2x4 steel stud wall (corner)

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 steel studs
  - Thermal conductivity – 314 Btu-in/h-ft^2-F
  - Density – 490 lb/ft^3
  - Specific Heat – 0.12 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 11.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	5.28141	ft^2 °F h/Btu	0.92953	m^2 K/W
R^{-1}	0.18934	Btu/h ft^2 °F	1.07581	W/m^2 K
Capacitance	2.06174	Btu/ft^2 °F	42.12910	kJ/m^2 K

Table 11.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.27182	3.32708	1.00000
1	0.23733	-4.25094	-0.73120
2	-0.11860	1.46144	0.13649
3	0.00796	-0.14221	-0.00664
4	0.00019	0.00333	0.00004

$\Sigma\, c_n = 0.39870$, $E_1 = 0.00000$

Table 11.3
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	6.2995967E-01	5.1462278E-02
1	-3.4426224E-01	8.2568397E-02
2	-6.0995006E-02	3.0893166E-02
3	-2.0355202E-02	1.3167919E-02
4	-8.2360738E-03	5.9929699E-03
5	-3.6364340E-03	2.7882727E-03
6	-1.6677169E-03	1.3072998E-03
7	-7.7702305E-04	6.1466250E-04
8	-3.6437102E-04	2.8930577E-04
9	-1.7130858E-04	1.3622180E-04
10	-8.0623047E-05	6.4149332E-05
11	-3.7958745E-05	3.0210118E-05
12	-1.7873944E-05	1.4226715E-05
13	-8.4166238E-06	6.6994609E-06
14	-3.9632355E-06	3.1547067E-06

Table 11.4
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			3.32708	0.27179	3.32708	0.27179
1	-0.54648	1.60445	-1.81819	0.43608	-3.38486	0.30809
2	0.17718	0.37415	-0.32214	0.16316	0.53402	-0.04218
3	0.33372	0.42624	-0.10750	0.06955	0.04419	-0.00728
4	0.40462	0.45512	-0.04350	0.03165	0.00712	-0.00110
5	0.44153	0.46526	-0.01921	0.01473	0.00128	-0.00018
6	0.45861	0.46886	-0.00881	0.00690	0.00024	-0.00003
7	0.46592	0.47018	-0.00410	0.00325	0.00004	
8	0.46893	0.47067	-0.00192	0.00153	0.00001	
9	0.47015	0.47086	-0.00090	0.00072		
10	0.47063	0.47092	-0.00043	0.00034		
11	0.47082	0.47093	-0.00020	0.00016		
12	0.47088	0.47093	-0.00009	0.00008		
13	0.47089	0.47091	-0.00004	0.00004		
14	0.47088	0.47089	-0.00002	0.00002		

$\alpha = 0.47089$, $\tau_1 = 1.32777$

Equivalent wall model: 3 layers plane wall

Table 11.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.29102	$R \cdot C \cdot \varphi_{ii}$	3.169
φ_{ie}	0.11581	$R \cdot C \cdot \varphi_{ie}$	1.261
φ_{ee}	0.47735	$R \cdot C \cdot \varphi_{ee}$	5.198
		$R \cdot C$	10.889

Table 11.6a
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	0.73527	0.41667	0.5	0.680	40	0.25
2	3.92264	0.82254	3.5	0.892	11.280	0.25
3	0.62350	0.82254	1	1.604	39.482	0.25

Table 11.6b
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	0.12941	8.51408	0.013	0.098	640	1.048
2	0.69039	16.80751	0.089	0.129	180.488	1.048
3	0.10974	16.80751	0.025	0.231	631.707	1.048

Table 11.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.12549	3.84117	1.00000	
1	0.54484	-3.45205	-0.22626	0.652
2	0.10500	0.38954	0.00230	0.219
3	0.00070	-0.002624		0.117

$\Sigma\, c_n = 0.77604$, $\alpha = 0.21562$

Table 11.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	7.272995E-01	2.376066E-02
1	-4.890655E-01	1.085379E-01
2	-3.856676E-02	4.438479E-02
3	-8.100118E-03	9.926393E-03
4	-1.744355E-03	2.144109E-03
5	-3.760997E-04	4.623580E-04
6	-8.109544E-05	9.969533E-05
7	-1.748603E-05	2.149660E-05
8	-3.770387E-06	4.635157E-06
9	-8.129816E-07	9.994459E-07
10	-1.752974E-07	2.155034E-07
11	-3.779812E-08	4.646744E-08
12	-8.150137E-09	1.001944E-08
13	-1.757356E-09	2.160421E-09
14	-3.789261E-10	4.658360E-10

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

Table 11.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.99	-9°	1.13	21°
24	0.95	-18°	1.42	33°
12	0.83	-34°	2.12	39°
6	0.59	-55°	3.24	34°

Table 11.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	1.00	-9°	1.10	22°
24	0.98	-19°	1.35	37°
12	0.94	-37°	2.03	51°
6	0.80	-71°	3.39	55°