

thmass 02 metal connectors

Description

- 3-in concrete
 - Thermal conductivity – 9.1 Btu-in/h-ft²-F
 - Density – 140 lb/ft³
 - Specific Heat – 0.21 Btu/lb-F
- 2-in foam
 - Thermal conductivity – 0.20 Btu-in/h-ft²-F
 - Density – 1.5 lb/ft³
 - Specific Heat – 0.29 Btu/lb-F
- 3-in concrete
 - Thermal conductivity – 9.1 Btu-in/h-ft²-F
 - Density – 140 lb/ft³
 - Specific Heat – 0.21 Btu/lb-F
- Steel connectors: cross section 0.023-in² (0.15x0.15 in.)
 - Thermal conductivity – 314 Btu-in/h-ft²-F
 - Density – 490 lb/ft³
 - Specific Heat – 0.12 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 8.1
Resistance, transmittance and capacitance of the wall

	<i>IP</i>		<i>SI</i>	
R-value	7.65912	ft ² °F h/Btu	1.34800	m ² K/W
R ⁻¹	0.13056	Btu/h ft ² °F	0.74184	W/m ² K
Capacitance	14.77768	Btu/ft ² °F	301.96396	kJ/m ² K

Table 8.2
Dimensionless 3D z-transfer function coefficients

<i>n</i>	<i>b_n</i>	<i>c_n</i>	<i>d_n</i>
0	0.02377	35.22708	1.00000
1	0.24051	-49.09367	-0.70113
2	0.14861	15.08613	0.12272
3	0.00778	-0.79797	-0.00002

$$\Sigma c_n = 0.42158, E_1 = 0.00215$$

Table 8.3

3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft² °F]

n	X_n	Y_n
0	4.5993425E+00	3.1033096E-03
1	-3.1850754E+00	3.3577063E-02
2	-8.2790328E-01	4.2564475E-02
3	-2.9369415E-01	2.6738332E-02
4	-1.0436779E-01	1.3600281E-02
5	-3.7145506E-02	6.2833346E-03
6	-1.3240163E-02	2.7470239E-03
7	-4.7261663E-03	1.1587437E-03
8	-1.6894095E-03	4.7667736E-04
9	-6.0471308E-04	1.9249610E-04
10	-2.1673751E-04	7.6639199E-05
11	-7.7782394E-05	3.0172729E-05
12	-2.7948697E-05	1.1771700E-05
13	-1.0054319E-05	4.5584521E-06
14	-3.6211408E-06	1.7542401E-06
15	-1.3057658E-06	6.7159491E-07
16	-4.7140236E-07	2.5597968E-07
17	-1.7037423E-07	9.7196895E-08

Table 8.4

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			35.22690	0.02377	35.22690	0.02377
1	-0.69251	10.81976	-24.39486	0.25717	-37.44864	0.24836
2	0.25993	1.26767	-6.34101	0.32601	2.69882	0.23071
3	0.35474	0.62818	-2.24944	0.20479	0.10030	0.08399
4	0.35536	0.50864	-0.79936	0.10417	0.03419	0.02828
5	0.35591	0.46200	-0.28450	0.04812	0.01171	0.00952
6	0.35644	0.43719	-0.10141	0.02104	0.00402	0.00321
7	0.35696	0.42182	-0.03620	0.00887	0.00138	0.00108
8	0.35746	0.41137	-0.01294	0.00365	0.00047	0.00036
9	0.35794	0.40383	-0.00463	0.00147	0.00016	0.00012
10	0.35841	0.39813	-0.00166	0.00059	0.00006	0.00004
11	0.35888	0.39370	-0.00060	0.00023	0.00002	0.00001
12	0.35932	0.39014	-0.00021	0.00009	0.00001	
13	0.35974	0.38724	-0.00008	0.00003		
14	0.36016	0.38483	-0.00003	0.00001		
15	0.36060	0.38284	-0.00001	0.00001		
16	0.36102	0.38115				
17	0.36142	0.37971				

$$\alpha = 0.37056, \tau_1 = 0.97506$$

Equivalent wall model: 3 layers plane wall

Table 8.5
Structure factors and time constants

Structure factors		Time constants [h]	
φ_{ii}	0.43716	$R \cdot C \cdot \varphi_{ii}$	49.480
φ_{ie}	0.02140	$R \cdot C \cdot \varphi_{ie}$	2.422
φ_{ee}	0.52004	$R \cdot C \cdot \varphi_{ee}$	58.860
		$R \cdot C$	113.184

Table 8.6a
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	0.27140	6.62822	2.5	9.211	138.33	0.23
2	7.05314	0.18169	3	0.425	2.60	0.28
3	0.33462	7.96776	2.5	7.471	136.59	0.28

Table 8.6b
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	0.04777	135.440	0.064	1.329	2213.25	0.964
2	1.24135	3.713	0.076	0.061	41.53	1.173
3	0.05889	162.812	0.064	1.078	2185.44	1.173

Table 8.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.01398	40.47815	1.00000	
1	0.23684	-57.93454	-0.64046	1.064
2	0.19382	18.87789	0.09782	0.719
3	0.01261	-0.96509	0.00009	0.139
4	0.00003	0.00085		0.114

$$\Sigma c_n = 0.45727, \quad \alpha = 0.39065$$

Table 8.8**Response factors for the equivalent wall [Btu/h ft² °F]**

n	X_n	Y_n
0	5.284936E+00	1.824686E-03
1	-4.179302E+00	3.209096E-02
2	-7.288827E-01	4.567982E-02
3	-1.835433E-01	2.776333E-02
4	-4.651800E-02	1.331955E-02
5	-1.190446E-02	5.818992E-03
6	-3.090500E-03	2.426435E-03
7	-8.190443E-04	9.860280E-04
8	-2.233266E-04	3.946852E-04
9	-6.319174E-05	1.565467E-04
10	-1.869991E-05	6.174307E-05
11	-5.815292E-06	2.426633E-05
12	-1.900945E-06	9.516088E-06
13	-6.503170E-07	3.726532E-06
14	-2.310774E-07	1.458029E-06
15	-8.455373E-08	5.701419E-07
16	-3.160813E-08	2.228661E-07
17	-1.199361E-08	8.709762E-08

**Frequency response for the three-dimensional model and equivalent wall;
dimensionless amplitude and time shift**

Table 8.9a
3-D model

Period	Transmittance		Admittance	
	amplitude	time shift [h]	amplitude	time shift [h]
48	0.98	-1.21	6.63	4.94
24	0.93	-2.38	12.87	4.75
12	0.77	-4.56	23.82	4.04
6	0.44	-8.00	38.46	2.80

Table 8.9b
Equivalent wall

Period	Transmittance		Admittance	
	amplitude	time shift [h]	amplitude	time shift [h]
48	0.99	-1.21	6.60	5.13
24	0.95	-2.39	12.93	5.12
12	0.81	-4.59	24.62	4.73
6	0.52	-8.22	42.42	3.97