Steel stud wall: 3.5 stud 16GA 24oc 15 flange

Description

2x4 steel stud wall

- 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

COMPUTATION RESULTS

Three-dimensional model

Table 10.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	8.79595	ft^2 °F h/Btu	1.54809	m^2 K/W
R^{-1}	0.11369	Btu/h ft^2 °F	0.64596	W/m^2 K
Capacitance	1.49422	Btu/ft^2 °F	30.53265	kJ/m^2 K

Table 10.2
Dimensionless 3D z-transfer function coefficients

n	b_n	c_n	d_n
0	0.27544	5.38342	1.00000
1	0.46780	-5.43867	-0.32450
2	-0.03740	0.77712	0.02704
3	-0.00348	-0.01951	-0.00018

$\Sigma\, c_n = 0.70237$, $E_1 = 0.00000$

Table 10.3
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	6.1203450E-01	3.1314503E-02
1	-4.1971285E-01	6.3345428E-02
2	-6.4393145E-02	1.5457140E-02
3	-1.1657709E-02	2.9126873E-03
4	-2.1154436E-03	5.3999293E-04
5	-3.8420098E-04	9.9441677E-05
6	-6.9800378E-05	1.8243370E-05
7	-1.2681598E-05	3.3387061E-06
8	-2.3037049E-06	6.0994486E-07
9	-4.1835653E-07	1.1127435E-07
10	-7.5980960E-08	2.0286049E-08

Table 10.4
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			5.38342	0.27544	5.38342	0.27544
1	-0.68577	2.02288	-3.69177	0.55718	-4.66963	0.50678
2	0.15342	0.24401	-0.56640	0.13596	0.10418	0.03399
3	0.18104	0.18844	-0.10254	0.02562	0.00034	0.00074
4	0.18146	0.18539	-0.01861	0.00475	0.00002	0.00006
5	0.18162	0.18415	-0.00338	0.00087		0.00001
6	0.18168	0.18346	-0.00061	0.00016		
7	0.18168	0.18301	-0.00011	0.00003		
8	0.18166	0.18269	-0.00002	0.00001		
9	0.18160	0.18243	0.00000			
10	0.18162	0.18231	0.00000			

$\alpha = 0.18164$, $\tau_1 = 0.58626$

Equivalent wall model: 3 layers plane wall

Table 10.5
Structure factors and time constants

Structure factors		Time constants [h]	
φ_{ii}	0.37411	$R{\cdot}C{\cdot}\varphi_{ii}$	8.361
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 10.6a
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	0.10019	0.41667	0.5	4.990	40	0.25
2	8.37634	0.53878	3.5	0.418	7.389	0.25
3	0.31942	0.53878	1	3.131	25.861	0.25

Table 10.6b
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	0.01763	8.51408	0.013	0.720	640	1.048
2	1.47424	11.00928	0.089	0.060	118.223	1.048
3	0.05622	11.00928	0.025	0.452	413.782	1.048

Table 10.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

n	b_n	c_n	d_n	τ_n
0	0.24292	6.07542	1.00000	
1	0.57375	-5.79965	-0.14083	0.509
2	0.04255	0.58379	0.00008	0.134
3	0.00002	-0.00030		0.073

$\Sigma\, c_n = 0.85925$, $\alpha = 0.14026$

Table 10.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	6.907062E-01	2.761768E-02
1	-5.620835E-01	6.911879E-02
2	-1.284226E-02	1.456909E-02
3	-1.798363E-03	2.048870E-03
4	-2.522391E-04	2.873804E-04
5	-3.537941E-05	4.030836E-05
6	-4.962365E-06	5.653706E-06
7	-6.960281E-07	7.929966E-07
8	-9.762584E-08	1.112268E-07
9	-1.369313E-08	1.560082E-08
10	-1.920618E-09	2.188193E-09

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

Table 10.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	1.00	-7°	1.26	33°
24	0.98	-14°	1.82	47°
12	0.93	-27°	3.12	52°
6	0.75	-52°	5.38	43°

Table 10.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	1.00	-7°	1.22	34°
24	0.99	-14°	1.72	53°
12	0.96	-28°	2.94	67°
6	0.87	-53°	5.45	73°