ASCE

SEI Structural Engineering Institute of the American Society of Civil Engineers

ASCE 7 Standards Committee
Proposal to Revise the 2005 Edition of ASCE 7

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Submission date: ____3/22/07 (rev 7/14/07)___________

Considered by ASCE 7 Task Committee on: ___Wind______

Task Committee Action on Proposal: ____________________

SCOPE: ASCE 7-05 Commentary Section C6.1.3 and C6.5.2.2

PROPOSAL FOR CHANGE: (please use strike-out and underline format – please also include related modification/proposed addition to Commentary)

Relevant Existing Text in Standard (no change proposed):

6.1.3 Wind Pressures Acting on Opposite Faces of Each Building Surface. In the calculation of design wind loads for the MWFRS and for components and cladding for buildings, the algebraic sum of the pressures acting on opposite faces of each building surface shall be taken into account.

Add new commentary Section C6.1.3 and Figure C6-1 as follows:

C6.1.3 Wind Pressures Acting on Opposite Faces of Each Building Surface. Section 6.1.3 is included in the standard to ensure that internal and external pressures acting on a building surface are "taken into account" by determining a net pressure from the algebraic sum of those pressures. However, for components and cladding comprising a multi-layered building envelope system, the computed net pressure is actually distributed to each layer according to relative differences in stiffness and porosity or air-permeability of each layer, among other factors related to the characteristics of air spaces between each layer (e.g., volume of the air space and compartmentalization of the air space).

Currently, there is no standardized procedure or test method for determining an appropriate distribution of the computed net pressure to various layers of a multi-layered building envelope system. Such systems often include three dominant layers (e.g., cladding + exterior sheathing + interior sheathing or finish), each of which shares some portion of the computed net pressure differential acting on the building surface or envelope. For some air-permeable cladding types or products, when backed by a relatively stiff and air-impermeable layer (or layers), pressure reduction or equalization effects have been accounted for in the recognized literature as discussed in Commentary Section C6.5.2.2. However, these same principles also apply to other layers of a building envelope system such that the algebraic sum of the pressure differentials acting on each layer should sum to the computed net pressure acting across the building surface as a whole. This principle is conceptually illustrated in Figure C6-1.

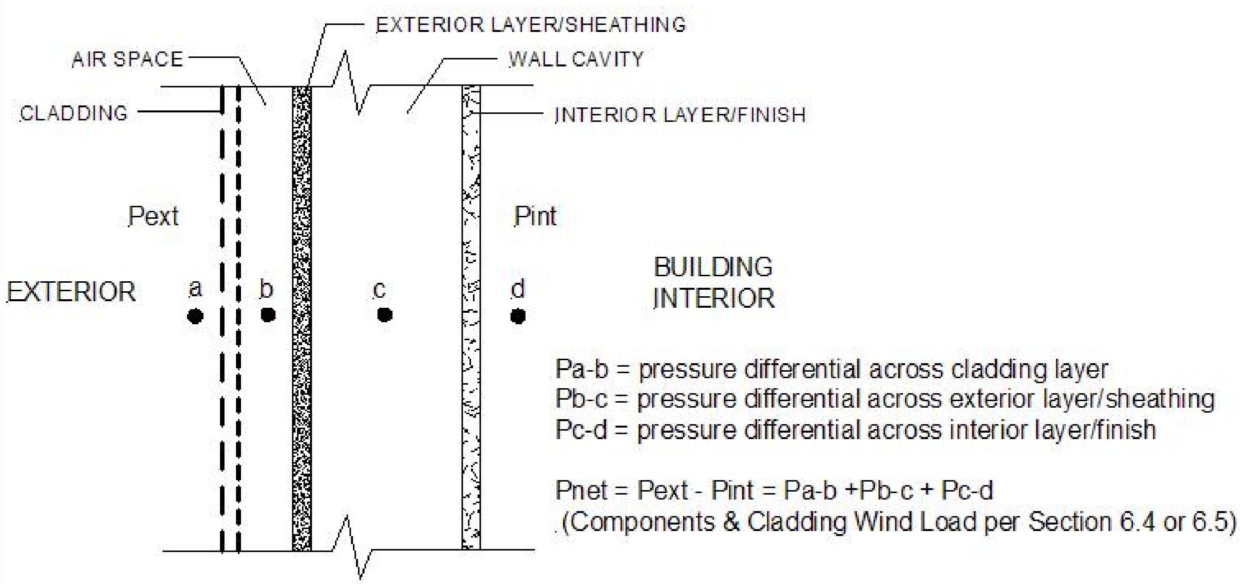

FIGURE C6-1 DISTRIBUTION OF NET PRESSURE ACTING ON A BUILDING SURFACE (BUILDING ENVELOPE) COMPRISED OF THREE COMPONENTS (LAYERS)

Relevant Existing Text in Standard (no change proposed):

6.4.3 Air Permeable Cladding. Design wind loads determined from Fig. 6.3 shall be used for all air permeable cladding unless approved test data or the recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

No commentary exists or is proposed for Section C6.4.3 because, as part of the simplified Method 1, this section derives its basis from Section 6.5.2.2 of Method 2 (analytical approach).

Relevant Existing Text in Standard (no change proposed):

6.5.2.2 Air Permeable Cladding. Design wind loads determined from Section 6.5 shall be used for air permeable cladding unless approved test data or recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

Revise existing commentary Section C6.5.2.2 as follows:

C6.5.2.2 Air-Permeable Cladding. Air-permeable roof or wall claddings allow partial air pressure equalization between their exterior and interior surfaces. Examples include siding, pressure-equalized rain screen walls, shingles, tiles, concrete roof pavers, and aggregate roof surfacing.

The degree of pressure equalization (reduction) experienced by any cladding type depends not only on the characteristics of the cladding itself, but also the relative air-permeability and stiffness of various layers of a building envelope system in response to dynamic (fluctuating) wind loads (see Commentary Section C6.1.3).

To maximize pressure equalization (reduction) across any cladding system (irrespective of the permeability of the cladding itself), the layer or layers behind the cladding should be:

- relatively stiff in comparison to the cladding material, and
- relatively air-impermeable in comparison to the cladding material.

Furthermore, the air space between the cladding and the next adjacent building envelop surface behind the cladding (e.g., the exterior sheathing) should be as small as practicable and compartmentalized to avoid communication or venting between different pressure zones of a building's surfaces. Because all of these features have a relative impact on the pressures experienced by each layer involved, the magnitude of pressure equalization is dependent on the characteristics of the other layers of the building envelope (see Section C6.1.3).

The design wind pressures derived from Section 6.5 represent the pressure differential between the exterior and interior surfaces of the exterior envelope (wall or roof system). Because of partial air-pressure equalization provided by air permeable claddings, the components and cladding pressures derived from Section 6.4 or 6.5 can overestimate the load on air-permeable cladding elements and also the distribution of net pressure differentials acting on other components (layers) of a multi-layered building envelope system.

Therefore, the designer may elect either to use the loads derived from Section 6.4 or 6.5, or to use loads derived by an approved alternative method. One such method, based on dynamic wind pressure testing to determine a standardized Pressure Equalization Factor (PEF), has been implemented for certified vinyl siding products installed on typical "solid" wall systems (Ref. C6-6). The term "solid" implies a relatively low air-permeability of the sheathing or wall construction immediately behind the vinyl cladding (such that the air cavity between the siding and wall system can readily equalize with dynamic pressure changes occurring in ambient exterior air). In this context, the PEF is the proportionate share of the net components and cladding wind pressure (determined from Section 6.4 or 6.5) applicable to an individual cladding or envelop layer.

Theoretically, the sum of PEF values for each layer of a multi-layered building envelope system should add to 1.0 (or, as shown in Figure C6-1, the pressure acting on each layer should sum to 100 percent of the net components and cladding pressure per Section 6.4 or 6.5). For hollow-backed vinyl siding products complying with ASTM D3679-06a, the PEF factor ranges from roughly 0.1 to 0.2, with a standardized value of 0.36 selected for use in ASTM D3679 to cover a variety of products (Ref C6-6). A dynamic pressure test chamber was used with three different dynamic loading conditions to evaluate PEFs for each wall assembly and to determine sensitivity to rate of negative pressure changes and peak magnitude of dynamic pressure differential created across the overall wall system (Ref. C6-7). This procedure resulted in pressure change rates from roughly 80 psf/sec to as much as 240 psf/sec and maximum peak net pressure magnitudes consistent with end zone components and cladding pressures for a 130 mph wind speed. The dynamic pressure testing used to justify the 0.36 PEF for hollow-backed vinyl siding products also indicates a typical PEF range of 0.5 to 0.7 for the exterior sheathing layer and 0.2 to 0.4 for interior gypsum wall board finishes on light-frame walls (Ref. C6-7). In this context, a low PEF value implies substantial pressure equalization and a PEF of 1.0 for a given layer implies no pressure equalization or pressure sharing with other layers (e.g., a single layer building envelope system).

If the designer desires to determine the pressure differential across a specific the air-permeable cladding element in combination with other elements comprising a specific building envelope assembly, appropriate full-scale pressure measurements should be made on the applicable building envelope assembly cladding element, or reference be made to recognized literature [Refs. C6-2, C6-3, C6-4, C6-5, C6-6, C6-7] for documentation pertaining to wind loads.

Add references to commentary as follows:

[Ref. C6-6] ASTM D 3679-06a, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Siding*, American Society of Testing and Materials, West Conshohocken, PA. 2006.

[Ref. C6-7] 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.

REASON FOR PROPOSAL: (a reason statement providing the rationale for the proposed change must be provided – attach additional pages if necessary)

Building envelop design is increasingly becoming the focus of efforts to improve wind-resistant (and wind-driven rain resistant) construction. Therefore, the proper distribution of components and cladding wind loads to multi-layered building envelope systems is very important to efficient building envelop design. This commentary proposal is intended to bring clarity to the principles involved and needed background to this issue. It is intended to establish a basis for future potential improvements to the standard as well as standardized procedures for determining pressure equalization effects on air-permeable claddings, rain-screen cladding systems, and building envelope systems in general.

The following background information is provided for additional information (excerpt from *Residential Building Loads: Review and Roadmap for Future Progress,* ASCE-SEI, 2006, pp24-25):

Topic #10 Air-permeable Cladding Wind Loads

Description: Wind loads on air-permeable claddings are typically less than loads calculated across the entire building wall or roof system in accordance with ASCE 7 provisions. While ASCE 7 recognizes that air-permeable cladding load reductions are valid, guidance is lacking on methods of testing to determine wind load adjustments for air-permeability cladding products, and a generalized calculation method for air-permeable cladding load effects based on the degree of porosity or venting of the cladding system does not exist.

Existing Knowledge: Certain material standards (e.g., ASTM standard for vinyl siding) give recognition of a 50% cladding load reduction due to air-permeability, although the technical justification of this level of reduction is not known *[Author's Note (7/14/07): This value has been changed to 0.36 in ASTM D3679-06a and the dynamic pressure test basis of this value is known]*. Air-permeable cladding load reductions for various other cladding types (e.g. wood lap siding, brick veneer, etc.) is lacking.

The Forest Products Laboratory has conducted full-scale wind pressure measurements on one type of air-permeable cladding (hardboard siding) installed on a test building (TenWolde et al., 1998). The cladding pressures experienced was approximately two-thirds of the total pressure differential across the wall system. Research sponsored by the National Roofing Contractors Association has developed a method for determining roof shingle loads, also relying on full-scale pressure monitoring on a test building (Peterka, et al, 1997). In this full-scale study, air-permeable cladding wind load reductions were as high as 75 percent. Studies of various cladding systems with varying degrees venting and resulting pressure-equalization (known as pressure-equalized or pressure-moderated rain-screen cladding) have also shown cladding load reductions similar to that reported above (CMHC, 2000, 2001, 1998, 1997, and 1996). A simplified computer model has also been developed to predict pressure equalization effects for air-permeable or "rain-screen" cladding systems (CMHCa, 1996). Methods to accurately assess air-permeability wind load reductions are not standardized and often rely on expensive whole building pressure measurements under actual wind loads.

Implementation Progress & Barriers: Current building codes and standards do not give adequate guidance on air-permeable cladding wind loads. In some cases, air-permeable claddings are specifically not permitted to be considered as air-permeable and must be designed for significantly higher loads than actual. This problem affects accuracy and economy of design of claddings as well as attachment methods. For example, 24 CFR Part 3280 is interpreted by HUD to require that vinyl siding cladding loads cannot be reduced for air-permeability. However, the ASTM D3679-96a standard for vinyl siding specifically includes a reduction for air-permeability. Attempts to include available air-permeability data (in terms of cladding load reductions factors) for some exterior finish materials in the ASCE 7 wind provisions have been rejected without clarifying a method by which air-permeability load reductions may be considered in the future.

Recommendations:

- A literature search on the topic of air-permeable cladding wind loads is needed. Methods to calculate wind loads on air-permeable cladding systems or porous wall systems should also be sought in the literature.

- Basic research is needed to develop a suitable general test methodology for determining air-permeable cladding load effects, develop a data set of load characteristics for a variety of air-permeable cladding products with differing degrees of porosity, and evaluate the data to formulate a generalized method for calculating air-permeability load adjustments based on fundamental cladding properties (e.g., degree of porosity or ventilation).

- A proposal should be submitted to the ASCE 7 wind task committee to clarify intentions for the proper characterization of air-permeable cladding loads and in what form air-permeable cladding load adjustments may be recognized for use by the design community and cladding product manufacturers. Any position taken by ASCE 7 wind task committee should be communicated and coordinated with appropriate standards development activities within ASTM.

Other relevant literature include:

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.

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

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.

Proposals to revise ASCE/SEI 7-05 must be submitted using this form and are to be submitted electronically to Jim Rossberg, Secretary, ASCE/SEI 7 Standards Committee at jrossberg@asce.org