97-107 Technical Series

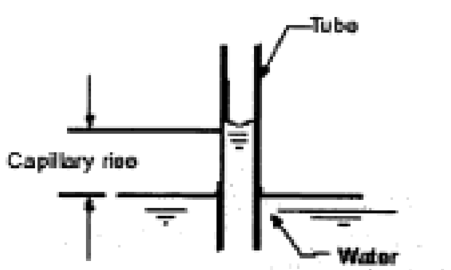
Water Flow by Means of Capillary Action

Introduction

A number of means have been put forward to control the effect of water in buildings. Of all these means, rain screens are certainly the best at preventing water from seeping into buildings. This construction technique regulates the impact of the various forces that are on the outside of the building. The pressure differential, capillary action, gravity, and air movement constitute the main elements in these forces.

Even though it is referred to regularly to explain the cause of water seepage, capillary action is certainly the phenomenon that is the least understood.

In the laboratory, capillary rise is the height attained by water in a capillary tube when its base touches the water.



In practice, this makes it possible to determine the height rain water can reach when a material comes in contact with the water and is drawn up through a crack within the material or between its constituents.
Capillary rise can take place in any situation in which there may be water seepage within cracks separating two materials.

This study is therefore aimed at determining for various cladding materials (brick, precast concrete panels, aluminium, wood and vinyl siding) and the exterior surfaces of doors and windows:

- capillary rise within a crack based on the size of the crack;
- the angle of contact of rain water with construction materials;
- the clearance between two horizontal surfaces that allows rain water to cling between them;
- the maximum height that rain water can reach on a horizontal surface.

Methods and Results of the Study

Samples of prepared materials and water were brought to a temperature of 2O° C.

The surface tension of the rain water collected was measured and compared with that of distilled water.

On average, the surface tension of the rain water measured was 71.1 dynes/cm and 72.0 for distilled water. The quality of water therefore has little impact on this property.

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Measurement of Capillary Rise and Angle of Contact

The samples separated by a spacer gauge were immersed in a basin of water for two minutes. They were then removed and separated. Capillary rise was then determined by measuring the difference in heights between the surfaces of the samples.

Capillary rise is inversely proportional to the distance between the two surfaces.

For all materials that are spaced more than *5* mm apart, capillary rise is negligible.

Glass-to-glass contacts are to be avoided because capillary rise for this type of material is twice as significant as for the other materials tested.

With the exception of glass, for which the angle of contact is 59.9°, all the other materials have a contact angle that varies between *7l.5°* and *85.6g.*

Adhesion Height In Horizontal Cracks

In the case of a horizontal capillary crack, the water seeps in along the entire length.

The diameter of the capillary crack plays a preponderant role. There is a particular width of crack that allows water to cling to both surfaces.

A sample of material was attached to a table and another to the moveable tray of a vertical vernier scale. Care was taken to ensure the two samples were precisely parallel. The height was marked when the two material surfaces were touching, then the upper sheet was lifted and *5* cm^3 of water was deposited on the lower surface. The upper surface was placed in contact with the water. This position was maintained for two minutes. Then the surface was raised at a rate of about 2 mm per minute using a micrometric screw. This movement was stopped when the adhesion of the water seemed about to cease. When adhesion ceased, the height was measured. The difference between the initial and the final height corresponds to the maximum height that permits water to adhere to the two surfaces.

The tests showed that rain water does not adhere between two horizontal surfaces spaced more than 8.8 mm apart.

The maximum height between two horizontal surfaces that permit rain water to adhere to the two surfaces fluctuates between *5.2* mm for plywood and 8.8 mm for Pentox waferboard.

The Maximum Height That Water Can Reach on a Horizontal Surface

When rain water is poured onto a horizontal surface, it reaches a height that permits water retention. Any extra water will have the effect of disrupting the equilibrium and the water will spread out over a larger surface or escape from the horizontal surface while still maintaining the equilibrium height.

The sample material was attached to the table with the surface to be tested facing upwards. The height of the surface was noted. *5* cm^3 of water was poured on to the surface. The height of the water was measured and noted. The difference between the initial and final heights corresponds to the equilibrium height of rain water at rest.

The maximum height that rain water reaches on a horizontal surface is 5.2 mm for the materials tested.

Description of the Surface		**Angle of contact^0**	**Capillary rise**				**(mm) 2**			**Distance required For Adhesion (mm) 7,1 6,3**
Material	**Finish**		0.25 13,5	*0,5*	**1**	**1,5 2,3**		**1 1,1**	0 0 0,8 1,0	
White pine	Glossy oil	*76,5*			3,4		1,7 2,0			
	Latex semi-gloss paint	74,3	15,7	7,8	3,9	2,6		1,3		
White pine	Varnish with plastic finish	77,4	12,6	6,3	3,2	2,1	1,6	1,1	0,8	7,8
White pine	Natural	80,2		4,9	25	1,6	1,2	0,8	0 0,6 0,5	6,7

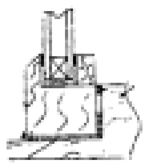
						1,4	1,1	0,7		6,7
White pine	Latex semi-gloss paint	81,5	8,6	4,3	2,1					
White pine	FlatOil Oil treated		7,8		1,9	1,3	1,0		0,5	7,8
		90								
Spruce	Natural	78,6	11,5	5,7			14	1,0	0,7	7,1 7,6 6,4 6,7
Spruce	Oil treated	90								
Cedar	Natural		8,9	4,4	2,2	15 3,1	11	0,7 1,5		
Plywood	Latex semi-gloss paint	71,5	18,4	9,2	4,6		2,3		1,1	
Plywood	Glossy oil paint	77,4					1,6	1,1	0,8	7,5 8,0
Plywood	Varnish with plastic finish	79,3	10,8	5,4	2,7	1,8	1,3	0,9	0,7	
Plywood	Flat oil finish			4,9	24	1,6	1 1,2	0,8	0,6	7,5
Plywood	Natural	80,7	9,4	4,7	2,3	1,6	1,2	0,6	0,6	
Plywood	Semi-gloss latex varnish	83,3	6,8	3,4	1,7	1,1	0,8		0,4	
Plywood	Oil treated	90						1,3 0,7		7,5 7,2
Wafer board	Natural on outside	74,2	15,6	7,9	3,9	2,6	2,0		1,0	
Waferboard	Naturalon inside	81,3	8,8	4,4	2,2	1,5	1,1	1,1	0,5	7,6
Aluminium	Anodised	90	13,7		3,4	2,3	1,7 1,6 1,4 1,0 0,9 1,0 0,6		0,9 0,8	6,8 6,7 7,0 6,0 5,9 7,0 7,2
Aluminium	Natural			6,6	3,3	2,2		0,9 0,6 0,6 0,7 0,4 0,4		
Aluminium	Painted	78,9 82,4	11,2	5,6					0, 7	
Vinyl	White		7,7 7,5		1,9 1,9 2,0 1,1	1,3 1,2				
	Brown	8 82,1 85,6		3,7					0,5	
Plexiglas	Natural		8,0 4,4	4,0 2,2		1,3 0,7				
Galvanised sheet metal	Natural								0, 3	
Acrylic	Natural	84,7	5,4	2,7	1,3	0,9 4,8	0, 7 3, 6	2,4 0,7	0, 3 1, 8	6,5 5,2 6,9 6,7 6,7 7,3 6,2 7,1 6,1 7,0 6,0 6,8 6,2

										7,0 *6,3*
Glass	**Clear**		**29,1**		**7,3**					
Mortar		**81,3**	**8,8**	**4,4**	2,2	**1,5**	**1,1**		*0,5*	
Brick	**Clay**	**75-85**								
Concrete		*75-85*								
Glass Aluminium	**Clear Painted**	**62,5**					**3,3** **0,9**	**2,2** **0,6**	**1,7** **0,5**	
Glass Aluminium	**Clear Anodised**	**64**		–			**3,2** **1,3**	**2,1** **0,9**	**1,6** **0,6**	
Glass Aluminium	**Clear Mill finish**	**65,2**					**3,0** **1,2** **2,8** **1,9** **3,5** **1,4**	**2,0** **0,8** **1,9** **1,3** **2,3** **1,0**	*1,5*	
Glass Vinyl	**Clear White**	**67,3**			–	**3,7** **2,6**			**1,4** **1,0** **1,7** **0,7**	
Glass White pine	Clear Natural	**61,2** **78,6**								
Glass White pine	Clear Varnish with plastic finish	63,2 76					3,3 1,7	2,2 1,1	1,6 0,9	7,7 6,5

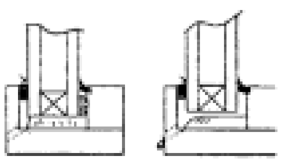
Conclusions and Repercussions for the Housing Sector

Wood windows must be designed with capillary rise and surface tension in mind. The space between the sill and the sash must not permit adhesion at least be greater than the height of water at rest, which for pine is 3.4 mm. For separations that are less than 3.4 mm, water will move through the space and may even rise by capillary action to a height that depends on the amount of space between the materials used.

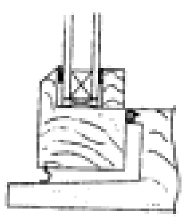
When the spacing is small the water migrate toward the inside.



If water fill the space under the opening the capillarity between the two surfaces is minimized by a greater spacing.



The same concept applies between a sealed window unit and the sash, and to a sliding window and its gliding rail. Presently, the design of window sashes often does not provide a wide enough gap to prevent leakage due to capillarity.



When the space is to narrow, there will be adhesion of water on the surfaces and capillary rise might **append.**

In the case of cracks, water movement will continue as long as water is supplied, or until the height of capillary rise for a given space is attained.

A crack in a concrete wall, for example, will remain full until the water supply stops. If the wind exerts a pressure exceeding the surface tension, the water will drain to the inside of the wall.

Project Manager: Jacques Rousseau

Research Report: Migration de Peau par capillarité (1993)

Research Consultant: Air-Ins inc.

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

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