thmass 01 plastic connectors

Description

- 3-in concrete
  - Thermal conductivity – 9.1 Btu-in/h-ft^2-F
  - Density – 140 lb/ft^3
  - Specific Heat – 0.21 Btu/lb-F
- 2-in foam
  - Thermal conductivity – 0.20 Btu-in/h-ft^2-F
  - Density – 1.5 lb/ft^3
  - Specific Heat – 0.29 Btu/lb-F
- 3-in concrete
  - Thermal conductivity – 9.1 Btu-in/h-ft^2-F
  - Density – 140 lb/ft^3
  - Specific Heat – 0.21 Btu/lb-F
- Plastic connectors: cross section 0.063-in^2 (0.25x0.25 in.)
  - Thermal conductivity – 1.7 Btu-in/h-ft^2-F
  - Density – 36 lb/ft^3
  - Specific Heat – 0.39 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 9.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	10.58216	ft^2 °F h/Btu	1.86246	m^2 K/W
R^{-1}	0.09450	Btu/h ft^2 °F	0.53692	W/m^2 K
Capacitance	14.76635	Btu/ft^2 °F	301.73244	kJ/m^2 K

Table 9.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.01576	50.74143	1.00000
1	0.22377	-71.97368	-0.71157
2	0.16632	23.01010	0.12653
3	0.00908	-1.36291	-0.00002

$\Sigma\, c_n = 0.41493$, $E_1 = 0.00000$

Table 9.3
3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft^2 °F]

n	X_n	Y_n
0	4.7949959E-00	1.4892385E-03
1	-3.3894197E-00	2.2208823E-02
2	-8.4409066E-01	3.1332014E-02
3	-3.0049272E-01	2.0343106E-02
4	-1.0708381E-01	1.0511719E-02
5	-3.8194673E-02	4.9060345E-03
6	-1.3635214E-02	2.1611749E-03
7	-4.8718203E-03	9.1719718E-04
8	-1.7421298E-03	3.7925653E-04
9	-6.2347132E-04	1.5383914E-04
10	-2.2330079E-04	6.1489780E-05
11	-8.0039443E-05	2.4293273E-05
12	-2.8710383E-05	9.5075756E-06
13	-1.0305852E-05	3.6920338E-06
14	-3.7020407E-06	1.4243830E-06
15	-1.3309094E-06	5.4653269E-07
16	-4.7884766E-07	2.0872504E-07
17	-1.7241657E-07	7.9392102E-08

Table 9.4
3D response factors ratio, dimensionless 3D response factors and transfer functions of the first order

n	X_n/X_{n-1}	Y_n/Y_{n-1}	$R*X_n$	$R*Y_n$	$R*X'_n$	$R*Y'_n$
0			50.74143	0.01576	50.74143	0.01576
1	-0.70687	14.91287	-35.86739	0.23502	-54.65269	0.22918
2	0.24904	1.41079	-8.93230	0.33156	4.34639	0.24455
3	0.35600	0.64928	-3.17986	0.21527	0.12702	0.09252
4	0.35636	0.51672	-1.13318	0.11124	0.04406	0.03154
5	0.35668	0.46672	-0.40418	0.05192	0.01534	0.01073
6	0.35699	0.44051	-0.14429	0.02287	0.00534	0.00365
7	0.35730	0.42440	-0.05155	0.00971	0.00186	0.00124
8	0.35759	0.41350	-0.01844	0.00401	0.00065	0.00042
9	0.35788	0.40563	-0.00660	0.00163	0.00023	0.00014
10	0.35816	0.39970	-0.00236	0.00065	0.00008	0.00005
11	0.35844	0.39508	-0.00085	0.00026	0.00003	0.00002
12	0.35870	0.39137	-0.00030	0.00010	0.00001	0.00001
13	0.35896	0.38833	-0.00011	0.00004		
14	0.35922	0.38580	-0.00004	0.00002		
15	0.35951	0.38370	-0.00001	0.00001		
16	0.35979	0.38191	-0.00001			
17	0.36007	0.38037				

$\alpha = 0.37022$, $\tau_1 = 1.00637$

Equivalent wall model: 3 layers plane wall

Table 9.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.45628	$R \cdot C \cdot \varphi_{ii}$	71.298
φ_{ie}	0.01607	$R \cdot C \cdot \varphi_{ie}$	2.512
φ_{ee}	0.51157	$R \cdot C \cdot \varphi_{ee}$	79.939
		$R \cdot C$	156.260

Table 9.6a
Thermophysical properties of the equivalent wall - IP units

Layer	R_n	C_n	l_n	k_n	ρ_n	c_{pn}
N	ft^2-°F-h/Btu	Btu/ft^2-°F	in	Btu-in/h-ft^2-°F	lb/ft^3	Btu/lb-°F
1	0.33024	6.89792	2.75	8.327	140	0.215
2	9.96042	0.15737	2.5	0.251	2.70	0.28
3	0.29151	7.71106	2.75	9.434	134.59	0.25

Table 9.6b
Thermophysical properties of the equivalent wall - SI units

Layer	R_n	C_n	l_n	k_n	ρ_n	c_{pn}
n	m^2 K/W	kJ/m^2 K	m	W/m K	kg/m^3	kJ/kg K
1	0.05812	140.951	0.070	1.201	2240	0.901
2	1.75303	3.216	0.064	0.036	43.16	1.173
3	0.05130	157.566	0.070	1.361	2153.49	1.048

Table 9.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.01061	53.05131	1.00000	
1	0.21301	-74.73371	-0.66839	0.941
2	0.20332	23.72255	0.11227	0.879
3	0.01663	-1.59980	-0.00025	0.162
4	0.00006	0.00329		0.102

$\Sigma\, c_n = 0.44364$, $\alpha = 0.34545$

Table 9.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	5.013277E+00	1.002803E-03
1	-3.711429E+00	2.079928E-02
2	-8.017600E-01	3.300312E-02
3	-2.691497E-01	2.129576E-02
4	-9.048383E-02	1.053944E-02
5	-3.045779E-02	4.661651E-03
6	-1.026511E-02	1.937759E-03
7	-3.463806E-03	7.743982E-04
8	-1.170183E-03	3.011912E-04
9	-3.957760E-04	1.148466E-04
10	-1.340062E-04	4.313757E-05
11	-4.542181E-05	1.601277E-05
12	-1.541172E-05	5.88789E-06
13	-5.234417E-06	2.148236E-06
14	-1.779504E-06	7.787545E-07
15	-6.055162E-07	2.807735E-07
16	-2.062206E-07	1.007626E-07
17	-7.029109E-08	3.601728E-08

Frequency response for the three-dimensional model and equivalent wall; dimensionless amplitude and phase angle

Table 9.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.98	-19°	9.44	77°
24	0.93	-37°	18.42	73°
12	0.77	-71°	34.14	61°
6	0.44	-125°	55.33	43°

Table 9.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.99	-19°	9.42	78°
24	0.94	-37°	18.40	76°
12	0.81	-72°	34.24	68°
6	0.51	-129°	55.80	55°