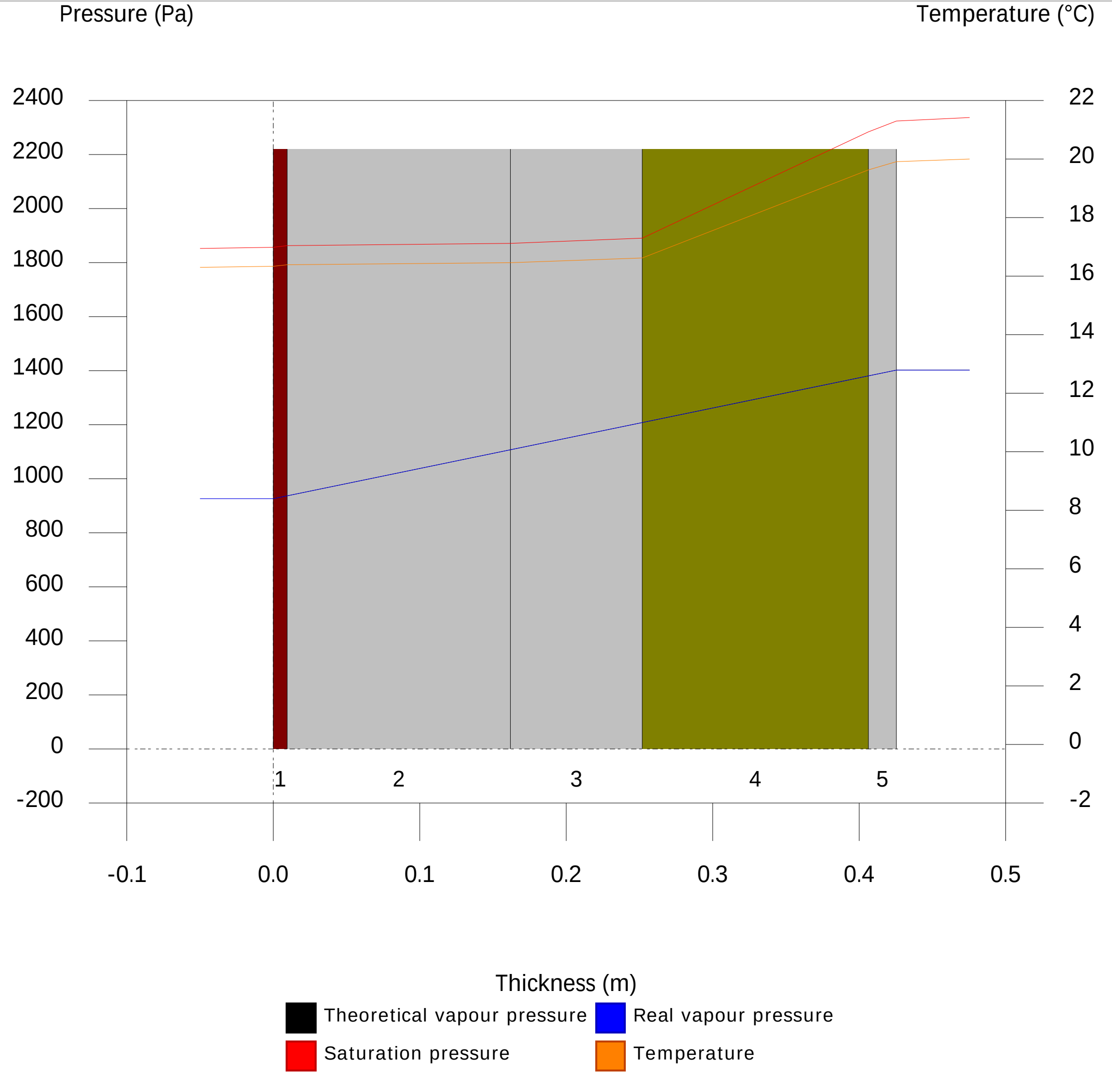
where:

- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*
- j: *Relative humidity, %.*
- g_c: *Condensation flow density, g/(m²·month).*
- M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.4.6.- Graphical representation of the foreseen interstitial condensation

January



1.5.- External floor slab

1.5.1.- Condensation analysis results

1.5.1.1.- Surface condensation

$f_{Rsi} = 0.889$ ³ $f_{Rsi,min} = 0.105$

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.444 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $j_{si,cr}$ £ 0.8.

1.5.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

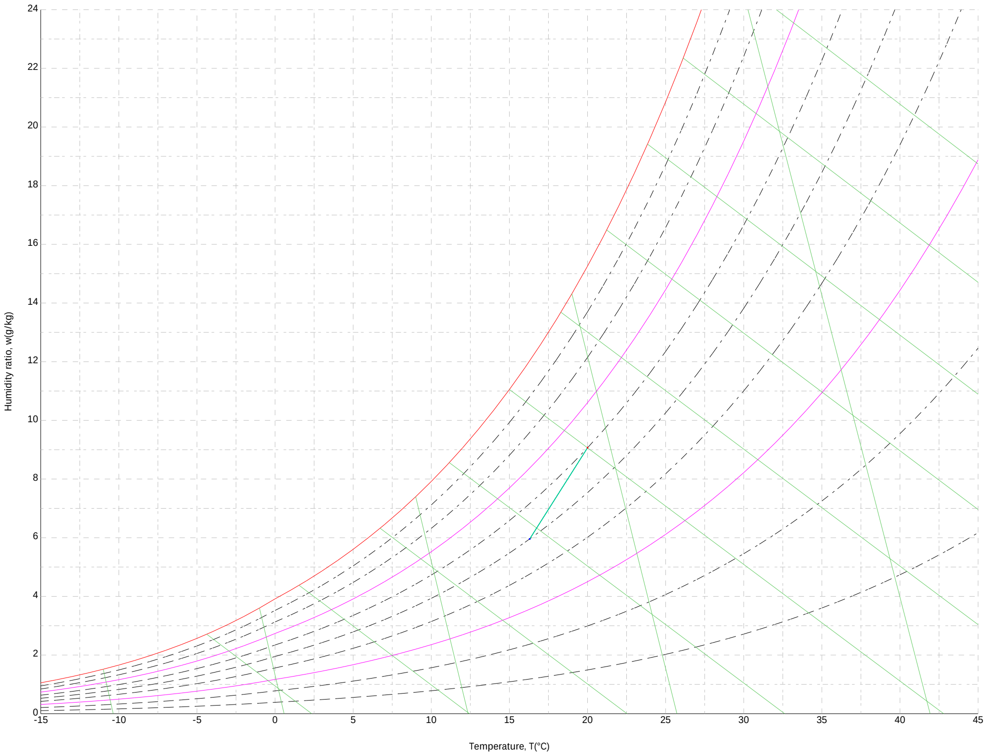
1.5.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

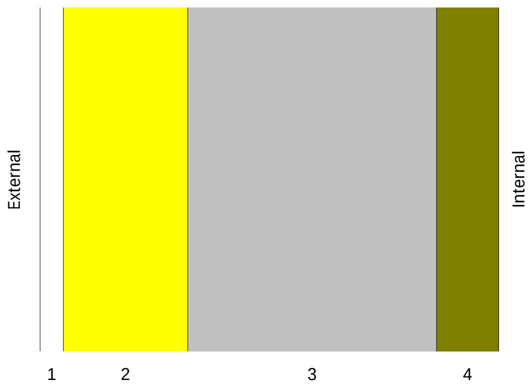
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.5.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

External floor slab		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.17		
1	EIFS finish	0.9	0.720	0.01319	1	0.0095
2	50 mm insulation board	5.1	0.030	1.69333	1	0.0508
3	100 mm lightweight concrete	10.2	0.530	0.19170	1	0.1016
4	Terrazzo	2.5	1.800	0.01411	1	0.0254
R_{si}				0.17		

where:

e: Thickness, cm.

l: Thermal conductivity of the material, W/(m·K).

R: Thermal resistance of the material, m²·K/W.

m: Water vapour diffusion resistance factor of the material.

S_d: Equivalent air thickness against the water vapour diffusion, m.

R_{se}: External surface thermal resistance of the element, m²·K/W.

R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	18.7
Total thermal resistance, R_T	m²·K/W	2.2523
Total equivalent air thickness, $S_{d,T}$	m	0.19
Thermal transmittance, U	W/(m²·K)	0.444
Internal surface resistance factor, f_{Rsi}	--	0.889

where:

E_T: Total thickness of the element, cm.

R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.

S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.

U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.444 W/m²·K and R_{si} = 0.25 m²·K/W.

1.5.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

q_e: External air temperature, °C.

j_e: *Relative humidity of the external air, %.*
q_i: *Internal air temperature, °C.*
j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
P_i: *Vapour pressure in the internal air, Pa.*
$P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
$q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
$f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.889 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.5.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

External floor slab	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.58	1885.614	926.197	49.1	--	--
Interface 1-2	16.60	1888.214	950.338	50.3	--	--
Interface 2-3	19.38	2249.125	1079.433	48.0	--	--
Interface 3-4	19.70	2293.557	1337.623	58.3	--	--
Internal surface	19.72	2296.858	1402.171	61.0	--	--
Internal air	20.00	2336.951	1402.171	60.0		

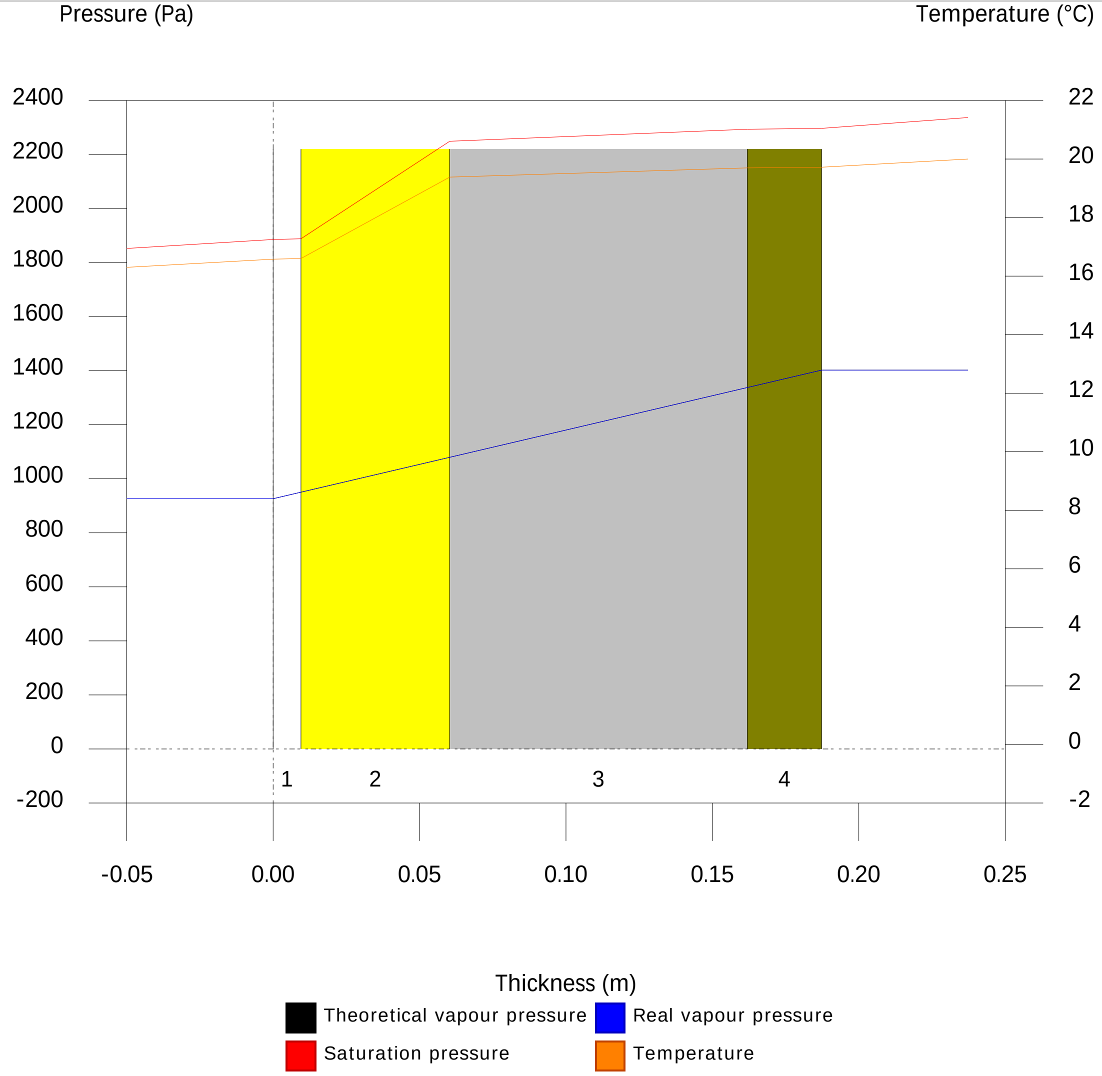
where:

q: *Temperature, °C.*
P_{sat}: *Water vapour saturation pressure, Pa.*
P_n: *Water vapour pressure, Pa.*
j: *Relative humidity, %.*
g_c: *Condensation flow density, g/(m²·month).*
M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.5.6.- Graphical representation of the foreseen interstitial condensation

January



1.6.- Screed

1.6.1.- Condensation analysis results

1.6.1.1.- Surface condensation

$f_{Rsi} = 0.877 \geq f_{Rsi,min} = 0.105$

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as $(1 - U \cdot R_{si})$, where $U = 0.490$ W/m²·K and $R_{si} = 0.25$ m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $\varphi_{si,cr} \leq$ 0.8.

1.6.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

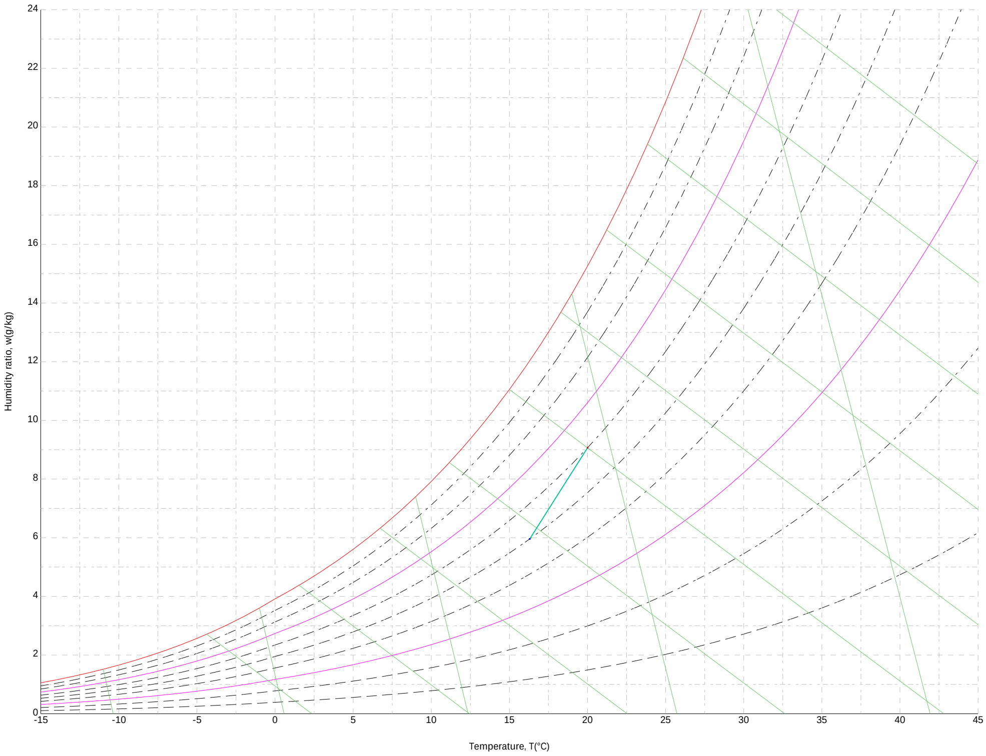
1.6.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

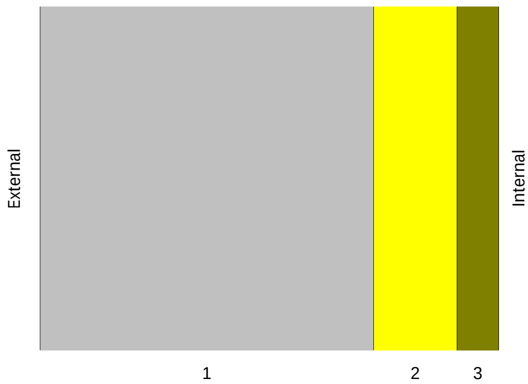
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



1.6.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

	Screed	e (cm)	l (W/m·K)	R (m^2·K/W)	m	S_d (m)
R_{se}				0.00		
1	M15 - 200 mm heavyweight concrete	20.3	1.947	0.10437	1	0.2032
2	I02 - 50 mm insulation board	5.1	0.029	1.75172	1	0.0508
3	F18 - Terrazzo	2.5	1.803	0.01409	1	0.0254
R_{si}				0.17		

where:

e: Thickness, cm.

l: Thermal conductivity of the material, W/(m·K).

R: Thermal resistance of the material, m^2·K/W.

m: Water vapour diffusion resistance factor of the material.

S_d: Equivalent air thickness against the water vapour diffusion, m.

R_{se}: External surface thermal resistance of the element, m^2·K/W.

R_{si}: Internal surface thermal resistance of the element, m^2·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	27.9
Total thermal resistance, R_T	m^2·K/W	2.0402
Total equivalent air thickness, $S_{d,T}$	m	0.28
Thermal transmittance, U	W/(m^2·K)	0.490
Internal surface resistance factor, f_{Rsi}	--	0.877

where:

E_T: Total thickness of the element, cm.

R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m^2·K/W.

S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.

U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m^2·K).

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.490 W/m^2·K and R_{si} = 0.25 m^2·K/W.

1.6.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

q_e: External air temperature, °C.

j_e: Relative humidity of the external air, %.

q_i: *Internal air temperature, °C.*
j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
P_i: *Vapour pressure in the internal air, Pa.*
$P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
$q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
$f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.877 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

1.6.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

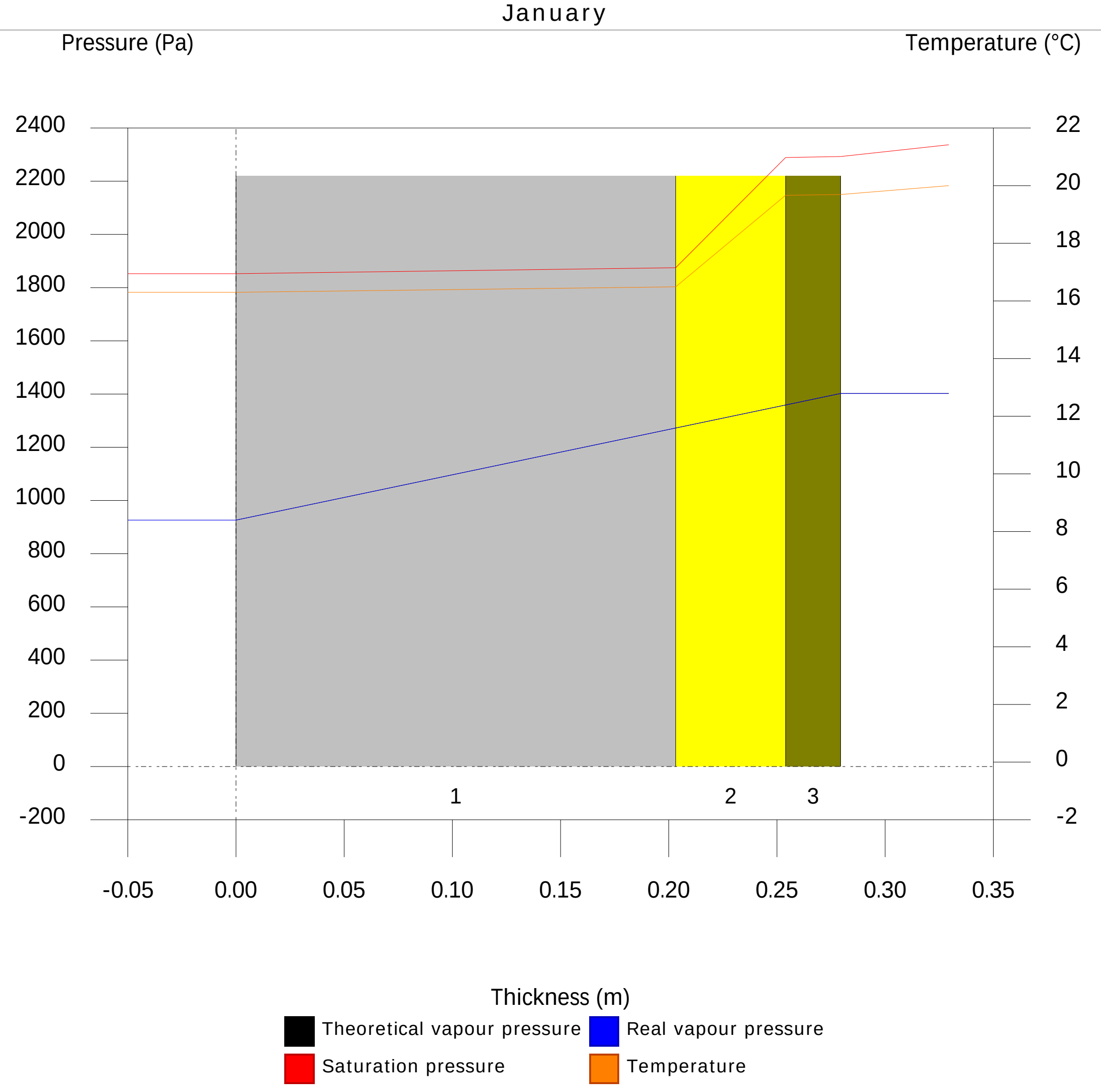
Screed	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.30	1852.393	926.197	50.0	--	--
Interface 1-2	16.49	1874.852	1272.360	67.9	--	--
Interface 2-3	19.67	2289.091	1358.900	59.4	--	--
Internal surface	19.69	2292.723	1402.171	61.2	--	--
Internal air	20.00	2336.951	1402.171	60.0		

where:

q: *Temperature, °C.*
P_{sat}: *Water vapour saturation pressure, Pa.*
P_n: *Water vapour pressure, Pa.*
j: *Relative humidity, %.*
g_c: *Condensation flow density, g/(m²·month).*
M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

1.6.6.- Graphical representation of the foreseen interstitial condensation



2.- OFFICES - NORTH

2.1.- Brick wall 13

2.1.1.- Condensation analysis results

2.1.1.1.- Surface condensation

f_{Rsi} = 0.929 ³ $f_{Rsi,min}$ = 0.105
The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of j $_{si,cr}$ £ 0.8.

2.1.1.2.- Interstitial condensation

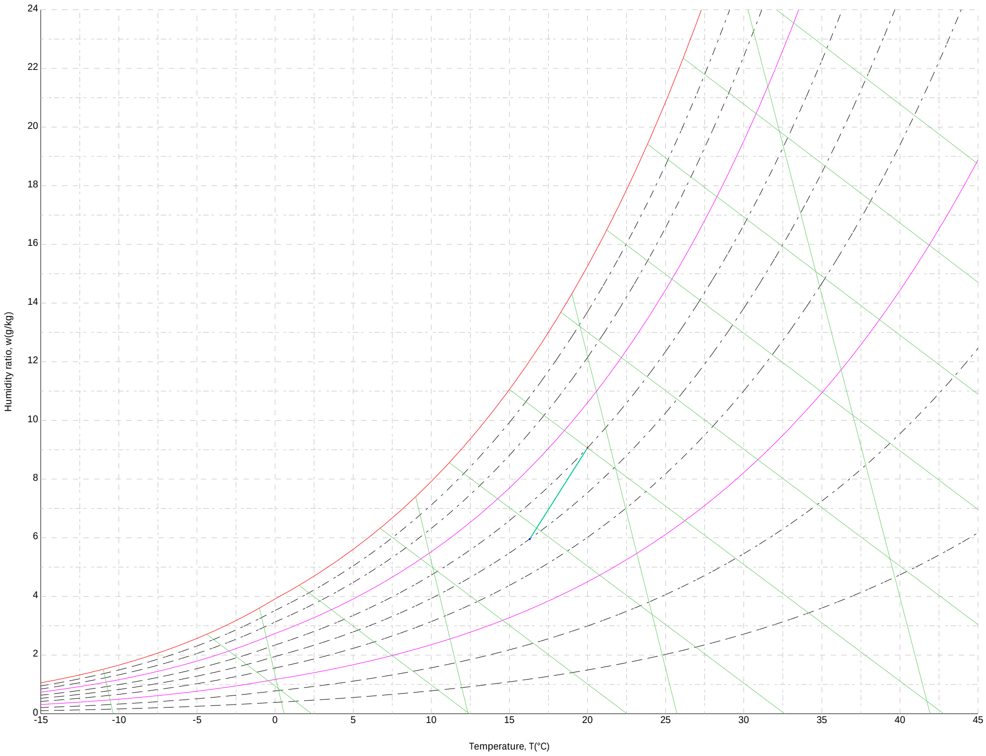
The construction element does not show any sign of interstitial condensation.

2.1.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

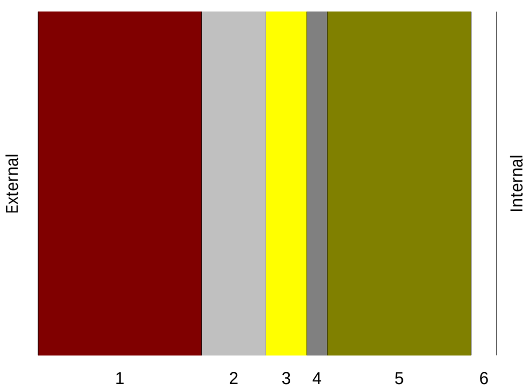
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



2.1.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides

making up the design model of the construction element are as follows:

	Brick wall 13	e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.04		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	G03 - 13 mm fiberboard sheathing	1.3	0.068	0.18676	1	0.0127
5	I04 - 89 mm batt insulation	8.9	0.046	1.94348	1	0.0894
6	G01 - 16 mm gyp board	1.6	0.160	0.09938	1	0.0159
R_{si}				0.13		

where:

e: Thickness, cm.

l: Thermal conductivity of the material, W/(m·K).

R: Thermal resistance of the material, m²·K/W.

m: Water vapour diffusion resistance factor of the material.

S_d: Equivalent air thickness against the water vapour diffusion, m.

R_{se}: External surface thermal resistance of the element, m²·K/W.

R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	28.5
Total thermal resistance, R_T	m²·K/W	3.5391
Total equivalent air thickness, $S_{d,T}$	m	0.26
Thermal transmittance, U	W/(m²·K)	0.283
Internal surface resistance factor, f_{Rsi}	--	0.929

where:

E_T: Total thickness of the element, cm.

R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.

S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.

U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.

2.1.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

Condensation

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.929 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

2.1.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 13	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.34	1857.335	926.197	49.9	--	--
Interface 1-2	16.46	1871.438	1115.840	59.6	--	--
Interface 2-3	16.62	1890.196	1134.505	60.0	--	--
Interface 3-4	17.53	2003.050	1181.916	59.0	--	--
Interface 4-5	17.73	2027.864	1205.621	59.5	--	--
Interface 5-6	19.76	2302.487	1372.492	59.6	--	--
Internal surface	19.86	2317.363	1402.171	60.5	--	--
Internal air	20.00	2336.951	1402.171	60.0		

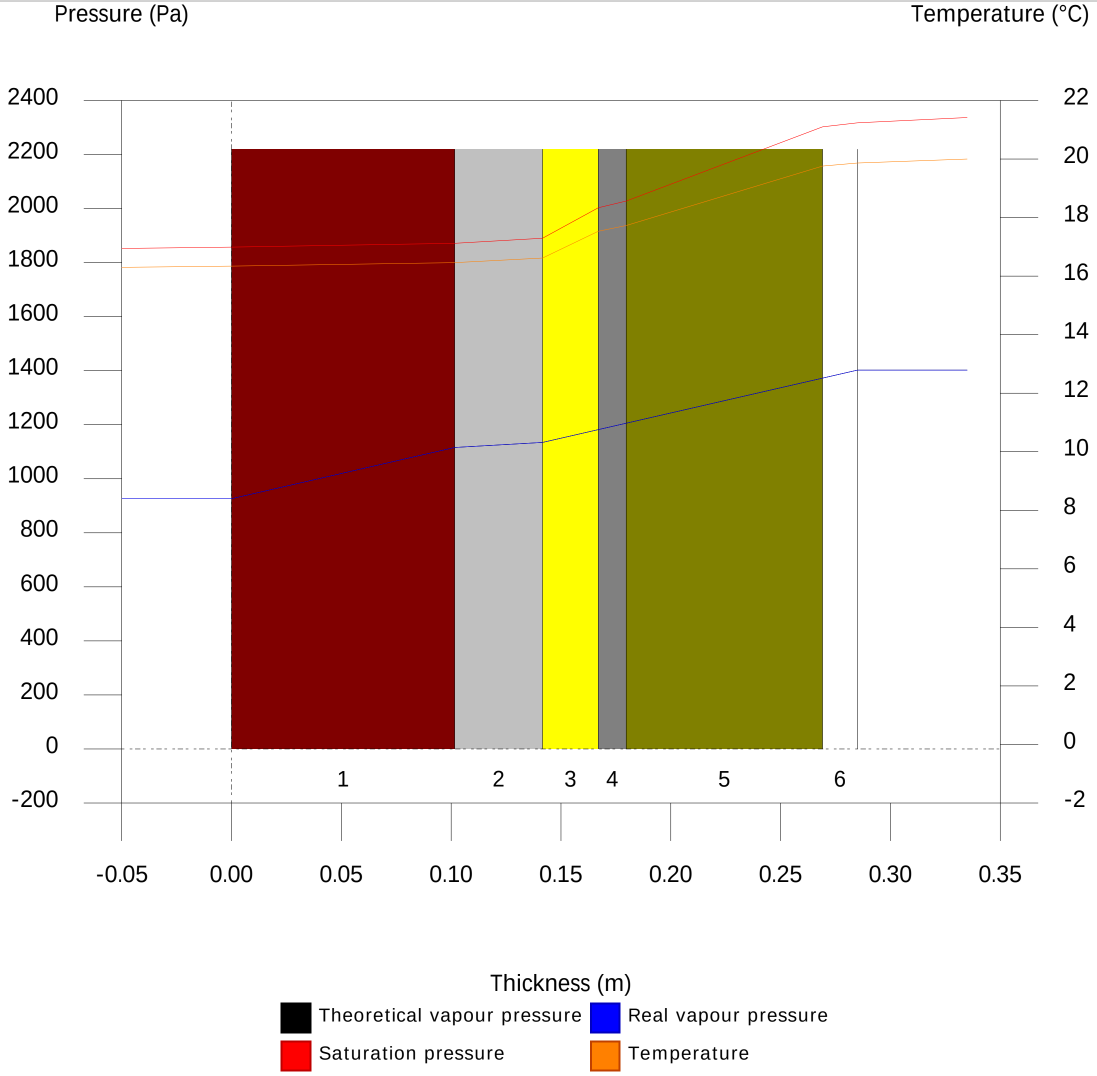
where:

- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*
- j: *Relative humidity, %.*
- g_c: *Condensation flow density, g/(m²·month).*
- M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

2.1.6.- Graphical representation of the foreseen interstitial condensation

January



2.2.- Brick wall 17

2.2.1.- Condensation analysis results

2.2.1.1.- Surface condensation

f_{Rsi} = 0.835 ³ $f_{Rsi,min}$ = 0.105

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of j $_{si,cr}$ £ 0.8.

2.2.1.2.- Interstitial condensation

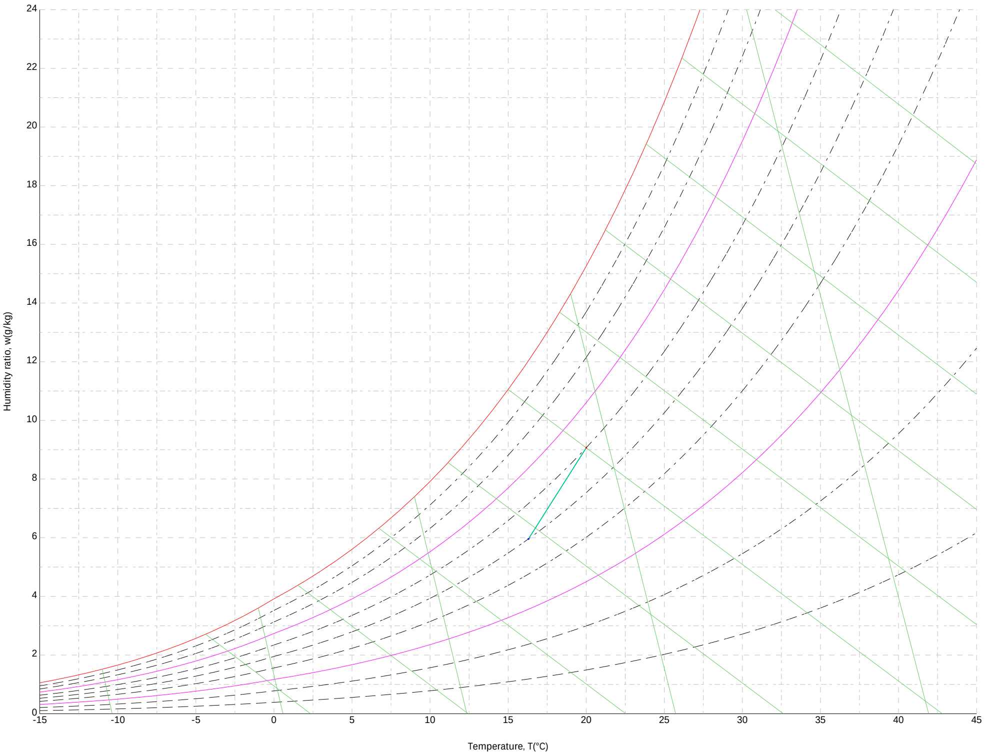
The construction element does not show any sign of interstitial condensation.

2.2.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

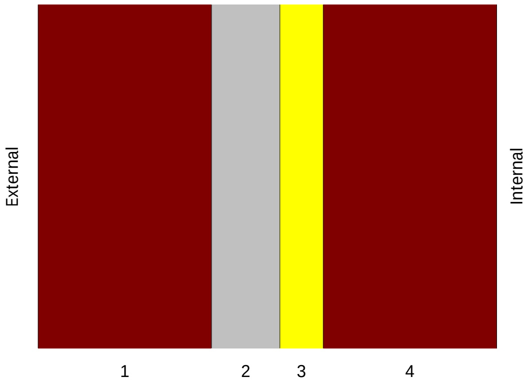
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



2.2.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Brick wall 17		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.13		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
R_{si}				0.13		

where:

e: Thickness, cm.
l: Thermal conductivity of the material, W/(m·K).
R: Thermal resistance of the material, m²·K/W.
m: Water vapour diffusion resistance factor of the material.
S_d: Equivalent air thickness against the water vapour diffusion, m.
R_{se}: External surface thermal resistance of the element, m²·K/W.
R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	26.9
Total thermal resistance, R_T	m²·K/W	1.5132
Total equivalent air thickness, $S_{d,T}$	m	0.24
Thermal transmittance, U	W/(m²·K)	0.661
Internal surface resistance factor, f_{Rsi}	--	0.835

where:

E_T: Total thickness of the element, cm.
R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.
S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.
U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).
f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.

2.2.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

q_e: External air temperature, °C.

φ_e: Relative humidity of the external air, %.
θ_i: Internal air temperature, °C.
φ_i: Relative humidity of the internal air, increased by a safety coefficient 5%, %.
P_i: Vapour pressure in the internal air, Pa.
$P_{sat}(\theta_{si})$: Minimum acceptable water vapour saturation pressure for the internal surface, Pa.
$\theta_{si,min}$: Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.
$f_{Rsi,min}$: Minimum internal surface resistance factor.

Given that f_{Rsi} = 0.835 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

2.2.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 17	θ (°C)	P_{sat} (Pa)	P_n (Pa)	φ (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.62	1890.248	926.197	49.0	--	--
Interface 1-2	16.90	1923.894	1128.875	58.7	--	--
Interface 2-3	17.26	1969.105	1148.823	58.3	--	--
Interface 3-4	19.40	2252.147	1199.493	53.3	--	--
Internal surface	19.68	2291.362	1402.171	61.2	--	--
Internal air	20.00	2336.951	1402.171	60.0		

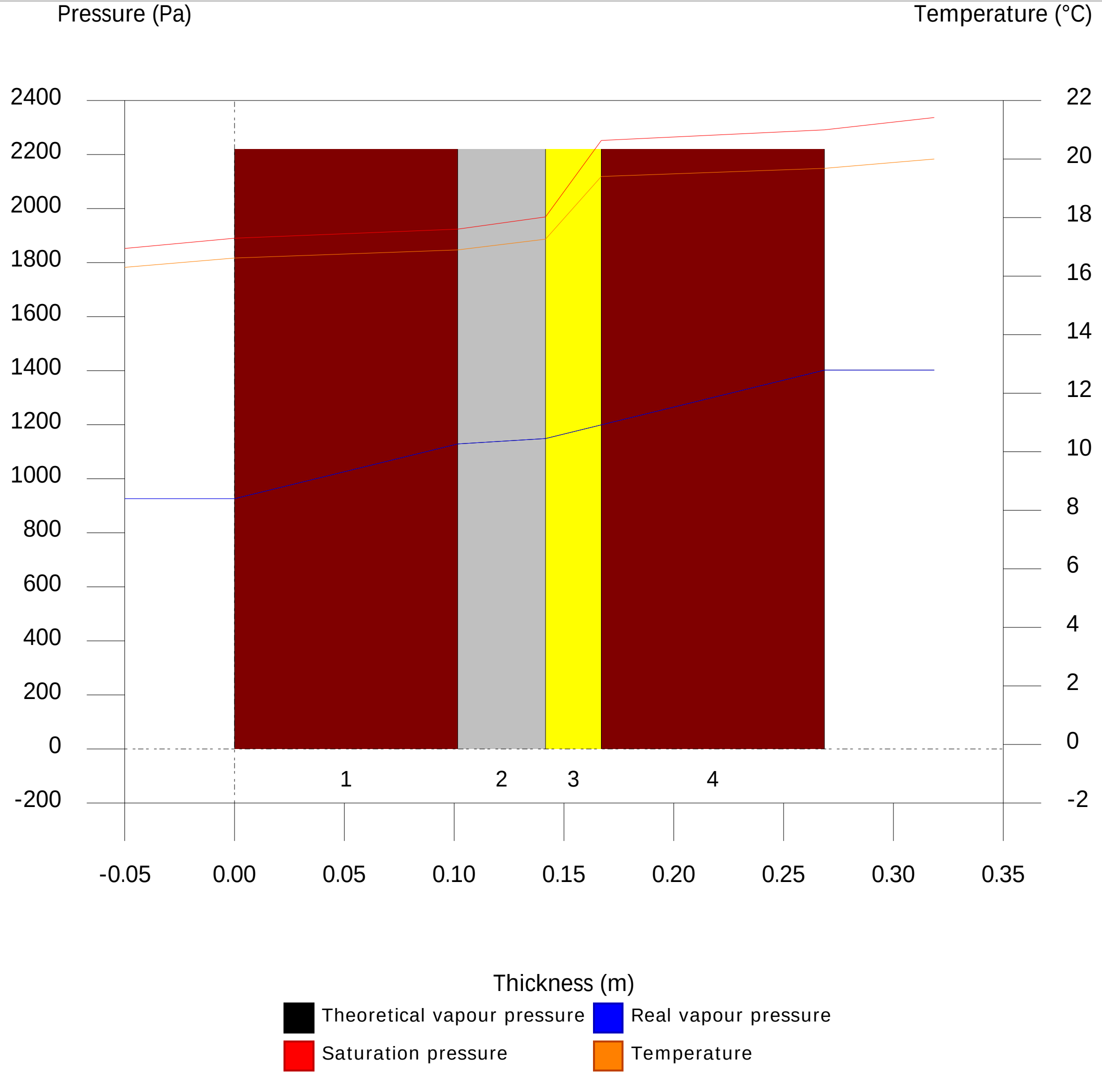
where:

θ: Temperature, °C.
P_{sat}: Water vapour saturation pressure, Pa.
P_n: Water vapour pressure, Pa.
φ: Relative humidity, %.
g_c: Condensation flow density, g/(m²·month).
M_a: Accumulated humidity content per unit area, g/m².

>> Graphical representation (January)

2.2.6.- Graphical representation of the foreseen interstitial condensation

January



2.3.- Concrete roof 19

2.3.1.- Condensation analysis results

2.3.1.1.- Surface condensation

f_{Rsi} = 0.939 ³ $f_{Rsi,min}$ = 0.105

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.242 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $j_{si,cr}$ £ 0.8.

2.3.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

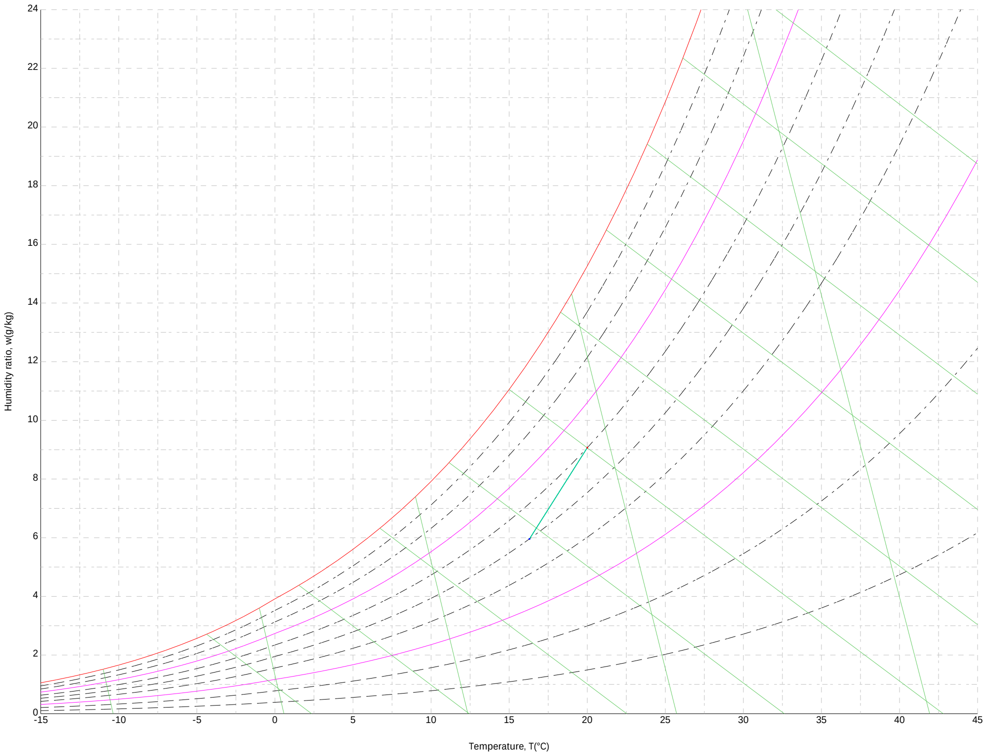
2.3.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

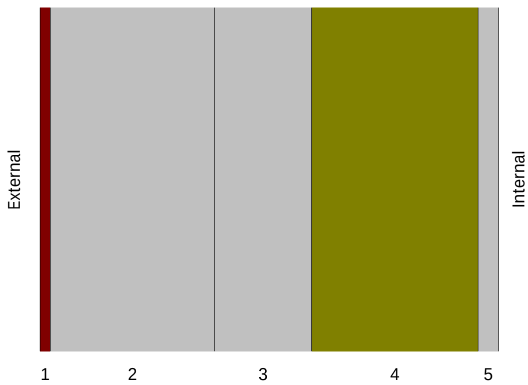
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



2.3.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

Concrete roof 19		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.04		
1	F13 - Built-up roofing	0.9	0.162	0.05864	1	0.0095
2	M14 - 150 mm heavyweight concrete	15.2	1.947	0.07827	1	0.1524
3	F05 - Ceiling air space resistance	9.0	0.500	0.18000	1	0.09
4	I05 - 154 mm batt insulation	15.4	0.046	3.35652	1	0.1544
5	F16 - Acoustic tile	1.9	0.061	0.31311	1	0.0191
R_{si}				0.10		

where:

e: Thickness, cm.

l: Thermal conductivity of the material, W/(m·K).

R: Thermal resistance of the material, m²·K/W.

m: Water vapour diffusion resistance factor of the material.

S_d: Equivalent air thickness against the water vapour diffusion, m.

R_{se}: External surface thermal resistance of the element, m²·K/W.

R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	42.5
Total thermal resistance, R_T	m²·K/W	4.1266
Total equivalent air thickness, $S_{d,T}$	m	0.43
Thermal transmittance, U	W/(m²·K)	0.242
Internal surface resistance factor, f_{Rsi}	--	0.939

where:

E_T: Total thickness of the element, cm.

R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.

S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.

U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.242 W/m²·K and R_{si} = 0.25 m²·K/W.

2.3.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- q_e: *External air temperature, °C.*
- j_e: *Relative humidity of the external air, %.*
- q_i: *Internal air temperature, °C.*
- j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
- P_i: *Vapour pressure in the internal air, Pa.*
- $P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
- $q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.939 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

2.3.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Concrete roof 19	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.34	1856.631	926.197	49.9	--	--
Interface 1-2	16.39	1862.858	936.826	50.3	--	--
Interface 2-3	16.46	1871.200	1107.344	59.2	--	--
Interface 3-4	16.62	1890.505	1208.044	63.9	--	--
Interface 4-5	19.63	2283.903	1380.800	60.5	--	--
Internal surface	19.91	2324.012	1402.171	60.3	--	--
Internal air	20.00	2336.951	1402.171	60.0		

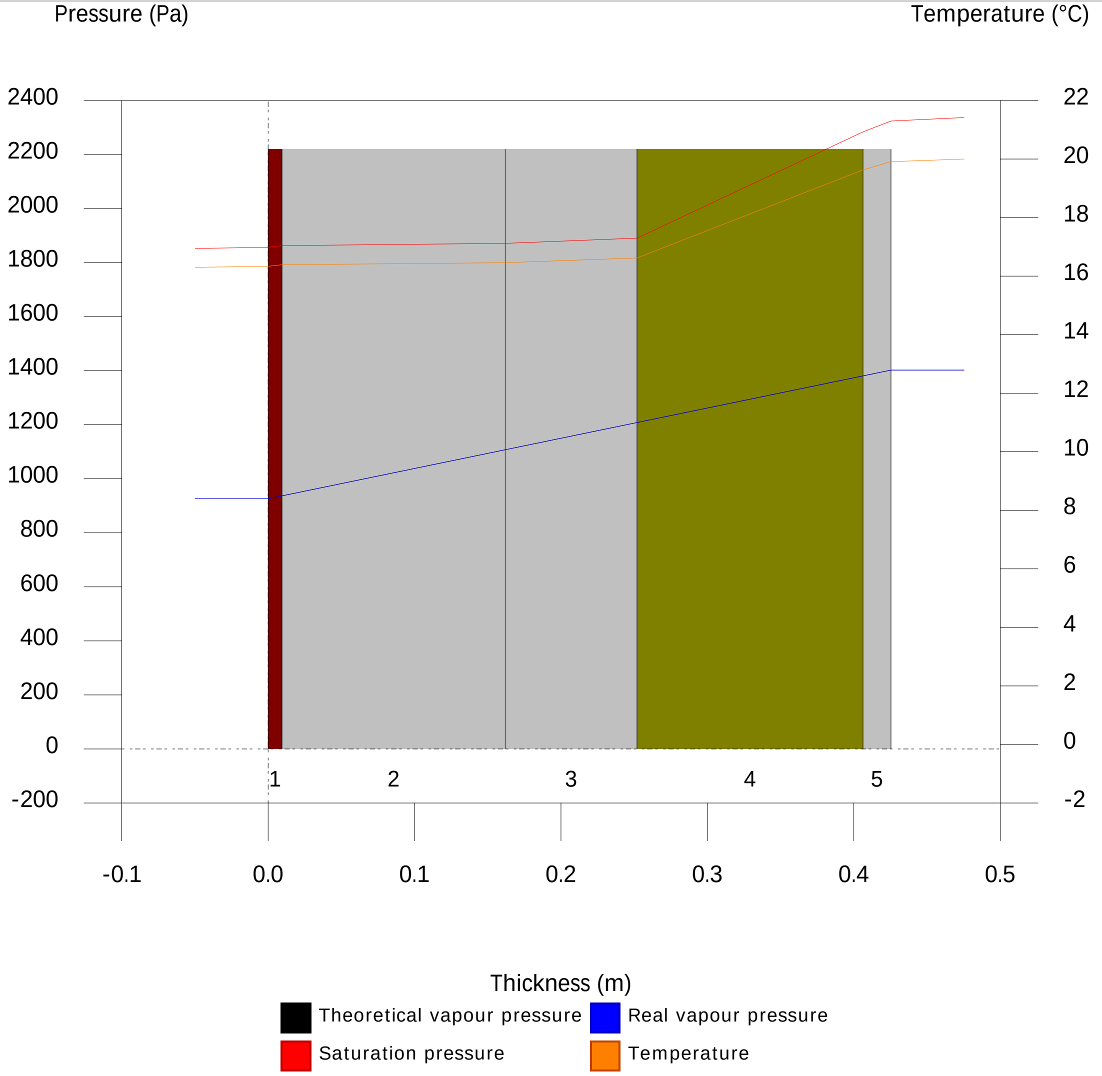
where:

- q: *Temperature, °C.*
- P_{sat}: *Water vapour saturation pressure, Pa.*
- P_n: *Water vapour pressure, Pa.*
- j: *Relative humidity, %.*
- g_c: *Condensation flow density, g/(m²·month).*
- M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

2.3.6.- Graphical representation of the foreseen interstitial condensation

January



3.- CAFETERIA

3.1.- Brick wall 13

3.1.1.- Condensation analysis results

3.1.1.1.- Surface condensation

f_{Rsi} = 0.929 ³ f $_{Rsi,min}$ = 0.105
The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of j $_{si,cr}$ £ 0.8.

3.1.1.2.- Interstitial condensation

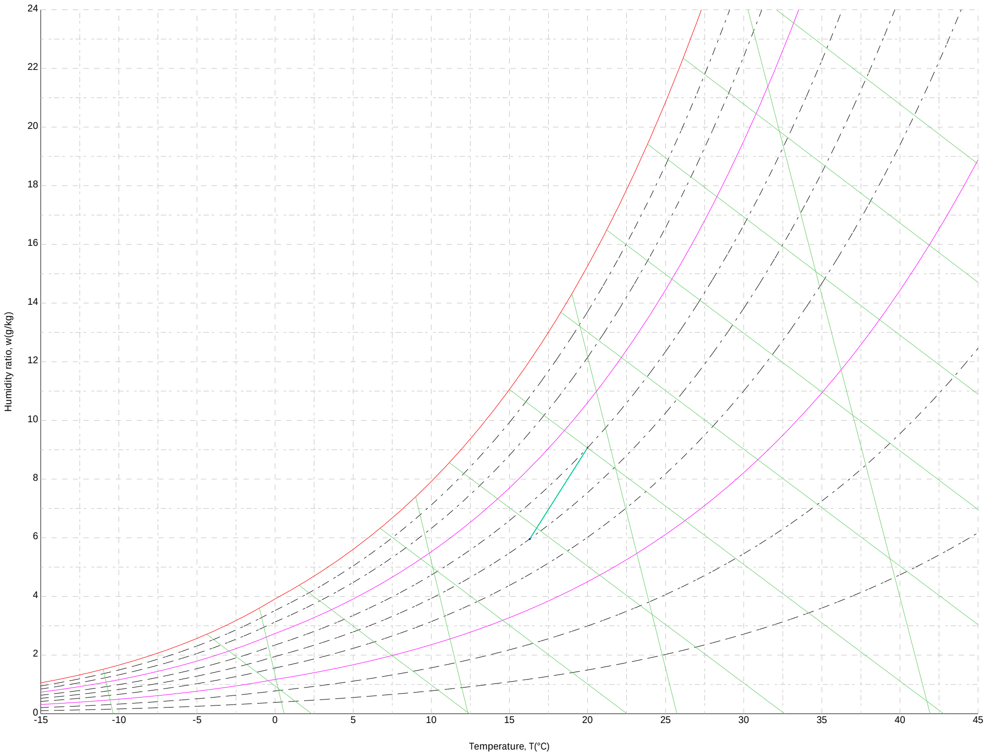
The construction element does not show any sign of interstitial condensation.

3.1.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

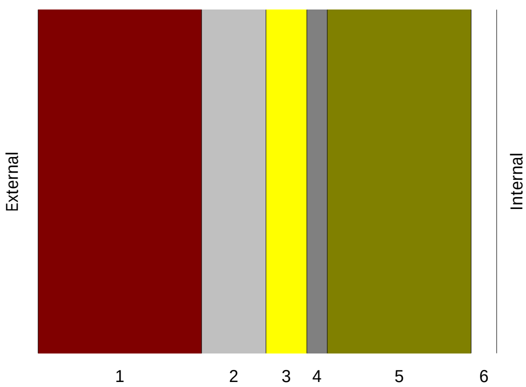
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



3.1.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides

making up the design model of the construction element are as follows:

	Brick wall 13	e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.04		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	G03 - 13 mm fiberboard sheathing	1.3	0.068	0.18676	1	0.0127
5	I04 - 89 mm batt insulation	8.9	0.046	1.94348	1	0.0894
6	G01 - 16 mm gyp board	1.6	0.160	0.09938	1	0.0159
R_{si}				0.13		

where:

- *e: Thickness, cm.*
- *l: Thermal conductivity of the material, W/(m·K).*
- *R: Thermal resistance of the material, m²·K/W.*
- *m: Water vapour diffusion resistance factor of the material.*
- *S_d: Equivalent air thickness against the water vapour diffusion, m.*
- *R_{se}: External surface thermal resistance of the element, m²·K/W.*
- *R_{si}: Internal surface thermal resistance of the element, m²·K/W.*

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	28.5
Total thermal resistance, R_T	m²·K/W	3.5391
Total equivalent air thickness, $S_{d,T}$	m	0.26
Thermal transmittance, U	W/(m²·K)	0.283
Internal surface resistance factor, f_{Rsi}	--	0.929

where:

- *E_T: Total thickness of the element, cm.*
- *R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.*
- *S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.*
- *U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).*
- *f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.283 W/m²·K and R_{si} = 0.25 m²·K/W.*

3.1.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

Condensation

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

q_e: *External air temperature, °C.*
j_e: *Relative humidity of the external air, %.*
q_i: *Internal air temperature, °C.*
j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
P_i: *Vapour pressure in the internal air, Pa.*
$P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
$q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
$f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.929 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

3.1.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 13	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.34	1857.335	926.197	49.9	--	--
Interface 1-2	16.46	1871.438	1115.840	59.6	--	--
Interface 2-3	16.62	1890.196	1134.505	60.0	--	--
Interface 3-4	17.53	2003.050	1181.916	59.0	--	--
Interface 4-5	17.73	2027.864	1205.621	59.5	--	--
Interface 5-6	19.76	2302.487	1372.492	59.6	--	--
Internal surface	19.86	2317.363	1402.171	60.5	--	--
Internal air	20.00	2336.951	1402.171	60.0		

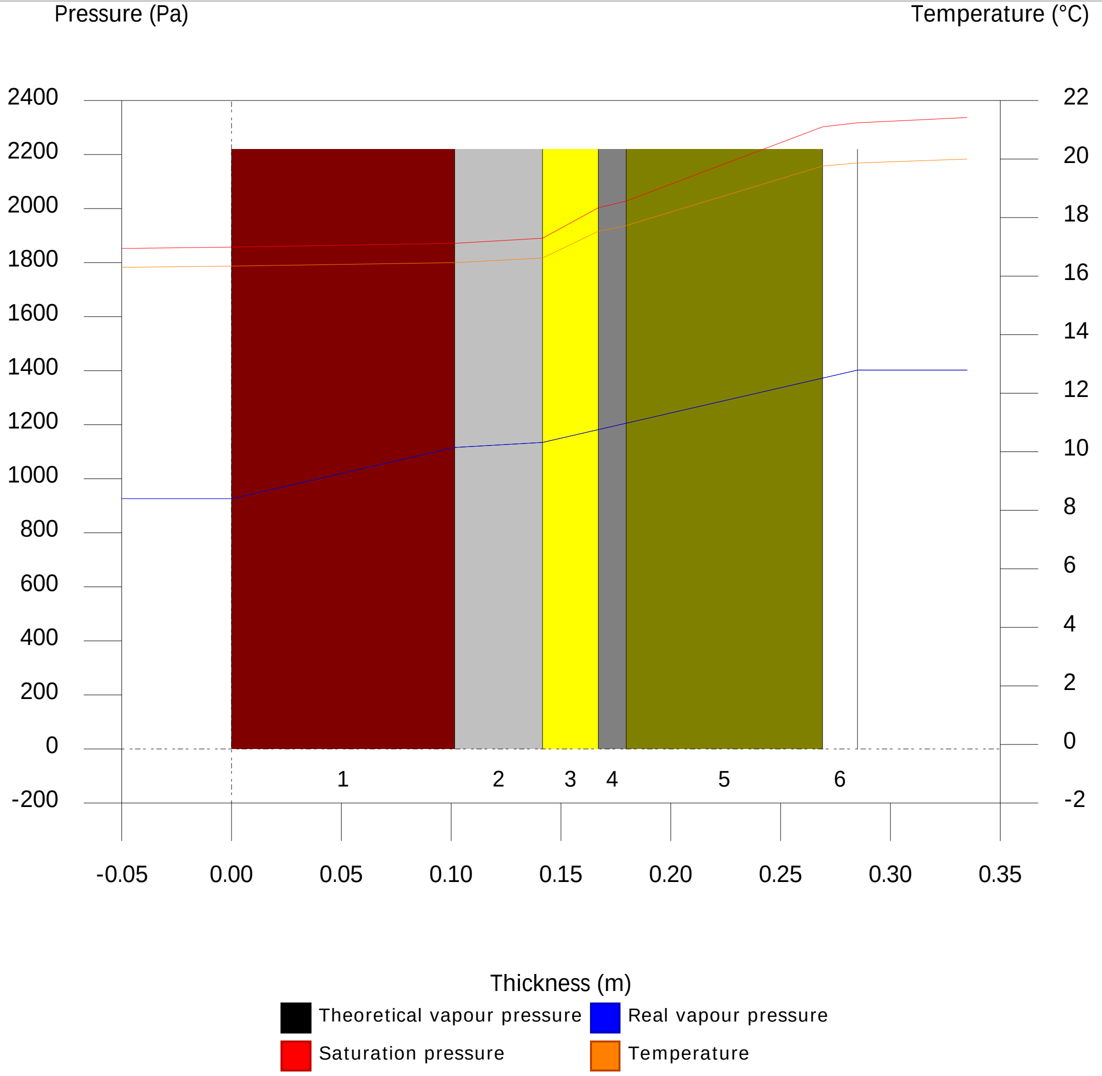
where:

q: *Temperature, °C.*
P_{sat}: *Water vapour saturation pressure, Pa.*
P_n: *Water vapour pressure, Pa.*
j: *Relative humidity, %.*
g_c: *Condensation flow density, g/(m²·month).*
M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

3.1.6.- Graphical representation of the foreseen interstitial condensation

January



3.2.- Brick wall 17

3.2.1.- Condensation analysis results

3.2.1.1.- Surface condensation

f_{Rsi} = 0.835 ³ f $_{Rsi,min}$ = 0.105

The construction element does not show any signs of surface condensation.

where:

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.

$f_{Rsi,min}$: Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of j $_{si,cr}$ £ 0.8.

3.2.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

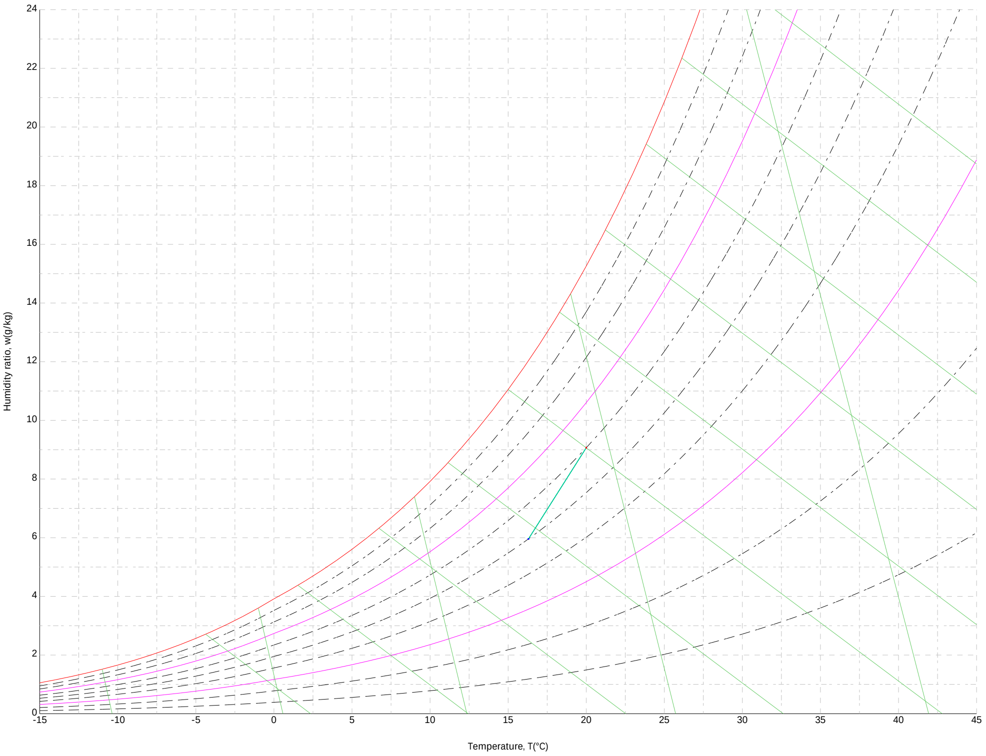
3.2.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

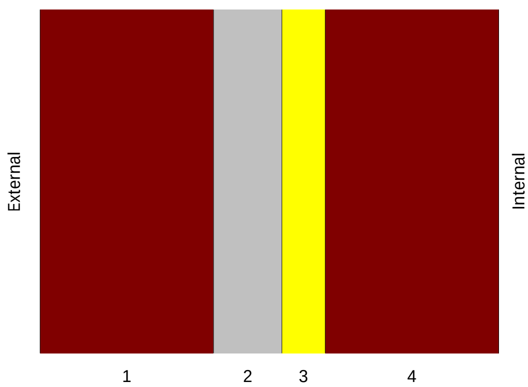
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



3.2.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

Brick wall 17		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.13		
1	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
2	F04 - Wall air space resistance	4.0		0.15000		0.01
3	I01 - 25 mm insulation board	2.5	0.029	0.87586	1	0.0254
4	M01 - 100 mm brick	10.2	0.894	0.11365	1	0.1016
R_{si}				0.13		

where:

e: Thickness, cm.

l: Thermal conductivity of the material, W/(m·K).

R: Thermal resistance of the material, m²·K/W.

m: Water vapour diffusion resistance factor of the material.

S_d: Equivalent air thickness against the water vapour diffusion, m.

R_{se}: External surface thermal resistance of the element, m²·K/W.

R_{si}: Internal surface thermal resistance of the element, m²·K/W.

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	26.9
Total thermal resistance, R_T	m²·K/W	1.5132
Total equivalent air thickness, $S_{d,T}$	m	0.24
Thermal transmittance, U	W/(m²·K)	0.661
Internal surface resistance factor, f_{Rsi}	--	0.835

where:

E_T: Total thickness of the element, cm.

R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.

S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.

U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).

f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.661 W/m²·K and R_{si} = 0.25 m²·K/W.

3.2.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

q_e: External air temperature, °C.

j_e: *Relative humidity of the external air, %.*
q_i: *Internal air temperature, °C.*
j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
P_i: *Vapour pressure in the internal air, Pa.*
$P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
$q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
$f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.835 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

3.2.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Brick wall 17	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.62	1890.248	926.197	49.0	--	--
Interface 1-2	16.90	1923.894	1128.875	58.7	--	--
Interface 2-3	17.26	1969.105	1148.823	58.3	--	--
Interface 3-4	19.40	2252.147	1199.493	53.3	--	--
Internal surface	19.68	2291.362	1402.171	61.2	--	--
Internal air	20.00	2336.951	1402.171	60.0		

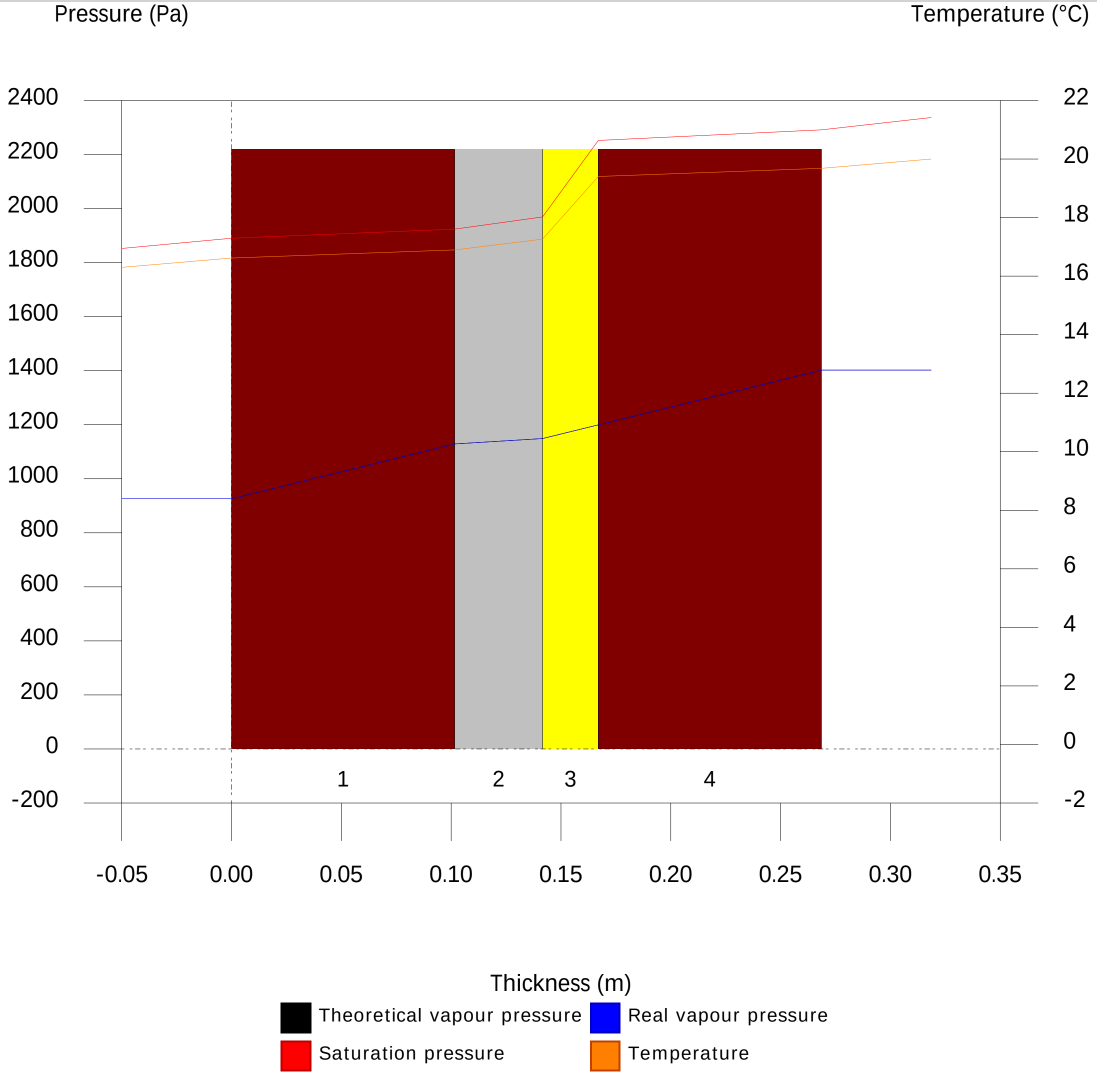
where:

q: *Temperature, °C.*
P_{sat}: *Water vapour saturation pressure, Pa.*
P_n: *Water vapour pressure, Pa.*
j: *Relative humidity, %.*
g_c: *Condensation flow density, g/(m²·month).*
M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

3.2.6.- Graphical representation of the foreseen interstitial condensation

January



3.3.- Screed

3.3.1.- Condensation analysis results

3.3.1.1.- Surface condensation

f_{Rsi} = 0.877 ³ $f_{Rsi,min}$ = 0.105

The construction element does not show any signs of surface condensation.

where:

- f_{Rsi}: *Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.490 W/m²·K and R_{si} = 0.25 m²·K/W.*
- $f_{Rsi,min}$: *Minimum internal surface resistance factor, required to avoid the critical surface humidity, calculated using a value of $j_{si,cr}$ £ 0.8.*

3.3.1.2.- Interstitial condensation

The construction element does not show any sign of interstitial condensation.

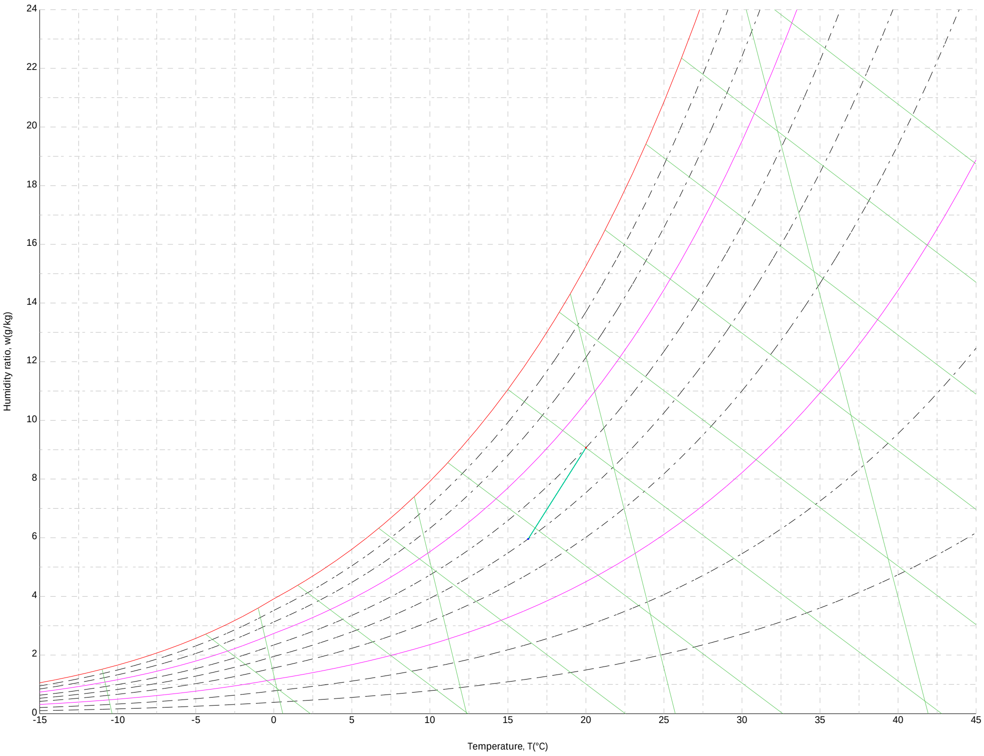
3.3.2.- Hygrothermal design conditions

The internal and external hygrothermal conditions used to carry out the condensation calculations are the following:

Condensation

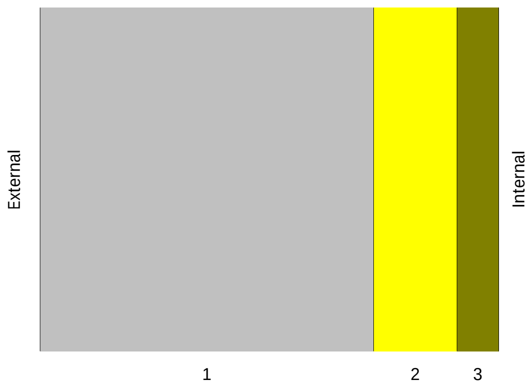
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
External conditions													
Temperature, θ_e	(°C)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Relative humidity, φ_e	(%)	50	50	50	50	50	50	50	50	50	50	50	50
Internal conditions													
Temperature, θ_i	(°C)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Relative humidity, φ_i	(%)	60	60	60	60	60	60	60	60	60	60	60	60

The psychrometric diagram associated with the location, with a height above sea level of 308 m, is displayed below. Represented using straight line segments are the transitions from each external design condition to its corresponding internal condition.



3.3.3.- Description of the construction element

Below is the section diagram of the composition of the construction element:



The thermal properties and water vapour diffusion properties of the homogenous layers of the parallel sides making up the design model of the construction element are as follows:

Condensation

Screed		e (cm)	l (W/m·K)	R (m²·K/W)	m	S_d (m)
R_{se}				0.00		
1	M15 - 200 mm heavyweight concrete	20.3	1.947	0.10437	1	0.2032
2	I02 - 50 mm insulation board	5.1	0.029	1.75172	1	0.0508
3	F18 - Terrazzo	2.5	1.803	0.01409	1	0.0254
R_{si}				0.17		

where:

- *e: Thickness, cm.*
- *l: Thermal conductivity of the material, W/(m·K).*
- *R: Thermal resistance of the material, m²·K/W.*
- *m: Water vapour diffusion resistance factor of the material.*
- *S_d: Equivalent air thickness against the water vapour diffusion, m.*
- *R_{se}: External surface thermal resistance of the element, m²·K/W.*
- *R_{si}: Internal surface thermal resistance of the element, m²·K/W.*

The design information regarding the hygrothermal parameters of the complete element, derived from the homogenous layer model, is the following:

Magnitude	Units	Value
Total thickness of the element, e_T	cm	27.9
Total thermal resistance, R_T	m²·K/W	2.0402
Total equivalent air thickness, $S_{d,T}$	m	0.28
Thermal transmittance, U	W/(m²·K)	0.490
Internal surface resistance factor, f_{Rsi}	--	0.877

where:

- *E_T: Total thickness of the element, cm.*
- *R_T: Total thermal resistance of the element, sum of the thermal resistance of each layer, including surface resistances R_{se} and R_{si}, m²·K/W.*
- *S_{dT}: Total equivalent air thickness, sum of the equivalent thickness of each layer of the element, m.*
- *U: Thermal transmittance of the element, calculated as the inverse of the total thermal resistance, W/(m²·K).*
- *f_{Rsi}: Internal surface resistance factor, calculated as (1 - U·R_{si}), where U = 0.490 W/m²·K and R_{si} = 0.25 m²·K/W.*

3.3.4.- Calculation of the internal surface temperature required to avoid the critical surface humidity

With the aim to prevent the adverse affects of the critical surface humidity, the maximum relative humidity on the internal surface has been limited to a value of $j_{si,cr}$ £ 0.8 .

Given the external and internal hygrothermal conditions, $f_{Rsi,min}$ is calculated as follows:

	q_e (°C)	j_e (%)	q_i (°C)	j_i (%)	P_i (Pa)	P_{sat} (q_{si}) (Pa)	$q_{si,min}$ (°C)	$f_{Rsi,min}$
January	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
February	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
March	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
April	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
May	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
June	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
July	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
August	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
September	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
October	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
November	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105
December	16.3	50.0	20.0	65.0	1519.02	1898.77	16.7	0.105

where:

- *q_e: External air temperature, °C.*
- *j_e: Relative humidity of the external air, %.*

q_i: *Internal air temperature, °C.*
j_i: *Relative humidity of the internal air, increased by a safety coefficient 5%, %.*
P_i: *Vapour pressure in the internal air, Pa.*
$P_{sat}(q_{si})$: *Minimum acceptable water vapour saturation pressure for the internal surface, Pa.*
$q_{si,min}$: *Minimum acceptable internal surface temperature, calculated based on the minimum acceptable saturation pressure, °C.*
$f_{Rsi,min}$: *Minimum internal surface resistance factor.*

Given that f_{Rsi} = 0.877 > $f_{Rsi,min}$ = 0.105, no surface condensation occurs in the construction element.

3.3.5.- Interstitial condensation calculation

Displayed below are the results obtained in the analysis of the temperatures and pressures at each interface of the homogenous layers making up the design model of the construction element.

Calculation of the interstitial condensation in the month of January.

Screed	q (°C)	P_{sat} (Pa)	P_n (Pa)	j (%)	g_c (g/(m²·month))	M_a (g/m²)
External air	16.30	1852.393	926.197	50.0		
External surface	16.30	1852.393	926.197	50.0	--	--
Interface 1-2	16.49	1874.852	1272.360	67.9	--	--
Interface 2-3	19.67	2289.091	1358.900	59.4	--	--
Internal surface	19.69	2292.723	1402.171	61.2	--	--
Internal air	20.00	2336.951	1402.171	60.0		

where:

q: *Temperature, °C.*
P_{sat}: *Water vapour saturation pressure, Pa.*
P_n: *Water vapour pressure, Pa.*
j: *Relative humidity, %.*
g_c: *Condensation flow density, g/(m²·month).*
M_a: *Accumulated humidity content per unit area, g/m².*

>> Graphical representation (January)

Condensation

3.3.6.- Graphical representation of the foreseen interstitial condensation

January