A Brief Literature Review
on Pressure Equalization of Air-permeable Claddings
and Multi-Layered Wall Systems
for
Wind Pressure Testing of Wall Assemblies
with
Foam Sheathing and Vinyl Siding Products

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ASTM D 3679-06a, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Siding,* American Society of Testing and Materials, West Conshohocken, PA. 2006.

ASTM D3679 Annex A1 gives pressure equalization factor of 0.36 for vinyl siding. ASCE 7 components and cladding wind pressure (pressure differential across the entire building envelope) is multiplied by the PEF to determine a design wind pressure for the vinyl siding (cladding) layer. Test method and results for 24 different wall assemblies and rate of dynamic negative pressure loading are described in a separate report reviewed below (ATI, 2002).

ATI, 2002. *Pressure Equalization Factor Project,* ATI Report No. 01-40776.01, prepared by Architectural Testing Inc. for Vinyl Siding Institute, Washington, DC. September 5, 2002.

This report presents the test method and results for dynamic wind pressure testing of 24 different light frame wall assemblies with gypsum wall board finish (on ambient pressure side of wall), wall cavity between framing members, exterior sheathing (1/2" plywood or ½" polystyrene foam sheathing), and various types of vinyl siding applied directly over the exterior sheathing on the negative pressure side of the wall. Variations with and without an air-barrier applied to the exterior sheathings were also investigated.

A single dynamic negative pressure fluctuation was created by a multi-chambered test apparatus and quick-acting vents to "dump" a negative pressure chamber into the wall test chamber. Using the test apparatus, three different dynamic loading conditions were investigated for each wall assembly to determine sensitivity to rate of negative pressure changes and peak magnitude of dynamic pressure differential created across the overall wall system. This resulted in pressure change rates from roughly 80 psf/sec to as much as 240 psf/sec. In terms of effective rate of change of wind speed: roughly 320 mph/sec to 615 mph/sec. Maximum instantaneous pressure differential across the wall ranged from about 10 psf (low test condition) to 35 psf (high test condition) corresponding to gust wind speeds of approximately 70 mph to 130 mph.

The study found pressure equalization factors (PEF) ranging from 0.03 to 0.18 for the vinyl siding layer of the three-layered wall systems tested (also including an additional air-barrier building wrap layer in some cases). PEF is determined as the ratio of peak pressure differential across the siding to the pressure differential across the overall wall system at the same time. From this data, a conservative PEF of 0.36 was recommended for vinyl siding applications (0.36 is twice the largest recorded PEF giving the least amount of pressure reduction relative to the overall wall system pressure differentials recorded).

The study also included a pressure tap in the wall cavity, thus the data indicate a maximum PEF (least pressure equalization) across the sheathing of about 0.7 for ½" plywood sheathing and 0.4 for ½" polystyrene foam sheathing. This difference is most likely due to the difference in dynamic response of these two sheathing materials rather than any difference in ventilation pathways through the sheathing surface. Assuming that a PEF of 0.1 conservatively represent the portion of total wall pressure differential acting on the vinyl siding, the above PEF values for exterior sheathings would suggest that the PEF for the ½" gypsum panel interior finish ranges from 0.2 (= 1.0 – 0.1 – 0.7) when ½" plywood sheathing is used to 0.5 (= 1.0 – 0.1 – 0.4) when ½" polystyrene foam sheathing is used. Thus, a PEF for gypsum panels for this type of light frame "double wall" system (sheathing on both sides) could be reasonably characterized as 0.5.

Carll, C. et al. 1998. *Performance of Backprimed and Factor Finished Hardboard Siding – Final Report*, USDA Forest Service, Forest Products Laboratory, Madison, WI. February 1998.

This full-scale experiment in actual wind events indicates that the interior finish (GWB) and exterior wall sheathing plus air-barrier each share no more than about 50% (PEF = 0.5) of the instantaneous peak total components and cladding wind load acting across a typical three-layered wall system with lap siding, exterior sheathing with air-barrier wrap, and interior GWB finish. This finding is reasonably consistent with the VSI/ATI study mentioned above where a PEF of 0.7 was determined for plywood sheathing. It also demonstrates that the VSI/ATI study tended to produce conservative results (higher PEF factor) relative to conditions observed in full-scale monitoring of a building wall system in actual wind events. The maximum instantaneous pressure differential across the hardboard lap siding only was about 67% of the total wall pressure differential from inside to outside at gust condition caused by a thunderstorm event. This finding suggests that hardboard lap siding may not experience the degree of pressure equalization determined for vinyl siding in the VSI/ATI study mentioned above. This difference in PEF performance may be attributed to the different response characteristics (e.g., stiffness) and ventilation that occurs with these two siding types. However, the combined peak dynamic pressure differential across the lap siding and sheathing plus air-barrier was no more than about 50% of the total pressure differential across the wall system.

Rousseau, M.Z., Poirier, G.F. and Brown, W.C. 1998. Pressure Equalization in Rainscreen Wall Systems, Construction Technology Update No. 17, Institute for Research in Construction, National Research Council of Canada, July 1998. http://irc.nrc-cnrc.gc.ca/pubs/ctus/ctu17e.pdf

"In a project jointly sponsored by Canada Mortgage and Housing Corporation (CMHC) and several wall system manufacturers, IRC used its unique dynamic wall testing facility to study the relationship between the three components (listed above) as a function of the physical characteristics of different wall assemblies subjected to static and dynamic air pressures. Specimens of precast concrete panels, brick veneer/stud wall assemblies and exterior insulation and finish systems (EIFS) were examined for their pressure-equalization performance." [references are included in the list below]

ADDITIONAL LITERATURE

From Canadian Rainscreen Cladding Research:

Poirier, G.F. and W.C. Brown. Pressure Equalization and the Control of Rainwater Penetration under Dynamic Wind Loading, Construction Canada, March/April 1994, p. 45-47

Inculet, D. and D. Surry. The Influence of Unsteady Pressure Gradients on Compartmentalization Requirements for Pressure-Equalized Rainscreens. Canada Mortgage and Housing Corporation, June 1996.

Skerlj, P.F. and D. Surry. A Study of Mean Pressure Gradients, Mean Cavity Pressures, and Resulting Residual Mean Pressures across a Rainscreen for a Representative Building. CMHC Report, September 1994. Canada Mortgage and Housing Corporation, Ottawa.

A Study of Mean Pressure Gradients, Mean Cavity Pressures, and Resulting Residual Mean Pressures across a Rainscreen for a Representative Building. CMHC Research & Development Highlights Technical Series 96-207, Canada Mortgage and Housing Corporation, Ottawa.

Inculet, D. and D. Surry. Optimum Vent Locations for Partially-Pressurized Rainscreens. CMHC report BLWTSS30-1997, September 1997, 183 p.

Brown et al. Field Testing of pressure-equalized rainscreen walls. ASTM. STP 1034, 1991.

Kumar, K.S., Sathopoulos, T., Wisse, J.A., "Field measurement data of wind loads on rainscreen walls," Journal of Wind Engr and Industrial Aerodynamics, Volume 91, Issue 11, November 2003, pp 1401-1417.

From ASCE 7-05 Section C6.5.2.2:

Cheung, J. C. J., and Melbourne, W.H. (1986). "Wind loadings on porous cladding." Proc. 9th Australian Conference on Fluid Mechanics, p.308

Haig, J.R. (June 1990). "Wind Loads on Tiles for USA." Redland Technology Limited, Horsham, West Sussex, England.

Peterka, J.A., Cermak, J.E., Cochran, L.S., Cochran, B.C., Hosoya, N., et al. (1997). "Wind uplift model for asphalt shingles." *Journal of Architectural Engineering* Dec: 147-155.