From equations 3.72, 3.73 and 3.74:

$$F_c = 1 - 0.13\,(4.16 + i1.65) = 0.459 - i0.214$$

$$F = 0.51$$

$$\psi = -1.67\ \text{h}$$

From equation 3.77:

$$\chi = \frac{86400}{2 \times 3.142}\left|\frac{-2.122 + i3.231}{-0.0329 - i0.7630}\right|$$

$$= 13749\left|\frac{(-2.122 + i3.231)(-0.0329 + i\,0.7630)}{0.329^2 + 0.7630^2}\right|$$

$$= 69590\ \text{J/m}^2\cdot\text{K or } 69.6\ \text{kJ/m}^2\cdot\text{K}$$

Appendix 3.A7: Properties of materials

The data tabulated in this appendix have been abstracted, with permission, from the report of a thorough review of existing data sets undertaken by the Building Performance Analysis Club (BEPAC) (Clark, Yaneske and Pinney, 1990). Fourteen data sets were studied, see Table 3.34.

Tables 3.35 to 3.45 contain only a selection of the data given in the BEPAC report, these being regarded as broadly representative of the materials listed. In each case the source of the data is identified by a code that refers to one of the data sets listed in Table 3.34.

Thermal conductivity, density and specific heat capacity data for typical materials are given in Tables 3.35 to 3.38. Table 3.35 refers to impermeable materials, i.e. those that act as a barrier to water in the vapour and/or liquid states, and whose hygrothermal properties do not alter by absorbing water. Table 3.36 includes lightweight insulation materials, such as mineral wools and foamed plastics, which display water vapour permeability, zero hygroscopic water content and an apparent thermal conductivity, and which operate under conditions of air dry equilibrium normally protected from wetting by rain. Table 3.37 deals with masonry and related materials, which are inorganic, porous and may contain significant amounts of water (due to hygroscopic absorption from the air or wetting by rain), which affects their hygrothermal properties and their thermal conductivity in particular. Table 3.38 provides data for organic materials such as wood and wood-based products, which are porous and strongly hygroscopic and which display a highly non linear water vapour permeability.

Tables 3.39 to 3.41 give absorptivity and emissivity data for impermeable, inorganic porous and hygroscopic materials, respectively.

Tables 3.42 to 3.45 contain vapour resistivity values for a wide variety of materials divided into four categories as for Tables 3.35 to 3.38.

Table 3.34 Sources of data

Data source	Code and source reference
ASHRAE, USA	A (ASHRAE, 1985)
BS 5250, UK	BS (BSI, 2011)
CIBSE, UK	C (CIBSE, 1986a/b)
CSTC, Belgium	T (Institut Belge de Normalisation, 1980)
DOE 2 Program, USA	D (Lawrence Berkley Laboratory, 1984)
ESP program, UK	E (Energy Simulation Research Unit/ University of Strathclyde, 1989)
Mineral Wool Insulation Manufacturers Association (MIMA), UK (formerly Eurisol)	Eu
France	F (Centre Scientific et Technique du Batiment, 1977)
Germany	G (Deutsches Institut fur Normung, 1981)
Italy	Y (Ente Nazionale Italiano di Unificazione, 1974)
India	I (Indian Standards Institution, 1978)
Leeds University, UK	L (Tinker, 1985; Tinker and O'Rourke, 1990)
Leuven University, Belgium	B (Laboratorium voor Bouwfysica/ Kotholieke Universiteit Leuven, 1991)
Netherlands	S (Stichting Bouwresearch, 1994)

Note: The data given in this appendix are not intended to replace values given in product standards and similar documents.

Table 3.35 Thermal conductivity, density and specific heat capacity: impermeable materials

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Asphalt:		C	0.5	1700	1000
		E	1.2	2300	1700
— poured		T	1.2	2100	920
— reflective coat		E	1.2	2300	1700
— roofing, mastic		E	1.15	2330	840
Bitumen:					
— composite, flooring		E	0.85	2400	1000
— insulation, all types		T	0.2	1000	1700
Ceramic, glazed		T	1.4	2500	840
Glass:					
— cellular sheet		T	0.048	140	840
— foam	At 50 °C	I	0.056	130	750
		S	0.052	140	840
— solid (soda-lime)	At 10 °C	C	1.05	2500	840
Linoleum		T	0.19	1200	1470
Metals:					
— aluminium		T	230	2700	880
— aluminium cladding		D	45	7680	420
— brass		T	110	8500	390
— bronze		T	64	8150	—
— copper		T	384	8600	390
— duraluminium		T	160	2800	580
— iron		T	72	7900	530
— iron, cast		T	56	7500	530
— lead		T	35	11 340	130
— stainless steel, 5% Ni		T	29	7850	480
— stainless steel, 20% Ni		T	16	8000	480
— steel		T	45	7800	480
— tin		T	65	7300	240
— zinc		T	113	7000	390
Polyvinylchloride (PVC):		E	0.16	1380	1000
— tiles		T	0.19	1200	1470
Roofing felt		E	0.19	960	840
Rubber:		T	0.17	1500	1470
— expanded board, rigid		G	0.032	70	1680
— hard		E	0.15	1200	1000
— tiles		E	0.3	1600	2000

Table 3.36 Thermal conductivity, density and specific heat capacity: non-hygroscopic materials

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Carpet/underlay:					
— with cellular rubber underlay		E	0.1	400	1360
— synthetic		E	0.06	160	2500
Foam:					
— phenol		C	0.04	30	1400
— phenol, rigid		S	0.035	110	1470
— polyisocyanate		S	0.03	45	1470
— polyurethane		T	0.028	30	1470
— polyurethane, freon-filled		S	0.03	45	1470
— polyvinylchloride		S	0.035	37	1470
— urea formaldehyde		C	0.04	10	1400
— urea formaldehyde resin		S	0.054	14	1470
Glass fibre/wool:					
— fibre quilt		C	0.04	12	840
— fibre slab		C	0.035	25	1000
— fibre, strawboard-like		S	0.085	300	2100

Table continues

Table 3.36 Thermal conductivity, density and specific heat capacity: non-hygroscopic materials — *continued*

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Glass fibre/wool:					
— wool	At 10 °C	Eu	0.04	10	840
	At 10 °C	Eu	0.04	12	840
	At 10 °C	Eu	0.037	16	840
	At 10 °C	Eu	0.032	32	840
	At 10 °C	Eu	0.03	48	840
	At 10 °C	Eu	0.031	80	840
— wool, resin bonded	At 50 °C	I	0.036	24	1000
Loose fill/powders:					
— cellulosic insulation		A	0.042	43	1380
— exfoliated vermiculite	At 50 °C	I	0.069	260	880
— floor/roof screed		C	0.41	1200	840
— glass, granular cellular		T	0.07	180	840
— gravel		E	0.36	1840	840
— perlite, expanded		A	0.051	100	1090
— polystyrene, moulded beads	At 10 °C	A	0.036	16	1210
— roof gravel or slag		D	1.44	880	1680
— sand		I	1.74	2240	840
— stone chippings for roofs		C	0.96	1800	1000
— white dry render		E	0.5	1300	1000
Mineral fibre/wool:					
— fibre blanket, bonded	At 10 °C	A	0.042	12	710
	At 10 °C	A	0.036	24	710
	At 10 °C	A	0.032	48	710
— fibre blanket, metal reinforced	At 37.7 °C	A	0.038	140	710
	At 93.3 °C	A	0.046	140	710
— fibre board, preformed		D	0.042	240	760
— fibre board, wet felted		A	0.051	290	800
— fibre board, wet moulded		A	0.061	370	590
— fibre board, resin bonded		A	0.042	240	710
— fibre, textile, organic-bonded	At 10 °C	A	0.043	10	710
— fibre slag, pipe insulation	At 23.8 °C	A	0.036	100	710
	At 23.8 °C	A	0.048	200	710
	At 93.3 °C	A	0.048	100	710
	At 93.3 °C	A	0.065	200	710
— wool		S	0.038	140	840
— wool, fibrous		D	0.043	96	840
— wool, resin bonded		I	0.036	99	1000
Miscellaneous materials:					
— acoustic tile		D	0.057	290	1340
— felt sheathing		E	0.19	960	950
— mineral filler for concrete		S	0.13	430	840
— perlite, bitumen bonded		S	0.061	240	840
— perlite, expanded, hard panels		T	0.055	170	840
— perlite, expanded, pure		T	0.046	65	840
— plastic tiles		E	0.5	1050	840
— polyurethane, expanded		D	0.023	24	1590
— polyurethane, unfaced	At 10 °C	G	0.023	32	1590
Carpet/underlay:					
— polyurethane board, cellular		A	0.023	24	1590
— polyisocyanurate board		A	0.02	32	920
— polyisocyanurate board, foil-faced, glass-fibre reinforced	At 10 °C	A	0.019	32	920
— polystyrene, expanded (EPS)		S	0.035	23	1470
— polystyrene, extruded (EPS)		S	0.027	35	1470
— polyvinylchloride (PVC), expanded		E	0.04	100	750
— vermiculite, expanded, panels		T	0.082	350	840
— vermiculite, expanded, pure		T	0.058	350	840
— silicon		E	0.18	700	1000
Rock wool	At 10 °C	Eu	0.037	23	710
	At 10 °C	Eu	0.033	60	710
	At 10 °C	Eu	0.033	100	710
	At 10 °C	Eu	0.034	200	710
— unbonded		I	0.047	92	840
		I	0.043	150	840

Table 3.37 Thermal conductivity, density and specific heat capacity: inorganic, porous materials

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)	
Asbestos-related materials:						
— asbestos cement		S	1.02	1750	840	
— asbestos cement building board		D	0.6	1920	840	
— asbestos cement decking		C	0.36	1500	1050	
— asbestos cement sheet	Conditioned	C	0.36	700	1050	
— asbestos fibre	At 50 °C	I	0.06	640	840	
— asbestos mill board	At 50 °C	I	0.25	1400	840	
Brick:		D	0.72	1920	840	
		D	1.31	2080	921	
— aerated		S	0.3	1000	840	
— brickwork, inner leaf		C	0.62	1700	800	
— brickwork, outer leaf		C	0.84	1700	800	
— burned		S	0.75	1300	840	
		S	0.85	1500	840	
		S	1	1700	840	
— mud	At 50 °C	I	0.75	1730	880	
— paviour		E	0.96	2000	840	
— reinforced	At 50 °C	I	1.1	1920	840	
— tile	At 50 °C	I	0.8	1890	880	
Cement/plaster/mortar:						
— cement		D	0.72	1860	840	
— cement blocks, cellular		T	0.33	520	2040	
— cement fibreboard, magnesium oxysulphide binder		A	0.082	350	1300	
— cement mortar		S	0.72	1650	920	
	Dry		T	0.93	1900	840
	Moist		T	1.5	1900	840
— cement/lime plaster		S	0.8	1600	840	
— cement panels, wood fibres	Dry	T	0.08	350	1890	
	Moist	T	0.12	350	3040	
		T	0.12	400	1470	
	Dry	T	0.35	1650	840	
— cement plaster		S	0.72	1760	840	
		S	1.5	1900	840	
— cement plaster, sand aggregate		A	0.72	1860	840	
— cement screed		E	1.4	2100	650	
— gypsum		E	0.42	1200	840	
— gypsum plaster		S	0.51	1120	960	
— gypsum plaster, perlite aggregate		A	0.22	720	1340	
— gypsum plaster, sand aggregate		A	0.81	1680	840	
— gypsum plasterboard		D	0.16	800	840	
		S	0.65	1100	840	
— gypsum plastering		S	0.8	1300	840	
— limestone mortar		T	0.7	1600	840	
— plaster		T	0.22	800	840	
		T	0.35	950	840	
		T	0.52	1200	840	
— plaster ceiling tiles		E	0.38	1120	840	
— plaster, lightweight aggregate		D	0.23	720	840	
— plaster, sand aggregate		D	0.82	1680	840	
— plasterboard		C	0.16	950	840	
— render, synthetic resin, exterior insulation		T	0.7	1100	900	
— rendering	Moisture content 1%	E	1.13	1430	1000	
	Moisture content 8%	E	0.79	1330	1000	
— vermiculite plaster		E	0.2	720	840	
Ceramic/clay tiles:						
— ceramic tiles	Dry	T	1.2	2000	850	
— ceramic floor tiles	Dry	T	0.8	1700	850	
— clay tiles		E	0.85	1900	840	
— clay tile, burnt		S	1.3	2000	840	
— clay tile, hollow, 10.2 mm, 1 cell		D	0.52	1120	840	
— clay tile, hollow, 20.3 mm, 2 cells		D	0.623	1120	840	
— clay tile, hollow, 32.5 mm, 3 cells		D	0.693	1120	840	
— clay tile, pavior		D	1.803	1920	840	

Table continues

Table 3.37 Thermal conductivity, density and specific heat capacity: inorganic, porous materials — *continued*

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Concrete blocks/tiles:					
— block, aerated		E	0.24	750	1000
— block, heavyweight, 300 mm		D	1.31	2240	840
— block, lightweight, 150 mm		D	0.66	1760	840
— block, lightweight, 300 mm		D	0.73	1800	840
	Dry	T	0.24	620	840
	Dry	T	0.25	670	840
	Dry	T	0.26	720	840
	Dry	T	0.3	750	840
	Dry	T	0.28	770	840
	Dry	T	0.29	820	840
	Dry	T	0.3	870	840
— block, medium-weight, 150 mm		D	0.77	1900	840
— block, medium-weight, 300 mm		D	0.83	1940	840
	Dry	T	0.31	920	840
	Dry	T	0.32	970	840
	Dry	T	0.35	1050	840
	Dry	T	0.4	1150	840
— block, hollow, heavyweight, 300 mm		D	1.35	1220	840
— block, hollow, lightweight, 150 mm		D	0.48	880	840
— block, hollow, lightweight, 300 mm		D	0.76	780	840
— block, hollow, medium-weight, 150 mm		D	0.62	1040	840
— block, hollow, medium-weight, 300 mm		D	0.86	930	840
— block, partially filled, heavyweight, 300 mm		D	1.35	1570	840
— block, partially filled, lightweight, 150 mm		D	0.55	1170	840
— block, partially filled, lightweight, 300 mm		D	0.74	1120	840
— block, partially filled, medium-weight, 150 mm		D	0.64	1330	840
— block, partially filled, medium-weight, 300 mm		D	0.85	1260	840
— block, perlite-filled, lightweight, 150 mm		D	0.17	910	840
— block, perlite-filled, medium-weight, 150 mm		D	0.2	1070	840
— block, with perlite, lightweight, 150 mm		D	0.33	1180	840
— block, with perlite, medium-weight, 150 mm		D	0.39	1340	840
— tiles		E	1.1	2100	840
Concrete, cast:					
— aerated		E	0.16	500	840
		S	0.29	850	840
		S	0.42	1200	840
— aerated, cellular		S	0.15	400	840
		S	0.23	700	840
		S	0.7	1000	840
		S	1.2	1300	840
— aerated, cement/lime based		S	0.21	580	840
— cellular		T	0.16	480	840
	At 50 °C	I	0.19	700	1050
— cellular bonded		T	0.3	520	2040
— dense		S	1.7	2200	840
— compacted,		S	2.2	2400	840
— dense, reinforced		S	1.9	2300	840
— compacted		S	2.3	2500	840
— expanded clay filling		S	0.26	780	840
		S	0.6	1400	840
— foamed	At 50 °C	I	0.07	320	920
	At 50 °C	I	0.08	400	920
	At 50 °C	I	0.15	700	920
— foam slag		E	0.25	1040	960
— glass reinforced		E	0.9	1950	840
— heavyweight	Dry	T	1.3	2000	840
	Moist	T	1.7	2000	840

Table continues

Table 3.37 Thermal conductivity, density and specific heat capacity: inorganic, porous materials — *continued*

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Concrete, cast (continued):					
— lightweight	Dry	T	0.2	620	840
	Dry	T	0.25	750	840
	Dry	T	0.21	670	840
	Dry	T	0.22	720	840
	Dry	T	0.23	770	840
	Dry	T	0.24	820	840
	Dry	T	0.25	870	840
	Moist	T	0.43	750	840
	Moist	T	0.38	770	840
	Moist	T	0.4	820	840
	Moist	T	0.43	870	840
		S	0.08	200	840
		S	0.12	300	840
		S	0.17	500	840
		S	0.23	700	840
— medium-weight	Dry	T	0.32	1050	840
	Dry	T	0.37	1150	840
	Dry	T	0.59	1350	840
	Dry	T	0.84	1650	840
	Dry	T	0.37	1050	840
	Dry	T	0.27	920	840
	Dry	T	0.29	980	840
	Moist	T	0.59	1050	840
		S	0.5	1000	840
		S	0.8	1300	840
		S	1.2	1600	840
		S	1.4	1900	840
— medium-weight, with lime	At 50 °C	I	0.73	1650	880
— no fines		E	0.96	1800	840
— residuals of iron works		S	0.35	1000	840
		S	0.45	1300	840
		S	0.7	1600	840
		S	1	1900	840
— roofing slab, aerated		C	0.16	500	840
— vermiculite aggregate		E	0.17	450	840
— very lightweight		T	0.14	370	840
		T	0.15	420	840
		T	0.16	470	840
		T	0.17	520	840
		T	0.18	570	840
		T	0.12	350	840
		T	0.18	600	840
Masonry:					
— block, lightweight		T	0.19	470	840
		T	0.2	520	840
		T	0.22	570	840
		T	0.22	600	840
— block, medium-weight	Dry	T	0.6	1350	840
	Dry	T	0.85	1650	840
	Dry	T	1.3	1800	840
— heavyweight	Dry	T	0.9	1850	840
	Dry	T	0.73	1850	840
	Dry	T	0.79	1950	840
	Dry	T	0.9	2050	840
	Moist	T	0.81	1650	840
— lightweight	Dry	T	0.22	750	840
	Dry	T	0.27	850	840
	Dry	T	0.24	850	840
	Dry	T	0.27	950	840
— medium-weight	Dry	T	0.32	1050	840
	Dry	T	0.54	1300	840
	Dry	T	0.37	1150	840
	Dry	T	0.42	1250	840
— medium-weight	Dry	T	0.45	1350	840
	Dry	T	0.49	1450	840
	Dry	T	0.54	1550	840
— quarry stones, calcareous	Dry	T	1.4	2200	840

Table continues

Table 3.37 Thermal conductivity, density and specific heat capacity: inorganic, porous materials — *continued*

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Miscellaneous materials:					
— aggregate	Undried	D	1.8	2240	840
— aggregate (sand, gravel or stone)	Oven dried	A	1.3	2240	920
— building board, tile and lay-in panel		A	0.058	290	590
— calcium silicate brick		S	1.5	2000	840
— granolithic		E	0.87	2085	840
— mud phuska	At 50 °C	I	0.52	1620	880
— tile bedding		E	1.4	2100	650
— tile hanging		C	0.84	1900	800
Roofing materials:					
— built-up roofing		D	0.16	1120	1470
— roof tile		C	0.84	1900	800
— tile, terracotta		T	0.81	1700	840
Soil:					
— alluvial clay, 40% sands		I	1.21	1960	840
— black cotton clay, Indore		I	0.61	1680	880
— black cotton clay, Madras		I	0.74	1900	880
— diatomaceous Kieselguhr or infusorial earth	Moisture content 9%	E	0.09	480	180
— earth, common		E	1.28	1460	880
— earth, gravel-based		E	0.52	2050	180
Stone:					
— basalt		T	3.49	2880	840
— gneiss		T	3.49	2880	840
— granite		T	3.49	2880	840
— granite, red		E	2.9	2650	900
— hard stone (unspecified)		T	3.49	2880	840
		S	2.9	2750	840
— limestone		E	1.5	2180	720
		S	2.9	2750	840
	At 50 °C	I	1.8	2420	840
— marble		S	2.9	2750	840
	Dry	T	2.91	2750	840
	Moist	T	3.49	2750	840
— marble, white		E	2	2500	880
— petit granit (blue stone)	Dry	T	2.91	2700	840
	Moist	T	3.49	2700	840
— porphyry		T	3.49	2880	840
— sandstone		E	1.83	2200	710
		T	3	2150	840
		T	1.3	2150	840
		S	5	2150	840
— sandstone tiles	Dry	T	1.2	2000	840
— slate		D	1.44	1600	1470
	At 50 °C	I	1.72	2750	840
— slate shale		T	2.1	2700	840
— white calcareous stone	Firm, moist	T	2.09	2350	840
	Firm, dry	T	1.74	2350	840
	Hard, moist	T	2.68	2550	840
	Hard, dry	T	2.21	2550	840
— tufa, soft	Dry	T	0.35	1300	840
	Moist	T	0.5	1300	1260

Table 3.38 Thermal conductivity, density and specific heat capacity: organic, hygroscopic materials

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m³)	Specific heat capacity (J/kg·K)
Cardboard/paper:					
— bitumen impregnated paper		E	0.06	1090	1000
— laminated paper		A	0.072	480	1380
Cloth/carpet/felt:					
— bitumen/felt layers		C	0.5	1700	1000
— carpet, simulated wool		E	0.06	200	1360
— carpet, Wilton		E	0.06	190	1360
— felt, semi-rigid, organic bonded	At 37.7 °C	A	0.035	48	710
	At 37.7 °C	A	0.039	88	710
— jute felt	At 50 °C	I	0.042	290	880
— jute fibre	At 50 °C	I	0.067	330	1090
— wool felt underlay		E	0.04	160	1360
Cork:		E	0.04	110	1800
— board		E	0.04	160	1890
— expanded		S	0.044	150	1760
— expanded, impregnated		S	0.043	150	1760
— slab		I	0.043	160	960
		I	0.055	300	960
— tiles	Conditioned	E	0.08	530	1800
Grass/straw materials:					
— straw board	At 50 °C	I	0.057	310	1300
— straw fibreboard or slab		S	0.1	300	2100
— straw thatch		E	0.07	240	180
Miscellaneous materials:					
— afzelia, minunga, meranti		T	0.29	850	2070
— ebonite, expanded		S	0.035	100	1470
— perlite board, expanded, organic-bonded	A	0.052	16	1260	
— glass fibre board, organic-bonded		A	0.036	100	960
— weatherboard		E	0.14	650	2000
Organic materials and their derivatives:					
— coconut pith insulation					
— board	At 50 °C	I	0.06	520	1090
— coir board	At 50 °C	I	0.038	97	1000
— flax shive, cement-bonded board		S	0.1	520	1470
— flax shive, resin-bonded board		S	0.12	500	1880
— rice husk	At 50 °C	I	0.051	120	1000
— vegetable fibre sheathing		A	0.055	290	1300
Woods:					
— fir, pine		A	0.12	510	1380
— hardwood (unspecified)		T	0.05	90	2810
	Dry	T	0.17	700	1880
		S	0.23	800	1880
— maple, oak and similar hardwoods		A	0.16	720	1260
— oak, radial		E	0.19	700	2390
— oak, beech, ash, walnut meranti	Moist	T	0.23	650	3050
	Dry	T	0.17	650	2120
— pine, pitch pine	Dry	T	0.17	650	2120
	Moist	T	0.23	650	3050
— red fir, Oregon fir	Dry	T	0.14	520	2280
	Moist	T	0.17	520	3440
— resinous woods (spruce, sylvester pine)	Dry	T	0.12	530	1880
— softwood		D	0.12	510	1380
		E	0.13	630	2760
		S	0.14	550	1880
— timber	At 50 °C	I	0.072	480	1680
	At 50 °C	I	0.14	720	1680
— timber flooring		C	0.14	650	1200
— willow, North Canadian gaboon		T	0.12	420	2400
— willow, birch, soft beech		T	0.14	520	2280
	Moist	T	0.17	520	3440
Wood derivatives:					
— cellulosic insulation, loose fill		A	0.042	43	1380
— chipboard	At 50 °C	I	0.067	430	1260
— chipboard, bonded with PF	Dry	T	0.12	650	2340
	Moist	T	0.25	650	5020

Table continues

Table 3.38 Thermal conductivity, density and specific heat capacity: organic, hygroscopic materials — *continued*

Material	Condition/test (where known)	Source	Thermal conductivity (W/m·K)	Density (kg/m^3)	Specific heat capacity (J/kg·K)
Wood derivatives (continued):					
— chipboard, bonded with UF	Dry	T	0.12	630	2260
	Moist	T	0.25	630	5020
— chipboard, bonded with melamine	Dry	T	0.12	630	2260
	Moist	T	0.25	630	5020
— chipboard, perforated	At 50 °C	I	0.066	350	1260
— flooring blocks		C	0.14	650	1200
— hardboard		E	0.08	600	2000
		A	0.12	880	1340
		S	0.29	1000	1680
— multiplex, beech	Dry	T	0.15	650	2300
— multiplex, North Canadian gaboon	Dry	T	0.12	450	2300
— multiplex, red fir	Dry	T	0.13	550	2300
	Moist	T	0.21	550	2300
— particle board		I	0.098	750	1300
		A	0.17	1000	1300
		A	0.12	800	1300
— plywood		A	0.12	540	1210
		E	0.15	700	1420
— sawdust	At 50 °C	I	0.051	190	1000
— softboard	At 50 °C	I	0.047	250	1300
— wallboard	At 50 °C	I	0.047	260	1260
— wood chip board, cement-bonded		S	0.15	530	1470
— wood fibres, compressed		Y	0.055	320	100
— wood (soft) fibre, loose fill		A	0.043	45	1380
— wood particle panels		T	0.09	300	1880
		T	0.12	500	1880
		T	0.14	700	1880
	Hard	T	0.29	1000	1990
	Soft	T	0.08	250	2520
— wood shingle		D	0.12	510	1260
— woodwool board, cement-bonded	At 50 °C	I	0.081	400	1130
	At 50 °C	I	0.11	670	1130
— woodwool roofing slabs		C	0.1	500	1000
— woodwool, xylolite cement slabs		S	0.11	450	1470
— woodwool		E	0.1	500	1000

Table 3.39 Absorptivity and emissivity: impermeable materials

Material	Condition (where known)	Absorptivity	Emissivity
Aluminium	Polished	0.10–0.40	0.03–0.06
	Dull/rough polish	0.40–0.65	0.18–0.30
	Anodised	—	0.72
Aluminium surfaced roofing		—	0.216
Asphalt	Newly-laid	0.91–0.93	—
	Weathered	0.82–0.89	—
	Block	0.85–0.98	0.90–0.98
Asphalt pavement		0.852–0.928	—
Bitumen/felt roofing		0.86–0.89	0.91
Bitumen pavement		0.86–0.89	0.90–0.98
Brass	Polished	0.30–0.50	0.03–0.05
	Dull	0.40–0.065	0.20–0.30
	Anodised	—	0.59–0.61
Bronze		0.34	—
Copper	Polished	0.18–0.50	0.02–0.05
	Dull	0.40–0.065	0.20–0.30
	Anodised	0.64	0.6
Glass	Normal	*	0.88
	Hemispherical	*	0.84
Iron	Unoxidised	—	0.05
	Bright/polished	0.40–0.65	0.20–0.377
	Oxidised	—	0.736–0.74
	Red rusted	—	0.61–0.65
	Heavily rusted	0.737	0.85–0.94
Iron, cast	Unoxidised/polished	—	0.21–0.24
	Oxidised	—	0.64–0.78
	Strongly oxidised	—	0.95
Iron, galvanised	New	0.64–0.66	0.22–0.28
	Old/very dirty	0.89–0.92	0.89
Lead	Unoxidised	—	0.05–0.075
	Old/oxidised	0.77–0.79	0.28–0.281
Rubber	Hard/glossy	—	0.945
	Grey/rough	—	0.859
Steel	Unoxidised/polished/ stainless	0.2	0.074–0.097
	Oxidised	0.2	0.79–0.82
Tin	Highly polished/ unoxidised	0.10–0.40	0.043–0.084
Paint:			
— aluminium		0.30–0.55	0.27–0.67
— zinc		0.3	0.95
Polyvinylchloride (PVC)		—	0.90–0.92
Tile	Light colour	0.3–0.5	0.85–0.95
Varnish		—	0.80–0.98
Zinc	Polished	0.55	0.045–0.053
	Oxidised	0.05	0.11–0.25*

* See manufacturer's data

Table 3.40 Absorptivity and emissivity: inorganic, porous materials

Material	Condition (where known)	Absorptivity	Emissivity
Asbestos:			
— board		—	0.96
— paper		—	0.93–0.94
— cloth		—	0.9
— cement	New	0.61	0.95–0.96
	Very dirty	0.83	0.95–0.96
Brick	Glazed/light	0.25–0.36	0.85–0.95
	Light	0.36–0.62	0.85–0.95
	Dark	0.63–0.89	0.85–0.95
Cement mortar, screed		0.73	0.93
Clay tiles	Red, brown	0.60–0.69	0.85–0.95
	Purple/dark	0.81–0.82	0.85–0.95
Concrete:		0.65–0.80	0.85–0.95
— tile		0.65–0.80	0.85–0.95
— block		0.56–0.69	0.94
Plaster		0.30–0.50	0.91
Stone:			
— granite (red)		0.55	0.90–0.93
— limestone		0.33–0.53	0.90–0.93
— marble		0.44–0.592	0.90–0.93
— quartz		—	0.9
— sandstone		0.54–0.76	0.90–0.93
— slate		0.79–0.93	0.85–0.98

Table 3.41 Absorptivity and emissivity: hygroscopic materials

Material	Condition (where known)	Absorptivity	Emissivity
Paper:		—	0.091–0.94
— white, bond		0.25–0.28	—
Cloth:			
— cotton, black		0.67–0.98	—
— cotton, deep blue		0.82–0.83	—
— cotton, red		0.562	—
— wool, black		0.75–0.88	—
— felt, black		0.775–0.861	—
— fabric (unspecified)		—	0.89–0.92
Wood:			
— beach		—	0.94
— oak		—	0.89–0.90
— spruce		—	0.82
— walnut		—	0.83

Table 3.42 Vapour resistivity: impermeable materials

Material	Density	Vapour resistivity (MN·s/g·m)
Asphalt (laid)	—	∞
Bitumen roofing sheets	—	2000–60 000
Bituminous felt	—	15 000
Glass:		
— brick	—	∞
— cellular	—	∞
— expanded/foamed	—	∞
— sheet/mirror/window	—	∞
Linoleum	1200	9000
Metals and metal cladding	—	∞
Paint, gloss (vapour resistant)	—	40–200
Plastic, hard	—	45 000
Polyvinylchloride (PVC) sheets on tile	—	800–1300
Rubber	1200–1500	4500
Rubber tiles	1200–1500	∞
Tiles:		
— ceramic	—	500–5000
— glazed ceramic	—	∞

Table 3.43 Vapour resistivity: non-hygroscopic materials

Material	Density	Vapour resistivity (MN·s/g·m)
Mineral fibre/wool:		
— glass fibre/wool	—	5–7
— mineral fibre/wool	—	5–9
— rock wool	—	6.5–7.5
Phenol formaldehyde	—	19–20
Phenolic (closed cell)	—	150–750
Polyethylene foam	—	20 000
Polystyrene:		
— expanded	—	100–750
— extruded	—	600–1500
— extruded without skin	—	350–400
Polyurethylene foam	—	115–1000
Polyvinylchloride (PVC) foam, rigid	—	40–1300
Urea formaldehyde foam	—	5–20

Table 3.44 Vapour resistivity: inorganic, porous materials

Material	Density	Vapour resistivity (MN·s/g·m)
Asbestos cement	800	70
Asbestos cement sheet, substitutes	1600–1900	185–1000
Brick:		
— blast furnace slag	1000–2000	350–500
— calcium silicate	<1400	25–50
	>1400	75–125
— dense	>2000	100–250
— heavyweight	>1700	45–70
— lightweight	<1000	25–50
— medium-weight	>1300	23–45
— sand lime	<1400	25–50
	>1500	75–200
Concrete:		
— blocks (lightweight)	—	15–150
— cast	<1000	14–33
	>1000	30–80
	>1900	115–1000
— cellular	450–1300	9–50
— close textured	—	350–750
— expanded clay	500–1000	25–33
	1000–1800	33–75
— foamed steam hardened	400–800	25–50
— insulating	—	23–26
— natural pumice	500–1400	25–75
— no fines	1800	20
— polystyrene, foamed	400	80–100
— porous aggregate	1000–2000	15–50
— porous aggregate (without quartz sand)	—	25–75
— slag and Rhine sand	1500–1700	50–200
— Gypsum plasterboard	—	30–60
Plaster/mortar:		
— cement based	1900–2000	75–205
— lime based	1600–1800	45–205
— gypsum	—	30–60
Stone:		
— basalt	—	∞
— bluestone	—	∞
— clay	—	75
— granite	—	150–∞
— limestone, firm	—	350–450
— limestone, soft	—	130–160
— limestone, soft tufa	—	25–50
— marble	—	150–∞
— porphyry	—	∞
— sandstone	—	75–450
— slate	—	150–450
— slatey shale	—	>3000
Tile:		
— clay, ceramic	—	750–1500
— floor tiles, ceramic	—	115
— roof tiles, terracotta	—	180–220

Table 3.45 Vapour resistivity: organic, hygroscopic materials

Material	Density	Vapour resistivity (MN·s/g·m)
Carpet:		
— normal backing	—	7–20
— foam backed/underlay	—	100–300
Chipboard:	—	230–500
— bonded with melanine	—	300–500
— bonded with PF	—	250–750
— bonded with UF	—	200–700
— cement-bonded	—	19–50
Cork:		
— insulation	—	25–50
— expanded	—	23–50
— expanded, impregnated	—	45–230
— expanded, bitumous binding	—	45–230
Corkboard	—	50–200
Fibreboard:	—	150–375
— bitumen-coated	—	25
— cement-based	—	19–50
— hardwood fibres	—	350
— porous wood fibres	—	25
Hardboard	—	230–1000
Mineral/vegetable fibre insulation	—	5
Multiplex:	800	200–2000
— light pine	—	80
— North Canadian gaboon	—	80
— red pine	—	875–250
— triplex	700	200–500
Paper	—	500
Particle board, softwood	—	25
Plywood:	—	150–2000
— decking	—	1000–6000
— marine	—	230–375
— sheathing	—	144–1000
Strawboard	—	45–70
Wood:		
— ash	—	200–1850
— balsa	—	45–265
— beech	—	200–1850
— beech, soft	—	90–700
— birch	—	90–700
— fir	—	45–1850
— North Canadian gaboon	—	45–1850
— oak	—	200–1850
— pine	—	45–1850
— pine, Northern red/Oregon	—	90–200
— pine, pitch	—	200–1850
— spruce	—	45–1850
— teak	—	185–1850
— walnut	—	200–1850
— willow	—	45–1850
Wood lath	—	4
Woodwool:		
— slab	—	15–40
— cement slab	—	15–50
— magnesia slab	—	19–50

Appendix 3.A8: Thermal properties of typical constructions

Tables 3.48 to 3.54 provide values of thermal transmittance, thermal admittance, decrement factor, surface factor and heat capacity for a range of constructions. The tables are provided to illustrate the thermal properties of typical constructions. For design purposes, values should be calculated for the specific construction under consideration using the methods given in this Guide. The tabulated values have been calculated making certain assumptions about the densities, thermal conductivities and specific heat capacities of the materials involved, as set out in Tables 3.46 and 3.47.

Thermal transmittances in Tables 3.48 to 3.54 have been calculated:

— by the combined method described in 3.3.11, taking account of repeating thermal bridges such as mortar joints, timber framing and wall ties

— using surface resistances appropriate to the heat flow direction for the element concerned (upwards for roofs, horizontal for walls, downwards for floors).

The values of thermal admittance, decrement factor, surface factor and heat capacity in the tables:

— do not take account of thermal bridging, and so refer strictly to plain unbridged areas of the structures (see also 3.9.3)

— were calculated for average surface resistances (taken as equal to those for horizontal heat flow).

These parameters depend on heat flow direction and so, for roofs and floors, should strictly be different depending on whether heat is entering or leaving the building element (i.e. varying over the period of the cyclic temperature variation). The values shown should therefore be regarded as indicative.

Representative values for thermal conductivity (λ) were used for the calculations. Manufacturers' products may exhibit better thermal properties than those given for the generic types of material listed in Table 3.46. Where such products are likely to be used, *U*-values may be calculated using thermal conductivity data obtained from tests provided that the data and test methods have been properly accredited, see Appendix 3.A2.

Calculated *U*-values may underestimate the actual thermal transmittance due to ventilation within the construction. The effectiveness of thermal insulation depends largely on preventing air movement within the insulating layer. Air flow through gaps and cracks must be avoided, particularly on the warm side of the insulation. Air flow must also be avoided between insulation boards or batts and behind wall linings. Such deficiencies in installation have been shown to add between 0.05 and 0.2 $W/m^2 \cdot K$ to the nominal *U*-value of the construction.

The use of unrealistic values for the thermal conductivities of building materials also contributes to the underestimation of *U*-values. Tabulated values are usually based on laboratory measurements using small well-prepared samples. In buildings, the thermal conductivities of the same materials may differ appreciably from the laboratory measurements due to variations in quality during production, storage conditions on site and variations in construction techniques.

Table 3.46 Properties of materials used in calculation of thermal properties of typical constructions

Material	Density (kg/m^3)	Thermal conductivity (W/m·K)	Specific heat capacity (J/kg·K)
Masonry materials:			
— sandstone	2300	1.8	1000
— brick (exposed)	1750	0.77	1000
— brick (protected)	1750	0.56	1000
— no–fines concrete	2000	1.33	1000
— concrete block (dense) (exposed)	2300	1.87	1000
— concrete block (dense) (protected)	2300	1.75	1000
— precast concrete (dense) (exposed)	2100	1.56	1000
— precast concrete (dense) (protected)	2100	1.46	1000
— cast concrete	2000	1.33	1000
— cast concrete	1800	1.13	1000
— lightweight aggregate concrete			
— block	600	0.2	1000
— autoclaved aerated			
— concrete block	700	0.2	1000
— autoclaved aerated concrete block	500	0.15	1000
— screed	1200	0.46	1000
— ballast (chips or paving slab)	1800	1.1	1000
Surface materials/finishes:			
— external render (lime, sand)	1600	0.8	1000
— external render (cement, sand)	1800	1	1000
— plaster (dense)	1300	0.57	1000
— plaster (lightweight)	600	0.18	1000
— plasterboard (standard)	700	0.21	1000
— plasterboard (fire-resisting)	900	0.25	1000
Insulation materials:			
— mineral wool (quilt)	12	0.042	1030
— mineral wool (batts)	25	0.038	1030
— expanded polystyrene (EPS)	15	0.04	1450
— extruded polystyrene	40	0.035	1400
— polyurethane foam	30	0.025	1400
— urea formaldehyde (UF) foam	10	0.04	1400
— blown fibre	12	0.04	1030
Miscellaneous materials:			
— plywood sheathing	500	0.13	1600
— timber studding	500	0.13	1600
— timber battens	500	0.13	1600
— timber decking	500	0.13	1600
— timber flooring	500	0.13	1600
— timber flooring (hardwood)	700	0.18	1600
— chipboard	600	0.14	1700
— vinyl floor covering	1390	0.17	900
— waterproof roof covering	110	0.23	1000
— wood blocks	600	0.14	1700
— floor joists	500	0.13	1600
— cement-bonded particleboard	1200	0.23	1500
— carpet/underlay	200	0.6	1300
— steel	7800	50	450
— stainless steel	7900	17	460
— soil	1500	1.5	1800

Table 3.47 Values of surface and airspace resistance use in calculation of thermal properties of typical constructions

Structure	External surface resistance (m^2·K/W)	Internal surface resistance (m^2·K/W)	Airspace resistance (m^2·K/W)
External walls	0.04	0.13	0.18
Party walls and internal partitions	0.13	0.13	0.18
Roofs:			
— pitched	0.04	0.1	0.16
— flat	0.04	0.1	0.16
Ground floors	0.04	0.17	0.21
Internal floors/ceilings	0.13	0.13	0.18

Table 3.48 Thermal properties of typical wall constructions

Construction	Transmittance U (W/m²·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m²·K)
		Y (W/m²·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
1 Stone walls								
(*a*) 600 mm stone, 50 mm airspace, 25 mm dense plaster on laths	1.38	3	1.4	0.04	17.3	0.65	0.8	41
(*b*) 600 mm stone, 50 mm airspace/ timber battens, 25 mm EPS insulation, 12.5 mm plasterboard	0.72	1.13	1.8	0.03	17	0.87	0.3	15
2 No-fines concrete walls								
(*a*) 19 mm render, 220 mm no-fines concrete, 50 mm airspace/timber battens, 12.5 mm plasterboard	1.63	2.46	0.8	0.31	7.7	0.69	0.4	39
(*b*) 19 mm render, 220 mm no-fines concrete, 50 mm mineral fibre insulation between battens, 12.5 mm plasterboard	0.67	0.89	2.6	0.24	8.3	0.91	0.3	14
(*c*) 19 mm render, 50 mm mineral wool insulation between battens, 220 mm no-fines concrete, 50 mm airspace/battens, 12.5 mm plasterboard	0.52	2.47	0.8	0.09	9.4	0.69	0.4	34
3 Solid brick walls								
(*a*) 220 mm solid brick, 13 mm dense plaster	2.09	4.49	1.3	0.42	7.4	0.49	1.6	70
(*b*) 220 mm solid brick, 50 mm airspace/battens, 12.5 mm plasterboard	1.41	2.36	1	0.33	8	0.71	0.4	37
(*c*) 220 mm solid brick, 50 mm mineral wool insulation between battens, 12.5 mm plasterboard	0.63	0.89	2.6	0.25	8.7	0.91	0.3	14
(*d*) 19 mm render, 50 mm EPS insulation, 220 mm solid brick, 13 mm dense plaster	0.54	4.23	1.4	0.12	11.1	0.52	1.5	59
4 Dense concrete walls								
(*a*) 19 mm render, 200 mm dense concrete block, 13 mm dense plaster	3.02	5.19	0.9	0.42	6.5	0.38	1.6	79
(*b*) 19 mm render, 200 mm dense concrete block, 50 mm airspace/ battens, 12.5 mm plasterboard	1.78	2.51	0.8	0.34	7	0.68	0.4	39
(*c*) 19 mm render, 200 mm dense concrete block, 25 mm polyurethane insulation between battens, 12.5 mm plasterboard	0.9	1.01	2.1	0.26	7.5	0.89	0.3	16
(*d*) 19 mm render, 50 mm mineral wool between battens, 200 mm dense concrete block, 13 mm dense plaster	0.7	5.32	0.8	0.16	8.2	0.35	1.6	74
5 Precast concrete panel walls								
(*a*) 80 mm dense concrete, 25 mm EPS insulation, 100 mm dense concrete, 13 mm dense plaster	1.07	5.36	1.3	0.34	7.7	0.42	2.3	77
(*b*) 80 mm dense concrete, 25 mm EPS insulation, 100 mm dense concrete, 50 mm airspace/battens, 12.5 mm plasterboard	0.85	2.59	1	0.21	8.4	0.68	0.5	38
(*c*) 80 mm dense concrete, 50 mm EPS insulation, 100 mm dense concrete, 12.5 mm plasterboard	0.56	2.61	1	0.17	8.8	0.68	0.5	37

Table continues

Table 3.48 Thermal properties of typical wall constructions — *continued*

Construction	Transmittance U (W/m²·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m²·K)
		Y (W/m²·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
5 Precast concrete panel walls (continued)								
(*c*) 19 mm render, 80 mm dense concrete, 50 mm EPS insulation, 100 mm dense concrete, 13 mm dense plaster	0.63	5.42	1.4	0.26	9	0.42	2.4	77
6 Brick/brick cavity walls								
(*a*) 105 mm brick, 50 mm airspace, 105 mm brick, 13 mm dense plaster	1.44	4.38	1.5	0.35	8.8	0.53	1.7	67
(*b*) 105 mm brick, 50 mm airspace, 105 mm brick, 13 mm lightweight plaster	1.34	3.55	1.3	0.33	8.9	0.59	1	54
(*c*) 105 mm brick, 50 mm UF foam insulation, 105 mm brick, 13 mm dense plaster	0.59	4.57	1.5	0.25	10.1	0.51	1.8	65
(*d*) 105 mm brick, 50 mm blown wool insulation, 105 mm brick, 13 mm dense plaster	0.59	4.51	1.5	0.24	10.1	0.51	1.7	64
(*e*) 105 mm brick, 50 mm cavity, 25 mm EPS insulation, 105 mm brick, 22 mm airspace/battens, 12.5 mm plasterboard	0.67	2.39	1.2	0.17	10.6	0.71	0.5	34
7 Brick/dense concrete block cavity walls								
(*a*) 105 mm brick, 50 mm airspace, 100 mm dense concrete block, 13 mm dense plaster	1.77	5.37	1.2	0.34	8.1	0.4	2.2	80
(*b*) 105 mm brick, 50 mm UF foam insulation, 100 mm dense concrete block, 13 mm dense plaster	0.63	5.57	1.3	0.24	9.3	0.39	2.4	78
(*c*) 105 mm brick, 50 mm blown fibre insulation, 100 mm dense concrete block, 13 mm dense plaster	0.63	5.57	1.3	0.24	9.3	0.39	2.4	78
(*d*) 105 mm brick, 50 mm EPS insulation, 100 mm dense concrete block, 13 mm dense plaster	0.64	5.57	1.3	0.24	9.4	0.39	2.4	78
8 Brick/lightweight aggregate concrete block cavity walls								
(*a*) 105 mm brick, 50 mm airspace, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	1.06	2.72	2.6	0.53	7.4	0.76	1.1	44
(*b*) 105 mm brick, 50 mm UF foam insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	0.52	2.98	2.8	0.42	8.7	0.75	1.3	44
(*c*) 105 mm brick, 50 mm blown fibre insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	0.52	2.97	2.7	0.41	9.2	0.75	1.3	44
(*d*) 105 mm brick, 100 mm blown fibre insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	0.33	3.05	2.8	0.39	9.2	0.75	1.4	44
(*e*) 105 mm brick, 50 mm EPS insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	0.52	2.98	2.8	0.42	8.8	0.75	1.3	44

Table continues

Table 3.48 Thermal properties of typical wall constructions — *continued*

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
8 Brick/lightweight aggregate concrete block cavity walls (continued)								
(*f*) 105 mm brick, 25 mm airspace, 25 mm EPS insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster	0.66	2.92	2.8	0.46	8.3	0.76	1.3	44
9 Brick/autoclaved aerated concrete block cavity walls								
(*a*) 105 mm brick, 50 mm airspace, 100 mm autoclaved aerated concrete block (density 700 kg/m^3), 13 mm lightweight plaster	1.01	2.29	2.2	0.49	7.8	0.77	0.8	37
(*b*) 105 mm brick, 50 mm airspace, 150 mm autoclaved aerated concrete block (density 500 kg/m^3), 13 mm lightweight plaster	0.79	2.07	2.4	0.42	9	0.8	0.8	33
(*c*) 105 mm brick, 25 mm airspace, 25 mm EPS insulation, 150 mm autoclaved aerated concrete block (density 500 kg/m^3), 13 mm lightweight plaster	0.55	2.14	2.4	0.33	10.2	0.79	0.8	32
10 Timber frame walls								
(*a*) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 95 mm studding, 12.5 mm plasterboard	1.14	1.58	1.7	0.67	4.9	0.82	0.4	26
(*b*) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 95 mm studding, 95 mm mineral wool insulation between studs, 12.5 mm plasterboard	0.39	0.75	3.9	0.58	6	0.95	0.3	13
(*c*) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 140 mm studding, 140 mm mineral wool insulation between studs, 12.5 mm plasterboard	0.29	0.74	4.3	0.57	6.5	0.96	0.3	12
11 Party walls (internal)								
(*a*) 75 mm airspace, 100 mm lightweight aggregate concrete block, 22 mm airspace/battens, 12.5 mm plasterboard	0.56	1.98	2.2	—	—	0.8	0.7	27
(*b*) 13 mm dense plaster, 215 mm brick, 13 mm dense plaster	1.45	4.61	1.5	—	—	0.5	1.8	63
(*c*) 13 mm dense plaster, 215 mm dense concrete block, 13 mm dense plaster	2.33	5.63	1.2	—	—	0.38	2.4	77

Table 3.49 Thermal properties of typical roof constructions

Construction	Transmittance U (W/m²·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m²·K)
		Y (W/m²·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
1 Flat concrete roofs								
(*a*) Waterproof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	2.19	5.06	1	0.34	7.4	0.41	1.7	76
(*b*) Waterproof roof covering, 35 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	0.54	5.08	1	0.17	9	0.4	1.6	71
(*c*) Waterproof roof covering, 100 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	0.25	5.07	1	0.15	9.9	0.4	1.6	70
(*d*) Waterproof roof covering, 200 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	0.12	5.07	1	0.13	12.2	0.4	1.6	70
(*e*) Ballast (chips or paving slab), 50 mm extruded polystyrene insulation, waterproof roof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	0.59	5.07	1	0.16	10.5	0.4	1.6	71
(*f*) Ballast (chips or paving slab), 100 mm extruded polystyrene insulation, waterproof roof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster	0.39	5.07	1	0.14	11	0.4	1.6	70
2 Flat timber roofs								
(*a*) Waterproof roof covering, 19 mm timber decking, ventilated airspace, vapour control layer, 12.5 mm plasterboard	2.35	2.14	0.7	0.99	0.7	0.73	0.3	10
(*b*) Waterproof roof covering, 19 mm timber decking, ventilated airspace, 50 mm mineral fibre insulation, vapour control layer, 12.5 mm plasterboard	0.64	0.83	2.8	0.99	1	0.92	0.3	10
(*c*) Waterproof roof covering, 35 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard	0.53	1.39	3.4	0.93	1.9	0.9	0.6	19
(*d*) Waterproof roof covering, 100 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard	0.23	1.52	3.9	0.88	3	0.91	0.7	22
(*e*) Waterproof roof covering, 200 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard	0.13	1.58	4	0.75	5.3	0.91	0.7	23
3 Pitched roofs (insulated at ceiling level)								
(*a*) 12.5 mm plasterboard, no insulation, roof space, tiling	2.3	2.05	0.6	1	0.5	0.74	0.2	8
(*b*) 12.5 mm plasterboard, 25 mm mineral wool quilt between ceiling joists, roof space, tiling	1.1	1.11	1.6	1	0.4	0.87	0.3	8

Table continues

Table 3.49 Thermal properties of typical roof constructions — *continued*

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
3 Pitched roofs (insulated at ceiling level) (continued)								
(*c*) 12.5 mm plasterboard, 50 mm mineral wool quilt between ceiling joists, roof space, tiling	0.71	0.85	2.6	1	0.4	0.92	0.3	8
(*d*) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, roof space, tiling	0.42	0.72	3.7	1	0.6	0.95	0.3	9
(*e*) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 50 mm mineral wool quilt over joists, roof space, tiling	0.28	0.7	4.5	0.99	1	0.97	0.3	10
(*f*) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 100 mm mineral wool quilt over joists, roof space, tiling	0.21	0.68	4.5	0.99	1	0.97	0.3	10
(*g*) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 150 mm mineral wool quilt over joists, roof space, tiling	0.17	0.68	4.7	0.98	1.3	0.97	0.3	10
(*h*) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 200 mm mineral wool quilt over joists, roof space, tiling	0.14	0.72	4.8	0.97	1.7	0.98	0.3	10
4 Pitched roofs (insulated at rafter level)								
(*a*) 12.5 mm plasterboard, 25 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles	0.95	0.98	2.1	1	0.3	0.92	0.2	8
(*b*) 12.5 mm plasterboard, 50 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles	0.56	0.76	3.3	1	0.5	0.95	0.2	9
(*c*) 12.5 mm plasterboard, 100 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles	0.31	0.7	4.4	0.99	0.7	0.97	0.3	9
(*d*) 12.5 mm plasterboard, 150 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles	0.22	0.71	4.8	0.98	1.2	0.98	0.3	10
(*e*) 12.5 mm plasterboard, 150 mm PU insulation between rafters and 50 mm over rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles	0.15	0.73	4.9	0.96	4.9	0.98	0.3	11
5 Sheet metal construction								
(*a*) 0.4 mm inner sheet, 150 mm Z-spacer with mineral wool insulation, 0.7 mm outer sheet	0.35	0.28	1.2	0.99	0.7	0.97	0	2
(*b*) 0.4 mm inner sheet, 85 mm mineral wool insulation, 40 mm mineral wool insulation between rails, 0.7 mm profiles outer sheet	0.35	0.31	0.5	1	0.3	0.96	0	1

Table 3.50 Thermal properties of typical internal partitions

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
(*a*) 13 mm lightweight plaster, 105 mm brick, 13 mm lightweight plaster	1.69	3.76	2.2	0.52	5.4	0.65	1.6	52
(*b*) 13 mm lightweight plaster, 100 mm lightweight concrete block, 13 mm lightweight plaster	1.11	2.27	3.8	0.81	3.6	0.88	1.1	31
(*c*) 12.5 mm plasterboard, timber studding, 12.5 mm plasterboard	1.7	0.61	5.7	1	0.5	1	0.3	8

Table 3.51 Thermal properties of typical internal floors/ceilings

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
(*a*) 50 mm screed, 150 mm cast concrete, 13 mm dense plaster	2.25	5.44	1.4	0.34	7	0.43	2.5	75
(*b*) 25 mm wood block, 65 mm cast concrete, 50 mm airspace, 12.5 mm plasterboard ceiling	1.61	2.61	2.2	0.5	5	0.74	1	36
(*c*) 19 mm timber flooring or chipboard on 100 mm joists, 12.5 mm plasterboard ceiling	1.64	0.86	5.4	0.99	0.9	0.99	0.4	12

Table 3.52 Thermal properties of typical floors in contact with the ground

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
1 Solid concrete floors								
(*a*) Vinyl floor covering, 75 mm screed, 150 mm cast concrete	*	3.59	1.3	—	—	0.58	1	58
(*b*) 10 mm carpet/underlay, 75 mm screed, 150 mm cast concrete	*	2.35	0.9	—	—	0.71	0.4	38
(*c*) Vinyl floor covering, 75 mm screed, 50 mm extruded polystyrene insulation, 150 mm cast concrete	*	3.88	2.5	—	—	0.67	1.8	56
(*d*) Vinyl floor covering, 19 mm timber or chipboard, 50 mm extruded polystyrene insulation, 150 mm cast concrete	*	1.39	3.6	—	—	0.9	0.6	22
2 Suspended timber floors								
(*a*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, ventilated underfloor cavity	*	3.07	0.3	—	—	0.6	0.2	7
(*b*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre between joists, ventilated underfloor cavity	*	1.36	4.2	—	—	0.93	0.6	19
(*c*) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, ventilated under-floor cavity	*	2.09	0.3	—	—	0.73	0.1	5
(*d*) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre between joists, ventilated underfloor cavity	*	1.24	3.6	—	—	0.91	0.5	17

* Thermal transmittance of floors depends on the size and shape of the floor, see section 3.5.

Table 3.53 Thermal properties of typical floors exposed to outside air below

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
(*a*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete	2.26	3.77	1.1	0.55	5.7	0.55	1	59
(*b*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 50 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.63	3.91	1	0.16	8.2	0.53	1	55
(*c*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.38	3.91	1	0.15	8.5	0.53	1	54
(*d*) 10 mm carpet/underlay, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.36	2.46	0.7	0.1	8.9	0.69	0.3	34
(*e*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 12 mm cementitious building board on underside	1.59	1.97	1.1	0.99	1	0.76	0.4	14
(*f*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside	0.39	1.37	4.2	0.96	1.8	0.93	0.7	19
(*g*) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside	0.37	1.24	3.6	0.91	2.4	0.91	0.5	18

Table 3.54 Thermal properties of typical floors exposed to internal air below

Construction	Transmittance U (W/m^2·K)	Admittance		Decrement factor		Surface factor		Heat capacity, χ (kJ/m^2·K)
		Y (W/m^2·K)	ω (h)	f	ϕ (h)	F	ψ (h)	
(*a*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete	1.74	5.73	0.8	0.15	10.7	0.32	2	79
(*b*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 50 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.58	3.98	1.1	0.16	8.7	0.52	1.1	55
(*c*) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.36	3.95	1	0.15	9	0.52	1	54
(*d*) 10 mm carpet/underlay, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside	0.34	2.49	0.7	0.1	9.4	0.68	0.3	34
(*e*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 12 mm cementitious building board on underside	1.37	1.23	5.2	0.97	1.4	0.98	0.6	17
(*f*) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside	0.37	1.33	5.1	0.95	2.2	0.97	0.7	18
(*g*) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside	0.35	1.23	4.6	0.91	32.8	0.95	0.6	17