Corner: 2x4wood (3.5 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

<u>Comment:</u>
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 3.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	10.47675	ft^2 °F h/Btu	1.84391	m^2 K/W
R^{-1}	0.09545	Btu/h ft^2 °F	0.54233	W/m^2 K
Capacitance	2.13336	Btu/ft^2 °F	43.59265	kJ/m^2 K

Table 3.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.19209	6.43935	1.00000
1	0.20133	-9.92949	-0.93234
2	-0.14086	4.08246	0.20719
3	0.00992	-0.32742	-0.01098

$\Sigma\, c_n = 0.26248$, $E_1 = -0.00917$

Table 3.3
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	6.1463210E-01	1.8334572E-02
1	-3.7471861E-01	3.6310900E-02
2	-8.7044401E-02	1.6610060E-02
3	-2.8020668E-02	9.1111014E-03
4	-1.2203095E-02	5.5444530E-03
5	-6.5272274E-03	3.4638817E-03
6	-3.8668518E-03	2.1817010E-03
7	-2.4001418E-03	1.3820159E-03
8	-1.5252799E-03	8.8096515E-04
9	-9.8322950E-04	5.6543168E-04
10	-6.4020647E-04	3.6545040E-04
11	-4.2008069E-04	2.3778736E-04
12	-2.7734375E-04	1.5568227E-04
13	-1.8402364E-04	1.0249535E-04
14	-1.2260295E-04	6.7809554E-05
15	-8.1955924E-05	4.5051937E-05
16	-5.4934775E-05	3.0040092E-05
17	-3.6904960E-05	2.0091374E-05
18	-2.4837861E-05	1.3471718E-05
19	-1.6741307E-05	9.0522108E-06
20	-1.1297709E-05	6.0932000E-06
21	-7.6316626E-06	4.1073430E-06
22	-5.1593570E-06	2.7719725E-06
23	-3.4902320E-06	1.8725608E-06
24	-2.3623382E-06	1.2659743E-06
25	-1.5996155E-06	8.5643095E-07
26	-1.0835269E-06	5.7967737E-07
27	-7.3415161E-07	3.9252232E-07
28	-4.9754296E-07	2.6588370E-07
29	-3.3725266E-07	1.8015245E-07
30	-2.2863616E-07	1.2209189E-07
31	-1.5501967E-07	8.2758566E-08
32	-1.0511655E-07	5.6105250E-08
33	-7.1283601E-08	3.8040496E-08

Table 3.4
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			6.43935	0.19209	6.43935	0.19209
1	-0.60966	1.98046	-3.92583	0.38042	-8.29223	0.25017
2	0.23229	0.45744	-0.91194	0.17402	1.75009	-0.08394
3	0.32191	0.54853	-0.29357	0.09545	0.32480	-0.02254
4	0.43550	0.60854	-0.12785	0.05809	0.07121	-0.00664
5	0.53488	0.62475	-0.06838	0.03629	0.01831	-0.00310
6	0.59242	0.62984	-0.04051	0.02286	0.00586	-0.00175
7	0.62070	0.63346	-0.02515	0.01448	0.00232	-0.00102
8	0.63550	0.63745	-0.01598	0.00923	0.00107	-0.00059
9	0.64462	0.64183	-0.01030	0.00592	0.00053	-0.00033
10	0.65113	0.64632	-0.00671	0.00383	0.00028	-0.00019
11	0.65616	0.65067	-0.00440	0.00249	0.00015	-0.00010
12	0.66022	0.65471	-0.00291	0.00163	0.00008	-0.00006
13	0.66352	0.65836	-0.00193	0.00107	0.00004	-0.00003
14	0.66623	0.66159	-0.00128	0.00071	0.00002	-0.00002
15	0.66847	0.66439	-0.00086	0.00047	0.00001	-0.00001
16	0.67030	0.66679	-0.00058	0.00031	0.00001	-0.00001
17	0.67180	0.66882	-0.00039	0.00021		
18	0.67302	0.67052	-0.00026	0.00014		
19	0.67402	0.67194	-0.00018	0.00009		
20	0.67484	0.67312	-0.00012	0.00006		
21	0.67551	0.67409	-0.00008	0.00004		
22	0.67605	0.67488	-0.00005	0.00003		
23	0.67649	0.67553	-0.00004	0.00002		
24	0.67684	0.67607	-0.00002	0.00001		
25	0.67713	0.67650	-0.00002	0.00001		
26	0.67737	0.67685	-0.00001	0.00001		
27	0.67756	0.67714	-0.00001			
28	0.67771	0.67737	-0.00001			
29	0.67784	0.67756				
30	0.67794	0.67771				
31	0.67802	0.67784				
32	0.67809	0.67794				
33	0.67814	0.67802				

α = 0.67808, τ_1 = 2.57406

Equivalent wall model: 3 layers plane wall

Table 3.5
Structure factors and time constants

Structure factors		Time constants [h]	
φ_{ii}	0.37411	$R \cdot C \cdot \varphi_{ii}$	8.362
φ_{ie}	0.08625	$R \cdot C \cdot \varphi_{ie}$	1.928
φ_{ee}	0.45339	$R \cdot C \cdot \varphi_{ee}$	10.134
		$R \cdot C$	22.351

Table 3.6a
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	0.60786	0.62500	0.75	1.234	40	0.25
2	8.60373	0.60334	3.25	0.378	8.91	0.25
3	1.26517	0.90502	1	0.790	43.44	0.25

Table 3.6b
Thermophysical properties of the equivalent wall - SI units

Layer *N*	R_n m^2 K/W	C_n kJ/ m^2 K	l_n m	k_n W/m K	ρ_n kg/m^3	c_{pn} kJ/kg K
1	0.10698	12.77112	0.019	0.178	640	1.048
2	1.51426	12.32861	0.083	0.054	142.57	1.048
3	0.22267	18.49292	0.025	0.114	695.05	1.048

Table 3.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.02785	8.58692	1.00000	
1	0.35867	-10.53961	-0.40655	0.918
2	0.22002	2.69018	0.02384	0.368
3	0.01064	-0.12052	-0.00009	0.180
4	0.00002	0.00023		0.108

$\Sigma\, c_n = 0.61720$, $\alpha = 0.33648$

Table 3.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	8.196161E-01	2.658012E-03
1	-6.727811E-01	3.531585E-02
2	-3.628898E-02	3.529490E-02
3	-1.014172E-02	1.452287E-02
4	-3.295857E-03	5.068229E-03
5	-1.101356E-03	1.717371E-03
6	-3.700781E-04	5.786518E-04
7	-1.244897E-04	1.947559E-04
8	-4.188583E-05	6.553447E-05
9	-1.40935E-05	2.205111E-05
10	-4.742138E-06	7.419721E-06
11	-1.595622E-06	2.496572E-06
12	-5.368913E-07	8.400405E-07
13	-1.806520E-07	2.826549E-07
14	-6.078533E-08	9.510705E-08
15	-2.045291E-08	3.200139E-08
16	-6.881946E-09	1.076775E-08
17	-2.315621E-09	3.623109E-09
18	-7.791547E-10	1.219095E-09
19	-2.621681E-10	4.101983E-10
20	-8.821372E-11	1.380225E-10
21	-2.968194E-11	4.644151E-11
22	-9.987311E-12	1.562653E-11
23	-3.360507E-12	5.257978E-12
24	-1.130735E-12	1.769192E-12
25	-3.804672E-13	5.952935E-13
26	-1.280187E-13	2.003030E-13
27	-4.307543E-14	6.739748E-14
28	-1.449392E-14	2.267774E-14
29	-4.876881E-15	7.630554E-15
30	-1.640961E-15	2.567511E-15
31	-5.521468E-16	8.639101E-16
32	-1.857851E-16	2.906864E-16
33	-6.251251E-17	9.780948E-17

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

Table 3.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.97	-14°	1.58	42°
24	0.88	-26°	2.52	50°
12	0.70	-43°	4.19	49°
6	0.46	-63°	6.61	38°

Table 3.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.99	-14°	1.51	46°
24	0.97	-29°	2.46	61°
12	0.88	-56°	4.48	68°
6	0.65	-103°	8.09	67°