Foundation: 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

Foundation

concrete
Thermal conductivity -9.09 Btu-ihn./ hft2F
Density - 140lb/ft3,
Specific heat 0.21 Btu/lbF
foam: thermal conductivity -0.2 Btu-ihn./ hft2F
density - 2.0lb/ft3
specific heat 0.29 Btu/lbF

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

COMPUTATION RESULTS

Three-dimensional model

Table 5.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	9.79471	ft^2 °F h/Btu	1.72387	m^2 K/W
R^{-1}	0.10210	Btu/h ft^2 °F	0.58009	W/m^2 K
Capacitance	3.05594	Btu/ft^2 °F	62.44441	kJ/m^2 K

Table 5.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.08635	5.34251	1.00000
1	0.14395	-7.49327	-0.89680
2	-0.00347	2.44246	0.13624
3	0.00869	-0.05226	

$\Sigma\, c_n = 0.23944$, $E_1 = -0.01638$

Table 5.3
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	5.4595294E-01	8.8156868E-03
1	-2.7542022E-01	2.2602619E-02
2	-7.2012966E-02	1.8714657E-02
3	-3.2393773E-02	1.4591037E-02
4	-1.9239809E-02	1.0535610E-02
5	-1.2817469E-02	7.4458702E-03
6	-8.9210126E-03	5.2739201E-03
7	-6.3295309E-03	3.7687749E-03
8	-4.5386665E-03	2.7189594E-03
9	-3.2773554E-03	1.9781309E-03
10	-2.3786882E-03	1.4491980E-03
11	-1.7332172E-03	1.0676942E-03
12	-1.2668014E-03	7.9020833E-04
13	-9.2819911E-04	5.8700761E-04
14	-6.8148493E-04	4.3739364E-04
15	-5.0119863E-04	3.2675114E-04
16	-3.6914189E-04	2.4463535E-04
17	-2.7222331E-04	1.8351046E-04
18	-2.0097637E-04	1.3789685E-04
19	-1.4852753E-04	1.0378501E-04
20	-1.0986954E-04	7.8226357E-05
21	-8.1345031E-05	5.9043648E-05
22	-6.0276735E-05	4.4623858E-05
23	-4.4701303E-05	3.3768627E-05
24	-3.3176701E-05	2.5585568E-05
25	-2.4642380E-05	1.9408779E-05
26	-1.8317446E-05	1.4740464E-05
27	-1.3626311E-05	1.1207884E-05
28	-1.0144315E-05	8.5315151E-06
29	-7.5578679E-06	6.5014461E-06
30	-5.6352122E-06	4.9598254E-06
31	-4.2049291E-06	3.7877984E-06
32	-3.1401343E-06	2.8957610E-06
33	-2.3468384E-06	2.2160783E-06
34	-1.7553684E-06	1.6976375E-06
35	-1.3140397E-06	1.3017662E-06
36	-9.8448507E-07	9.9917032E-07
37	-7.3820263E-07	7.6763493E-07
38	-5.5400457E-07	5.9029412E-07
39	-4.1612891E-07	4.5432888E-07
40	-3.1284170E-07	3.4998532E-07

Table 5.4
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			5.34745	0.08635	5.34745	0.08635
1	-0.50448	2.56391	-2.69766	0.22139	-6.76741	0.15567
2	0.26147	0.82799	-0.70535	0.18330	1.34774	0.01482
3	0.44983	0.77966	-0.31729	0.14291	0.21952	0.00341
4	0.59394	0.72206	-0.18845	0.10319	0.05303	-0.00557
5	0.66620	0.70673	-0.12554	0.07293	0.01788	-0.00561
6	0.69600	0.70830	-0.08738	0.05166	0.00817	-0.00385
7	0.70951	0.71461	-0.06200	0.03691	0.00450	-0.00240
8	0.71706	0.72144	-0.04445	0.02663	0.00273	-0.00146
9	0.72210	0.72753	-0.03210	0.01938	0.00173	-0.00089
10	0.72580	0.73261	-0.02330	0.01419	0.00113	-0.00055
11	0.72864	0.73675	-0.01698	0.01046	0.00076	-0.00035
12	0.73090	0.74011	-0.01241	0.00774	0.00051	-0.00022
13	0.73271	0.74285	-0.00909	0.00575	0.00035	-0.00014
14	0.73420	0.74512	-0.00667	0.00428	0.00024	-0.00009
15	0.73545	0.74704	-0.00491	0.00320	0.00017	-0.00006
16	0.73652	0.74869	-0.00362	0.00240	0.00012	-0.00004
17	0.73745	0.75014	-0.00267	0.00180	0.00009	-0.00003
18	0.73828	0.75144	-0.00197	0.00135	0.00006	-0.00002
19	0.73903	0.75263	-0.00145	0.00102	0.00004	-0.00001
20	0.73973	0.75373	-0.00108	0.00077	0.00003	-0.00001
21	0.74038	0.75478	-0.00080	0.00058	0.00002	
22	0.74100	0.75578	-0.00059	0.00044	0.00002	
23	0.74160	0.75674	-0.00044	0.00033	0.00001	
24	0.74219	0.75767	-0.00032	0.00025	0.00001	
25	0.74276	0.75858	-0.00024	0.00019	0.00001	
26	0.74333	0.75947	-0.00018	0.00014		
27	0.74390	0.76035	-0.00013	0.00011		
28	0.74447	0.76121	-0.00010	0.00008		
29	0.74503	0.76205	-0.00007	0.00006		
30	0.74561	0.76288	-0.00006	0.00005		
31	0.74619	0.76370	-0.00004	0.00004		
32	0.74677	0.76450	-0.00003	0.00003		
33	0.74737	0.76528	-0.00002	0.00002		
34	0.74797	0.76605	-0.00002	0.00002		
35	0.74858	0.76681	-0.00001	0.00001		
36	0.74920	0.76755	-0.00001	0.00001		
37	0.74984	0.76827	-0.00001	0.00001		
38	0.75048	0.76898	-0.00001	0.00001		
39	0.75113	0.76967				
40	0.75179	0.77033				

$\alpha = 0.76106$, $\tau_1 = 3.66247$

Equivalent wall model: 3 layers plane wall

Table 5.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.30603	$R \cdot C \cdot \varphi_{ii}$	9.160
φ_{ie}	0.11587	$R \cdot C \cdot \varphi_{ie}$	3.468
φ_{ee}	0.46222	$R \cdot C \cdot \varphi_{ee}$	13.835
		$R \cdot C$	29.932

Table 5.6a
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	3.72753	1.31351	1.5	0.402	42.03	0.25
2	4.42665	0.25776	2	0.452	6.19	0.25
3	1.64053	1.48467	1.5	0.914	39.59	0.30

Table 5.6b
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	0.65605	26.83997	0.038	0.058	672.52	1.048
2	0.77909	5.26691	0.051	0.065	98.98	1.048
3	0.28873	30.33752	0.038	0.132	633.46	1.257

Table 5.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

N	b_n	c_n	d_n	τ_n
0	0.00240	6.55741	1.00000	
1	0.10317	-9.59910	-0.86516	1.770
2	0.16998	3.77441	0.17379	0.783
3	0.02974	-0.43135	-0.00289	0.247
4	0.00045	0.00436		0.139

$\Sigma\, c_n = 0.30574$, $\alpha = 0.56831$

Table 5.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	6.694846E-01	2.448401E-04
1	-4.008186E-01	1.074511E-02
2	-7.776686E-02	2.660781E-02
3	-3.972540E-02	2.418976E-02
4	-2.156947E-02	1.638069E-02
5	-1.198169E-02	1.004505E-02
6	-6.732362E-03	5.913754E-03
7	-3.804629E-03	3.417983E-03
8	-2.156234E-03	1.958398E-03
9	-1.223747E-03	1.117415E-03
10	-6.950040E-04	6.362750E-04
11	-3.948491E-04	3.619463E-04
12	-2.243608E-04	2.057938E-04
13	-1.274966E-04	1.169816E-04
14	-7.245489E-05	6.648934E-05
15	-4.117610E-05	3.778867E-05
16	-2.340061E-05	2.147628E-05
17	-1.329874E-05	1.220537E-05
18	-7.557806E-06	6.936483E-06
19	-4.295175E-06	3.942089E-06
20	-2.440994E-06	2.240335E-06
21	-1.387242E-06	1.273207E-06
22	-7.883842E-07	7.235773E-07
23	-4.480470E-07	4.112170E-07
24	-2.546301E-07	2.336988E-07
25	-1.447088E-07	1.328136E-07
26	-8.223964E-08	7.547941E-08
27	-4.673764E-08	4.289572E-08
28	-2.656151E-08	2.437811E-08
29	-1.509518E-08	1.385434E-08
30	-8.578754E-09	7.873565E-09
31	-4.875399E-09	4.474632E-09
32	-2.770739E-09	2.542980E-09
33	-1.574642E-09	1.445203E-09
34	-8.948849E-10	8.213246E-10
35	-5.085730E-10	4.667671E-10
36	-2.890274E-10	2.652689E-10
37	-1.642573E-10	1.507551E-10
38	-9.334919E-11	8.567572E-11
39	-5.305134E-11	4.869044E-11
40	-3.014963E-11	2.767129E-11

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

Table 5.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.92	-25°	1.70	40°
24	0.77	-44°	2.60	43°
12	0.51	-69°	3.82	39°
6	0.24	-93°	5.38	31°

Table 5.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	0.97	-26°	1.66	44°
24	0.89	-50°	2.68	52°
12	0.67	-93°	4.31	50°
6	0.35	-156°	6.17	45°