3.5 wall/roof wood stud 16oc

Description

- ½-in. gypsum board
  - Thermal conductivity – 1.11 Btu-in/h-ft^2-F
  - Density – 50 lb/ft^3
  - Specific Heat – 0.26 Btu/lb-F
- 3.5-in. R-11 fiberglass batts
  - Thermal conductivity – 0.32 Btu-in/h-ft^2-F
  - Density – 5.3 lb/ft^3
  - Specific Heat – 0.23 Btu/lb-F
- 2x4 wood studs
  - Thermal conductivity – 1.0 Btu-in/h-ft^2-F
  - Density – 36 lb/ft^3
  - Specific Heat – 0.39 Btu/lb-F
- ½-in. plywood
  - Thermal conductivity – 0.8 Btu-in/h-ft^2-F
  - Density – 34 lb/ft^3
  - Specific Heat – 0.29 Btu/lb-F
- ½-in wood siding
  - Thermal conductivity – 0.5 Btu-in/h-ft^2-F
  - Density – 34 lb/ft^3
  - Specific Heat – 0.30 Btu/lb-F

Comment:
Total response of the thermal bridge is to be calculated by multiplying response factors or z-transfer function coefficients by the interior surface area.

COMPUTATION RESULTS

Three-dimensional model

Table 6.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	9.40040	ft^2 °F h/Btu	1.65447	m^2 K/W
R^{-1}	0.10638	Btu/h ft^2 °F	0.60442	W/m^2 K
Capacitance	3.45245	Btu/ft^2 °F	70.54664	kJ/m^2 K

Table 6.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.09812	7.10349	1.00000
1	0.14358	-9.93976	-0.92645
2	-0.01307	3.20196	0.16872
3	0.00500	-0.11769	

$\Sigma\, c_n = 0.24800$, $E_1 = -0.05932$

Table 6.3
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	7.5565882E-01	1.0438068E-02
1	-3.5729725E-01	2.4943656E-02
2	-1.1789681E-01	1.9957551E-02
3	-6.1460353E-02	1.4812612E-02
4	-3.7047810E-02	1.0355807E-02
5	-2.3712689E-02	7.1831811E-03
6	-1.5653619E-02	5.0263961E-03
7	-1.0550552E-02	3.5617738E-03
8	-7.2317275E-03	2.5564333E-03
9	-5.0312449E-03	1.8571735E-03
10	-3.5484861E-03	1.3643754E-03
11	-2.5347021E-03	1.0127225E-03
12	-1.8321041E-03	7.5882849E-04
13	-1.3389093E-03	5.7348934E-04
14	-9.8849225E-04	4.3679500E-04
15	-7.3665309E-04	3.3500767E-04
16	-5.5369363E-04	2.5853802E-04
17	-4.1942084E-04	2.0061942E-04
18	-3.1994395E-04	1.5642588E-04
19	-2.4559908E-04	1.2247961E-04
20	-1.8958904E-04	9.6249042E-05
21	-1.4708198E-04	7.5873509E-05
22	-1.1460778E-04	5.9972718E-05
23	-8.9649690E-05	4.7513765E-05
24	-7.0365175E-05	3.7717382E-05
25	-5.5393273E-05	2.9991215E-05
26	-4.3720287E-05	2.3881894E-05
27	-3.4585265E-05	1.9040265E-05
28	-2.7412843E-05	1.5195945E-05
29	-2.1765082E-05	1.2138518E-05
30	-1.7306619E-05	9.7035303E-06
31	-1.3779223E-05	7.7619623E-06
32	-1.0983069E-05	6.2122639E-06
33	-8.7628394E-06	4.9742780E-06
34	-6.9973276E-06	3.9845797E-06
35	-5.5916157E-06	3.1928777E-06
36	-4.4711389E-06	2.5592231E-06
37	-3.5771598E-06	2.0518334E-06
38	-2.8632965E-06	1.6453901E-06
39	-2.2928455E-06	1.3197008E-06
40	-1.8367080E-06	1.0586461E-06

Table 6.4
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			7.10349	0.09812	7.10349	0.09812
1	-0.47283	2.38968	-3.35874	0.23448	-9.05306	0.15582
2	0.32997	0.80011	-1.10828	0.18761	1.58416	-0.00036
3	0.52131	0.74221	-0.57775	0.13924	0.31067	-0.01115
4	0.60279	0.69912	-0.34826	0.09735	0.11488	-0.01427
5	0.64006	0.69364	-0.22291	0.06752	0.05627	-0.01051
6	0.66014	0.69975	-0.14715	0.04725	0.03154	-0.00688
7	0.67400	0.70861	-0.09918	0.03348	0.01878	-0.00439
8	0.68544	0.71774	-0.06798	0.02403	0.01152	-0.00281
9	0.69572	0.72647	-0.04730	0.01746	0.00720	-0.00181
10	0.70529	0.73465	-0.03336	0.01283	0.00456	-0.00117
11	0.71431	0.74226	-0.02383	0.00952	0.00291	-0.00076
12	0.72281	0.74930	-0.01722	0.00713	0.00188	-0.00050
13	0.73080	0.75576	-0.01259	0.00539	0.00122	-0.00033
14	0.73828	0.76164	-0.00929	0.00411	0.00080	-0.00022
15	0.74523	0.76697	-0.00692	0.00315	0.00052	-0.00014
16	0.75163	0.77174	-0.00520	0.00243	0.00035	-0.00009
17	0.75750	0.77598	-0.00394	0.00189	0.00023	-0.00006
18	0.76282	0.77971	-0.00301	0.00147	0.00015	-0.00004
19	0.76763	0.78299	-0.00231	0.00115	0.00010	-0.00003
20	0.77195	0.78584	-0.00178	0.00090	0.00007	-0.00002
21	0.77579	0.78830	-0.00138	0.00071	0.00005	-0.00001
22	0.77921	0.79043	-0.00108	0.00056	0.00003	-0.00001
23	0.78223	0.79226	-0.00084	0.00045	0.00002	-0.00001
24	0.78489	0.79382	-0.00066	0.00035	0.00001	
25	0.78723	0.79516	-0.00052	0.00028	0.00001	
26	0.78927	0.79630	-0.00041	0.00022	0.00001	
27	0.79106	0.79727	-0.00033	0.00018		
28	0.79262	0.79810	-0.00026	0.00014		
29	0.79397	0.79880	-0.00020	0.00011		
30	0.79516	0.79940	-0.00016	0.00009		
31	0.79618	0.79991	-0.00013	0.00007		
32	0.79707	0.80035	-0.00010	0.00006		
33	0.79785	0.80072	-0.00008	0.00005		
34	0.79852	0.80104	-0.00007	0.00004		
35	0.79911	0.80131	-0.00005	0.00003		
36	0.79961	0.80154	-0.00004	0.00002		
37	0.80006	0.80174	-0.00003	0.00002		
38	0.80044	0.80191	-0.00003	0.00002		
39	0.80077	0.80206	-0.00002	0.00001		
40	0.80106	0.80219	-0.00002	0.00001		

$\alpha = 0.80162$, $\tau_1 = 4.52251$

Equivalent wall model: 3 layers plane wall

Table 6.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.43161	$R \cdot C \cdot \varphi_{ii}$	14.008
φ_{ie}	0.10289	$R \cdot C \cdot \varphi_{ie}$	3.339
φ_{ee}	0.36260	$R \cdot C \cdot \varphi_{ee}$	11.768
		$R \cdot C$	32.454

Table 6.6a
Thermophysical properties of the equivalent wall - IP units

Layer *N*	R_n Ft^2-°F-h/Btu	C_n Btu/ft^2-°F	l_n in	k_n Btu-in/h-ft^2-°F	ρ_n lb/ft^3	c_{pn} Btu/lb-°F
1	1.75663	1.57823	1	0.569	75.76	0.25
2	6.17058	0.65847	3	0.486	10.54	0.25
3	1.47319	1.21575	1	0.679	48.63	0.30

Table 6.6b
Thermophysical properties of the equivalent wall - SI units

Layer *N*	R_n m^2K/W	C_n kJ/ m^2 K	l_n M	k_n W/mK	ρ_n kg/m^3	c_{pn} kJ/kgK
1	0.30917	32.24931	0.025	0.082	1212.08	1.048
2	1.08602	13.45500	0.076	0.070	168.57	1.048
3	0.25928	24.84234	0.025	0.098	778.08	1.257

Table 6.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

N	b_n	c_n	d_n	τ_n
0	0.00183	9.97765	1.00000	
1	0.09898	-14.73223	-0.83254	1.568
2	0.19047	5.73102	0.17254	0.739
3	0.04155	-0.65979	-0.00626	0.321
4	0.00091	0.01711	0.00001	0.143
5		-0.00001		0.102

$\Sigma\, c_n = 0.33374$, $\alpha = 0.52837$

Table 6.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	1.061407E+00	1.944097E-04
1	-6.835266E-01	1.069138E-02
2	-1.425394E-01	2.912916E-02
3	-6.428111E-02	2.682785E-02
4	-3.138774E-02	1.747366E-02
5	-1.592991E-02	1.010111E-02
6	-8.248203E-03	5.562465E-03
7	-4.314521E-03	2.997363E-03
8	-2.268403E-03	1.598810E-03
9	-1.195650E-03	8.486705E-04
10	-6.309969E-04	4.494250E-04
11	-3.332079E-04	2.377256E-04
12	-1.760082E-04	1.256757E-04
13	-9.298525E-05	6.642136E-05
14	-4.912772E-05	3.509988E-05
15	-2.595697E-05	1.854707E-05
16	-1.371479E-05	9.800107E-06
17	-7.246491E-06	5.178209E-06
18	-3.828849E-06	2.736056E-06
19	-2.023064E-06	1.445669E-06
20	-1.068936E-06	7.638563E-07
21	-5.647984E-07	4.036030E-07
22	-2.984253E-07	2.132537E-07
23	-1.576803E-07	1.126779E-07
24	-8.331439E-08	5.953624E-08
25	-4.402122E-08	3.145744E-08
26	-2.32597E-08	1.662132E-08
27	-1.228985E-08	8.782294E-09
28	-6.493647E-09	4.640342E-09
29	-3.431080E-09	2.451840E-09
30	-1.812897E-09	1.295491E-09
31	-9.578890E-10	6.845049E-10
32	-5.061247E-10	3.616753E-10
33	-2.674235E-10	1.911001E-10
34	-1.412999E-10	1.009725E-10
35	-7.465933E-11	5.335134E-11
36	-3.944811E-11	2.818953E-11
37	-2.084339E-11	1.489463E-11
38	-1.101313E-11	7.869950E-12
39	-5.819060E-12	4.158285E-12
40	-3.074645E-12	2.197134E-12

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

Table 6.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.92	-23°	2.22	48°
24	0.77	-41°	3.63	48°
12	0.53	-65°	5.45	39°
6	0.26	-89°	7.37	28°

Table 6.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.97	-25°	2.18	55°
24	0.9	-49°	3.84	60°
12	0.71	-91°	6.53	56°
6	0.38	-158°	9.76	48°