National Exams December 2017

07-Bld-A7, Building Envelope Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
   Casio or sharp calculator allowed
3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value.
5. For questions that require an answer in essay format, clarity and organization of the answer are important.
6. Equations, charts, and data required for calculations are provided in the appendix of this exam booklet.

Question 1 (20 marks)

1.1: (20 Marks) Decide for each statement whether it is true or false. Provide the answers directly on this question sheet.

No.	Statement	True	False
1	It is not possible to have vapor diffused through a wall in the direction opposite to air leakage.		
2	Wetting by condensation is promoted on cold indoor surfaces and on cold surfaces within the construction when moist air is in contact with surfaces at temperature above its dew point.		
3	The SHGC of window is not only influenced by the properties of glazing but also the configuration of the window frame.		
4	Moisture induced dimensional change is the greatest along the longitudinal direction in wood.		
5	In any climate condition, the vapor barrier is beneficial to prevent moisture-induced damage if placed on the interior or indoor side of the wall.		
6	The suction pressure on the roof perimeter is more severe when wind blows perpendicular to the face of the building than when wind blows towards the corner of the building.		
7	A low-sloped roof must have a minimum slope of 5%		
8	Asphalt impregnated building paper can be considered as an air barrier.		
9	The principal function of a vapour barrier is to stop or, more accurately, to retard the passage of moisture as it diffuses through the assembly of materials in a wall, so the vapor barrier must be continuous.		
10	Air barrier may be placed anywhere in the building envelope as long as it is structurally supported and does not need to be continuous.		
11	In cold climate, if the air barrier is positioned on the outside of the insulation, the air barrier material needs to be 10-20 times more permeable to water vapor diffusion than the vapor barrier material.		
12	The principal function of masonry mortar is to develop a complete, strong and durable bond with masonry units. Mortar must also create a water resistant seal.		
13	Differences in air density due to differences in temperature between indoors and outdoors give rise to stack effect, which promotes air leakage through a building enclosure and a generally downward movement of air within a building in cold weather.		

14	For safety reason it is good to use a mortar that has more compressive strength than required by the structural requirements of the project.		
15	The optimum glazing cavity thickness is ½” (12.5mm) for both Argon and Krypton gas filling in a double IGU.		
16	For hygroscopic materials, their vapour permeability changes with the change of ambient relative humidity. Typically the vapour permeability increases with the decrease of relative humidity.		
17	Lack of movement joints often results in cracks in brick veneer walls, especially at corners.		
18	A thermal insulation can also function as air barrier, water resistive barrier and vapour retarder.		
19	Blisters in built-up roof are more frequently *interfacial* than *interply*.		
20	When the water content level of brick is under its critical degree of saturation, S_{crit}, frost damage won’t occur regardless of the number of freeze/thaw cycles the brick is exposed to.		

Question 2 (20 marks):

A typical wood-frame brick veneer wall construction that is commonly used in Part 9 low-rise residential building is made up of the following components:

- 100mm exterior brick (RSI 0.13)
- 25mm air space (RSI 0.22)
- one layer of Tyvek water resistive membrane, 0.2mm
- 12.5 mm plywood sheathing (RSI 0.11)
- 140mm glass fiber insulation (RSI 3.67)
- 6 mil polyethylene as vapour and air barrier
- 12.5mm gypsum board (RSI 0.08)

To improve the energy efficiency of homes, the thermal resistance of walls, roofs, and below grades will need to be significantly improved.

1) Calculate the effective RSI value of the wall assembly given using the Parallel path method. The wood stud spacing is 16” at centre, and assume the thermal conductivity of the wood stud is 0.11W/m•K. The actual dimension of 2x6 wood stud is 38mm by 140mm. A frame factor of 25% can be assumed in the calculation.

2) Propose one wall configuration to achieve an effective thermal resistance of R40 (RSI 7.0) using the wall assembly given as the base case.

3) Comment on the moisture performance of your solution in comparison to the conventional 2x6 wood-frame wall given.

4) Sketch a typical floor/wall junction with the wall construction you have chosen. On your drawing, label and trace the air barrier, vapour barrier, water resistive barrier, and rain shedding surface.

In your calculation, you can assume a RSI 0.12 for the interior surface thermal resistance, a RSI 0.03 for the exterior surface thermal resistance, and a RSI 0.22 for the thermal resistance of rainscreen air cavity. Material properties are provided in the appendix.

Question 3 (20 marks)

Design a low-slope, exposed membrane roofing assembly for a warehouse building located in Toronto. The primary membrane is Modified Bitumen (SBS). This warehouse has a brick veneer steel stud wall assembly with concrete roof deck and concrete floor slab.

1) Sketch the roof/wall junction and label the main components for both the roof and the wall;
2) List the potential failures of a low-slope roof with Modified Bitumen membrane and elaborate on how to prevent these failures.

Question 4 (20 marks):

Part A (12 marks)

1) Sketch a horizontal joint, label each component and explain the function of each component;
2) Comment on the requirement of the relative dimensions (give dimensions or range where you can);
3) With the aid of sketches, explain what sealant failures it would result if the joint is too wide or too deep.
4) Explain the difference between single-stage joint and two-stage joint with the help of sketches, and state the advantages of two-stage joint over single-stage joint.

Part B (8 marks)

1) List four forces that can cause rain penetration through building envelopes and explain how to counter these forces in the design with the help of sketches.
2) Name three commonly used water resistive barrier (WRB) materials, three insulation materials, and three vapour retarder materials.
3) List the requirements for an air barrier system.

Question 5 (20 marks, 5 marks each):

1) In a four-story wood-frame multi-unit residential building built in Vancouver, a back-sloped flashing was noticed at the second floor where the brick veneer is in transition with fiber-cement cladding, as shown in photo 1. 1) Explain what could have caused this problem. 2) What should have been done to prevent this?

2) Explain the failure mechanism shown in photo 2 and how to reduce the risk of such failures.

3) Explain the failure mechanism shown in photo 3 and how to reduce the risk of such failures.

4) In photo 4, note that icicles are formed at the eaves of a sloped roof. Explain what has caused it and how to avoid such a problem.

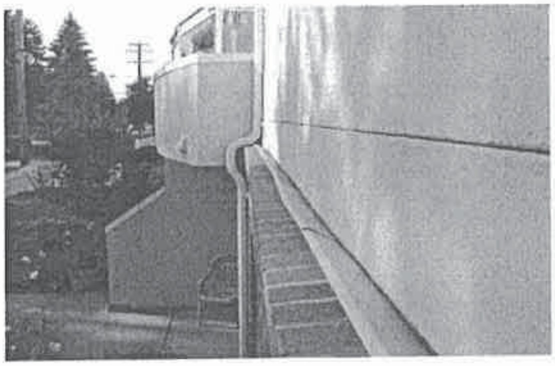


Photo 1

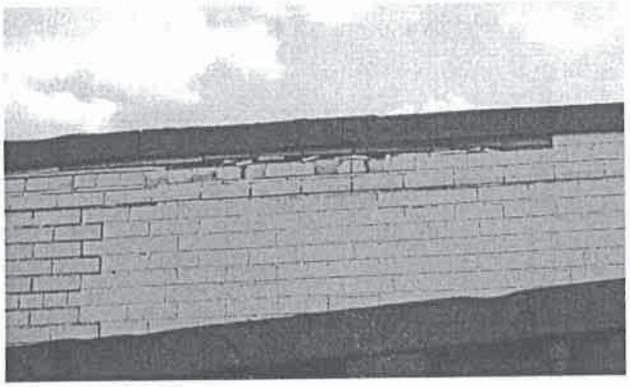


Photo 2

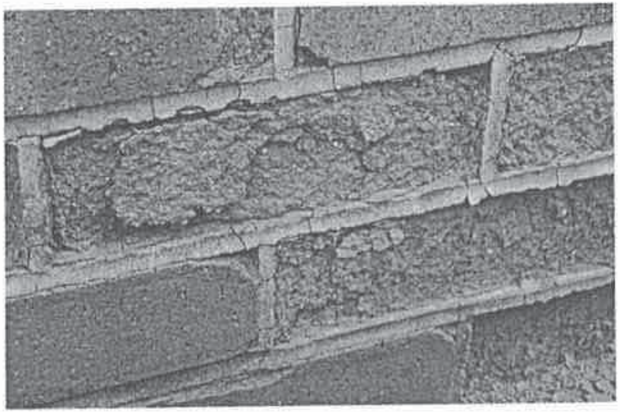


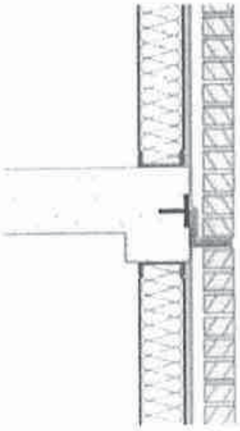
Photo 3

Photo 4

Question 6 (20 marks)

Part A (10 marks)

Identify thermal bridges in the cross section shown below and provide a new design to eliminate thermal bridges.



Part B (10 marks)

Review the case study “Crumbling concrete”. 1) Explain the failure mechanism of this case. 2) With the aid of sketches, explain how to properly design the precast concrete window sill that prevent such failures from occurring.

Crumbling Concrete

The panels were not waterproofed to reduce or stop further deterioration.

By David H. Nicastro

My firm recently removed large pieces of concrete from the precast concrete panels of a 20-story building (see photo). Although none fell out on their own, the pieces were loose and were removed using only plastic mallets. What is most interesting about this case is how rapidly the deterioration occurred.

The Second Time Around

The building was constructed in 1960. When the facade was evaluated about seven years ago, the findings indicated that the precast concrete units were beginning to suffer from environmental exposure. A few spalls were removed, and the cracks were routed and patched.

During a recent follow-up, we intended to use the mallets to create a sonic response for a routine auditory survey of the concrete condition. However, we found the concrete to be so deteriorated that we were able to remove hundreds of pieces. Most of the concrete spalls were found near the edges of the panels. Some were very deep and required the removal of the entire concrete sill.

Unfortunately, a key recommendation from the previous study was not implemented. While the existing distress was repaired, the panels were not waterproofed with a penetrating sealer, which would have reduced or eliminated further deterioration.

The observed distress is predominantly water related. Several contributing failure mechanisms are likely:

- freeze-thaw (repeated formation of ice crystals causes microcracking)
- corrosion of embedded steel reinforcement (the corrosion product is larger than the base steel, causing internal pressure)
- algae growth in cracks (which propagates them)
- debris carried into cracks by water (which wedges the cracks open wider)
- acid rain (pollutants carried in by rainwater become more concentrated as the water repeatedly evaporates).

Originally, the panels were poorly fabricated with voids, honeycombing, and weak structural details at the narrow fins and embedded weep tubes. We found a plaster-type material and wood in some spalls, apparently used to fill voids and grouted over to achieve the intended shape of the panels.

The concrete's porosity also allows water to migrate easily through the panels and leach an alkali solution that stains the windows. The glass lites can be mechanically buffed with a cleanser to improve the optical quality of the vision lites and prevent the glass from being etched.

The Solution

Not all of the loose concrete could be removed during the study, so immediate comprehensive remedial work is scheduled. This will involve using power hammers to remove incipient spalls, reconfiguring panels with cementitious material, and waterproofing panels with a penetrating sealer. ◆

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Appendix: equations

- Vapor flow equation:

$$W = MA\theta(p_1 - p_2) \qquad (1)$$

where:

W = total mass of vapor transmitted, ng

M = permeance coefficient, ng/(s·m²·Pa), $M = \frac{\bar{\mu}}{l}$

θ = time during which flow occurs, s

l = thickness, m

$\bar{\mu}$ = average permeability, ng/(s·m·Pa)

A = cross-section area of the flow path, m²

$(p_1 - p_2)$ = vapor pressure difference applied across the specimen, Pa.

- Conductive heat transmission equation

$$\frac{q}{A} = U(t_i - t_o) \qquad (2)$$

where

q/A = heat-flow rate, W/m²

U = overall coefficient of heat transmission, W/(m²·K)

t_i, t_o = inside and outside temperature, K

- Thermal resistance of composite section

$$R = \frac{1}{U} = R_1 + R_2 + R_3 \qquad (3)$$

- Average U-value by parallel method (area-weighted average)

$$U = \frac{A_1}{A_1 + A_2}U_1 + \frac{A_2}{A_1 + A_2}U_2 \qquad (4)$$

- Temperature index:

$$I_{\min imum} = (\frac{T_s - T_e}{T_i - T_e}) \times 100$$

where, T_s-glass surface temperature, °C
T_e-outdoor temperature, °C
T_i-indoor temperature, °C

Table 4 Typical Thermal Properties of Common Building and Insulating Materials: Design Values[a] (*Continued*)

Description	Density, kg/m³	Conductivity[b] *k*, W/(m·K)	Resistance *R*, (m²·K)/W	Specific Heat, kJ/(kg·K)	Reference[a]
Finish Flooring Materials					
Carpet and rebounded urethane pad 19 mm	110	—	0.42	—	NIST (2000)
Carpet and rubber pad (one-piece) 9.5 mm	320	—	0.12	—	NIST (2000)
Pile carpet with rubber pad 9.5 to 12.7 mm	290	—	0.28	—	NIST (2000)
Linoleum/cork tile 6.4 mm	465	—	0.09	—	NIST (2000)
PVC/Rubber floor covering	—	0.40	—	—	CIBSE (2006)
Rubber tile 25 mm	1900	—	0.06	—	NIST (2000)
Terrazzo 25 mm	—	—	0.014	0.80	
Insulating Materials					
Blanket and batt[c,d]					
Glass-fiber batts 85 to 90 mm	10 to 14	0.043	—	0.84	Kumaran (2002)
50 mm	8 to 13	0.045 to 0.048	—	0.84	Kumaran (2002)
Mineral fiber 140 mm	30	0.036	—	0.84	Kumaran (1996)
Mineral wool, felted	16 to 48	0.040	—	—	CIBSE (2006), NIST (2000)
	65 to 130	0.035	—	—	NIST (2000)
Slag wool	50 to 190	0.038	—	—	Raznjevic (1976)
	255	0.040	—	—	Raznjevic (1976)
	305	0.043	—	—	Raznjevic (1976)
	350	0.048	—	—	Raznjevic (1976)
	400	0.050	—	—	Raznjevic (1976)
Board and slabs					
Cellular glass	130	0.048	—	0.75	(Manufacturer)
Cement fiber slabs, shredded wood	400 to 430	0.072 to 0.076	—	—	
with Portland cement binder					
with magnesia oxysulfide binder	350	0.082	—	1.30	
Glass fiber board	160	0.032 to 0.040	—	0.84	Kumaran (1996)
Expanded rubber (rigid)	70	0.032	—	1.67	Nottage (1947)
Expanded polystyrene extruded (smooth skin)	25 to 40	0.022 to 0.030	—	1.47	Kumaran (1996)
Expanded polystyrene, molded beads	15 to 25	0.032 to 0.039	—	1.47	Kumaran (1996)
Mineral fiberboard, wet felted	160	0.038	—	0.84	Kumaran (1996)
core or roof insulation	255 to 270	0.049	—	—	
acoustical tile[g]	290	0.050	—	0.80	
	335	0.053	—	—	
wet-molded, acoustical tile[g]	370	0.061	—	0.59	
Perlite board	160	0.052	—	—	Kumaran (1996)
Polyisocyanurate, aged					
unfaced	25 to 35	0.020 to 0.027	—	—	Kumaran (2002)
with facers	65	0.019	—	1.47	Kumaran (1996)
Phenolic foam board with facers, aged	65	0.019	—	—	Kumaran (1996)
Loose fill					
Cellulosic (milled paper or wood pulp)	35 to 50	0.039 to 0.045	—	1.38	NIST (2000), Kumaran (1996)
Perlite, expanded	30 to 65	0.039 to 0.045	—	1.09	(Manufacturer)
	65 to 120	0.045 to 0.052	—	—	(Manufacturer)
	120 to 180	0.052 to 0.061	—	—	(Manufacturer)
Mineral fiber (rock, slag, or glass)[d]					
approx. 95 to 130 mm	10 to 30	—	1.92	0.71	
approx. 170 to 220 mm	10 to 30	—	3.33	—	
approx. 190 to 250 mm	10 to 30	—	3.85	—	
approx. 260 to 350 mm	10 to 30	—	5.26	—	
90 mm (closed sidewall application)	30 to 55	—	2.1 to 2.5	—	
Vermiculite, exfoliated	110 to 130	0.068	—	1.34	Sabine et al. (1975)
	64 to 96	0.063	—	—	(Manufacturer)
Spray-applied					
Cellulosic fiber	55 to 95	0.042 to 0.049	—	—	Yarbrough et al. (1987)
Glass fiber	55 to 70	0.038 to 0.039	—	—	Yarbrough et al. (1987)
Polyurethane foam (low density)	6 to 8	0.042	—	1.47	Kumaran (2002)
	40	0.026	—	1.47	Kumaran (2002)
aged and dry 40 mm	30	—	1.6	1.47	Kumaran (1996)
50 mm	55	—	1.92	1.47	Kumaran (1996)
120 mm	30	—	3.69	—	Kumaran (1996)
Ureaformaldehyde foam, dry	8 to 20	0.030 to 0.032	—	—	CIBSE (2006)

Table 8 Water Vapor Permeability of Building Materials at Various Relative Humidities

Material	Permeability at Various Relative Humidities, ng/(Pa·s·m)					Water Absorption Coefficient, (kg·s$^{1/2}$)/m^2	Mean Air Permeability, kg/(Pa·s·m)	References/ Comments
	10%	30%	50%	70%	90%			
Building Board and Siding								
Asbestos cement board, 3 mm thickness	← 0.66 to 1.37 →			← N/A →				Dry cup*
with oil-base finishes	← 0.05 to 0.09 →			← N/A →				
Cement board, 13 mm, 1130 kg/m^3	7.4	7.4	9.3	12	16	0.013	3×10^{-8}	Kumaran (2002)
Fiber cement board, 8 mm, 1380 kg/m^3	0.21	0.58	1.6	4.7	14.8	0.025	3×10^{-12}	Kumaran (2002)
Gypsum board		21		23	30			Kumaran (1996)/NRC
asphalt impregnated	← 0.038 →							
Gypsum wall board, 13 mm, 625 kg/m^3	23.4	27.2	31.9	37.6	44.7	0.0019[c]	4.2×10^{-9}	Kumaran (2002)
with one coat primer	6.83	14.9	22.0	28.9	35.9	N/A	2.2×10^{-6}	Kumaran (2002)
with one coat primer/two coats latex paint	1.1	2.1	4.0	8.0	16.5	N/A	2.5×10^{-9}	Kumaran (2002)
Hardboard siding, 11 mm, 740 kg/m^3	3.92	4.28	4.67	5.10	5.58	0.00072	4.5×10^{-9}	Kumaran (2002)
Oriented strand board (OSB), 9.5 mm, 660 kg/m^3	0.0064	0.177	0.487	1.35	3.83	0.0016	1×10^{-9}	Kumaran (2002)
11.1 mm	0.026	0.60	1.23	2.30	4.08	0.0022	2×10^{-9}	Kumaran (2002)
12.7 mm	0.044	0.344	0.90	1.70	2.75	0.0016	1×10^{-9}	Kumaran (2002)
Particleboard		4.4	6.0	10.2	15.2			Kumaran (1996)
Douglas fir plywood, 12 mm, 470 kg/m^3	0.19	0.59	1.46	3.19	6.50	0.0042[d]	4×10^{-11}	Kumaran (2002)
15 mm, 550 kg/m^3	0.15	0.41	1.09	2.91	7.99	0.0031	1×10^{-9}	Kumaran (2002)
Canadian softwood plywood, 18 mm, 445 kg/m^3	0.06	0.57	2.28	6.12	13.30	0.0037	2×10^{-11}	Kumaran (2002)
Plywood (exterior-grade), 12 mm, 580 kg/m^3	0.21	0.36		0.80	8.62			Burch et al.
Wood fiber board, 11 mm, 320 kg/m^3	12.4	13.6	15.0	16.4	18.1	0.00094	2.5×10^{-7}	Kumaran (2002)
25 mm, 300 kg/m^3	71.5	58.4		86.7	77.2			Burch and Desjarlais (1995)
Masonry Materials								
Aerated concrete, 460 kg/m^3	11.2	15.9	22.9	33.4	50	0.036	5×10^{-9}	Kumaran (2002)
600 kg/m^3	18	21.6	22	42	63			Kumaran (1996)
Cement mortar, 1600 kg/m^3	13.6	16.5	20.1	24.5	30.2	0.02	1.5×10^{-9}	Kumaran (2002)
Clay brick, 100 by 100 by 200 mm, 1980 kg/m^3	4.14	4.44	4.77	5.12	5.50	0.17	2 to 5×10^{-10}	Kumaran (2002)
Concrete, 2200 kg/m^3		1.26	1.4	2.5	6.5			Kumaran (1996)
Concrete block (cored, limestone aggregate), 200 mm	← 27.4 →							
Lightweight concrete, 1100 kg/m^3		12.3		11.4	18.7			Kumaran (1996)
Limestone, 2500 kg/m^3	0.26	0.26	0.26	0.26	0.26	0.00033	negligible	Kumaran (2002)
Perlite board		28		33	82			Kumaran (1996)
Plaster, on metal lath, 19 mm	← 16.3 →							
on wood lath	← 12.0 →							
on plain gypsum lath (with studs)	← 21.7 →							
Polystyrene concrete, 530 kg/m^3		0.88		1.1	2.7			Kumaran (1996)
Portland stucco mix, 1985 kg/m^3	0.81	1.15	1.63	2.31	3.26	0.012	1×10^{-11}	Kumaran (2002)
Tile masonry, glazed, 100 mm	← 0.69 →							
Woods								
Eastern white cedar, 20 mm, 360 kg/m^3 (transverse)	0.013	0.078	0.48	3.05	20.9	0.0016	negligible	Kumaran (2002)
Eastern white pine, 19 mm, 460 kg/m^3 (transverse)	0.47	0.17	0.67	2.58	10.2	0.0066	1×10^{-12}	Kumaran (2002)
Pine	0.35	0.51	1.1	3.1	6.3			Kumaran (1996)
Southern yellow pine, 20 mm, 350 kg/m^3 (transverse)	0.12	0.404	1.37	4.7	16.9	0.0014	3×10^{-11}	Kumaran (2002)
Spruce (longitudinal)	53	74	84	86	87			Kumaran (1996)
20 mm, 400 kg/m^3 (transverse)	0.37	1.08	3.13	9.27	29.5	0.002	5×10^{-11}	Kumaran (2002)
Western red cedar, 18 mm, 350 kg/m^3 (transverse)	0.106	0.228	0.491	1.06	2.29	0.001	$<1 \times 10^{-12}$	Kumaran (2002)
Insulation								
Air (still)	← 174 →							
Cellular glass	← 0.0 →							
Cellulose insulation, dry blown, 30 kg/m^3	112	140	156	168	178	0.1	2.9×10^{-4}	Kumaran (2002)
Corkboard		3.0 to 3.8		14				
Glass fiber batt, 11.5 kg/m^3	172	172	172	172	172	N/A	2.5×10^{-4}	Kumaran (2002)
Glass-fiber insulation board, 24 mm, 120 kg/m^3		238			152			Burch et al.
facer, 1.6 mm, 880 kg/m^3	0.004	0.00251		0.0184	0.0389			Burch et al.
Mineral fiber insulation, 30 to 190 kg/m^3		70		88	250			Kumaran (1996)
Mineral wool (unprotected)	← 245 →							

Table 8 Water Vapor Permeability of Building Materials at Various Relative Humidities (*Continued*)

	Permeability at Various Relative Humidities, ng/(Pa·s·m)					Water Absorption Coefficient, $(kg \cdot s^{1/2})/m^2$	Mean Air Permeability, kg/(Pa·s·m)	References/ Comments
Material	**10%**	**30%**	**50%**	**70%**	**90%**			
Phenolic foam (covering removed)	←		38		→			
Polystyrene								
expanded, 14.8 kg/m^3	2.85	3.36	3.96	4.66	5.50	N/A	1.1×10^{-8}	Kumaran (2002)
extruded, 28.6 kg/m^3	1.22	1.22	1.22	1.22	1.22	N/A		Kumaran (2002)
Polyurethane								
expanded board stock [(R = 1.94 W/(m^2·K)]		0.58 to 2.3						
sprayed foam, 39.0 kg/m^3	2.34	2.54	2.75	2.97	3.22	N/A	1×10^{-11}	Kumaran (2002)
6.5 to 8.5 kg/m^3	87.5	87.5	87.5	87.5	87.5	N/A	4.2×10^{-9}	Kumaran (2002)
Polyisocyanurate insulation, 26.5 kg/m^3	4.04	4.56	5.14	5.80	6.55	N/A		Kumaran (2002)
Polyisocyanurate glass-mat facer, 0.8 mm, 430 kg/m^3	0.49	0.90		1.30	2.29			Burch et al.
Structural insulating board, sheathing quality	←		29 to 73		→			
interior, uncoated, 13 mm	←		37.2 to 67		→			
Unicellular synthetic flexible rubber foam		0.029						
Foil, Felt, Paper								
Bituminous paper (#15 felt), 0.72 mm, 515 g/m^2 (transverse)	0.29	0.29	0.29	0.40	1.17	0.0005	2.5×10^{-6}	Kumaran (2002)
Asphalt-impregnated paper								
10 min rating, 0.2 mm, 170 g/m^2 (transverse)	0.24	0.43	0.78	1.48	3.06	0.001	1.1×10^{-6}	Kumaran (2002)
30 min rating, 0.22 mm, 200 g/m^2 (transverse)	0.44	0.74	1.28	2.31	4.67	0.093	6.6×10^{-6}	Kumaran (2002)
60 min rating, 0.34 mm, 280 g/m^2 (transverse)	1.51	1.91	2.44	3.18	4.24	0.0011	7.1×10^{-6}	Kumaran (2002)
Spun bonded polyolefin (SBPO) 0.14 to 0.15 mm, 65 g/m^2 (transverse)	4.37	4.37	4.37	4.37	4.37	0.00031	4.6×10^{-7}	Kumaran (2002)
with crinkled surface, 0.1 to 0.11 mm, 67 g/m^2 (transverse)	3.17	3.17	3.17	3.17	3.17	0.00024	3×10^{-7}	Kumaran (2002)
Wallpaper								
paper		0.12		1.2 to 1.7				Kumaran (1996)
textile		0.05		0.74 to 2.34				Kumaran (1996)
vinyl, 0.205 mm, 170 g/m^2 (transverse)	0.08	0.14	0.21	0.32	0.46	0.00025	5×10^{-9}	Kumaran (2002)
Other Construction Materials								
Built-up roofing (hot-mopped)	←		0.0		→			
Exterior insulated finish system (EIFS), 4.4 mm acrylic, 1140 kg/m^3	0.09	0.09	0.09	0.09	0.09	0.00053	0	Kumaran (2002)
Glass fiber reinforced sheet, acrylic, 1.4 mm	←		0.01		→			
polyester, 1.2 mm	←		0.035		→			

*Historical data, no reference available

N/A – Not applicable