Building Envelope Wind Design for Low-Rise Buildings per ASCE 7-22

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Module 1. Engineering Scope of Components and Cladding Wind Design

Wind damage in low-rise commercial buildings often begins at the building envelope rather than at the primary structural frame. A roof panel, wall panel, mullion, door assembly, fastener line, girt, or purlin can experience local wind pressure that is significantly higher than the pressure used for the main wind-force-resisting system. This distinction is fundamental to ASCE/SEI 7-22. The MWFRS provides overall support and stability for the building, while components and cladding are local envelope elements or supporting members that do not serve that global role.

In professional practice, the difference between MWFRS and C&C is not only a code classification. It changes the pressure coefficient, the effective wind area, the pressure zone, the sign convention, and the final design value transmitted to the architect, contractor, supplier, or delegated specialty engineer. A building frame may satisfy global wind drift and strength requirements while the roof corner fasteners, edge securement, wall panels, storefront mullions, or overhead door assembly remain underdesigned. This is why a C&C pressure schedule should be treated as part of the structural load path, not as a secondary product-submittal formality.

The local nature of C&C pressure is especially important in low-rise commercial, warehouse, retail, and light-industrial buildings. These structures often have large roof areas, lightweight wall and roof panels, repetitive secondary framing, large openings, and several product-based envelope systems. The structural engineer may not design every panel, clip, screw, window, or overhead door directly, but the engineer is usually responsible for defining the design pressure basis that others must use. If the pressure schedule is incomplete or unclear, the delegated designer may select a product based on field-zone pressure while the actual element is located in an edge or corner zone.

ASCE/SEI 7-22 Chapter 30 provides the analytical basis for determining C&C pressures. Chapter 26 provides the general wind parameters, including basic wind speed, exposure, topographic factor, ground elevation factor, velocity pressure, enclosure classification, and internal pressure coefficient. Chapter 30 then applies those parameters to the building envelope through external pressure coefficients that depend on surface, roof geometry, effective wind area, and pressure zone. The calculation is therefore not a single wind-pressure value. It is a sequence of engineering decisions that must remain traceable.

A common review problem occurs when C&C and MWFRS pressures are mixed. MWFRS loads are intended for the overall lateral and vertical wind response of the primary system. C&C pressures are intended for local envelope elements and their immediate supports. Using MWFRS pressures for wall panels, roof panels, fasteners, doors, or glazing can be unconservative because local peak pressures may be much higher than global average pressures. Conversely, using fastener-level C&C pressure over an entire primary frame may be unnecessarily conservative and may not represent the intended load path.

The course is limited to building-envelope C&C for low-rise commercial, retail, warehouse, and light-industrial buildings. Rooftop mechanical equipment, photovoltaic arrays, parapet design as a separate appurtenance, attached canopies, freestanding signs, tornado design, global MWFRS design, and wind tunnel testing are outside this course scope. Keeping that boundary is important because those topics use different ASCE 7 provisions, different pressure coefficients, or different design procedures. A focused scope also allows the course to develop the envelope calculation in the same way it is commonly needed in design offices and plan review.

For the purposes of this course, a useful C&C calculation is not only one that produces a correct number. It must also identify the surface, pressure zone, effective wind area, internal pressure assumption, pressure sign, pressure level, intended element, and connection interpretation. These items allow the pressure to be used correctly by a delegated designer or product supplier. They also allow a plan reviewer to verify whether the pressure belongs to the roof field, roof edge, roof corner, wall field, wall corner, opening, secondary member, panel, or fastener.

Professional Consideration: A C&C pressure schedule should identify the applicable surface, zone, effective wind area, pressure direction, pressure level, and intended element. Without those items, the schedule is difficult to review, difficult to coordinate, and difficult to defend after a wind-related envelope failure.

Module 2. ASCE 7-22 Wind Parameters and Design Pressure Formulation

A defensible C&C wind calculation should begin with applicability and wind parameters, not with pressure coefficients. The external pressure coefficient is only meaningful after the engineer has confirmed that the building falls within the selected ASCE/SEI 7-22 procedure, that the wind parameters are appropriate for the site, and that the enclosure classification is consistent with the assumed performance of the building envelope. In plan review, many C&C comments arise not because the arithmetic is difficult, but because the calculation does not clearly show how the basic wind inputs were established.

ASCE/SEI 7-22 Chapter 26 establishes the general wind parameters used throughout the wind provisions. These include the basic wind speed, wind directionality factor, exposure category, topographic factor, ground elevation factor, velocity pressure exposure coefficient, velocity pressure, enclosure classification, and internal pressure coefficient. Chapter 30 then applies those parameters to components and cladding by surface, roof geometry, pressure zone, effective wind area, and internal pressure condition. The calculation therefore moves from site and building classification to local envelope pressure demand.

For the building types addressed in this course, ASCE/SEI 7-22 Chapter 30 Part 1 is the governing procedure when the building is enclosed, partially enclosed, or partially open; the building qualifies as low-rise or has mean roof height not greater than 18.3 m; and the roof geometry is covered by the applicable Chapter 30 figures. This scope check should be made before selecting any wall or roof coefficient. If the building has unusual geometry, unusual response characteristics, rooftop equipment, solar arrays, attached canopies, or conditions outside the Chapter 30 Part 1 limits, another ASCE 7 procedure or additional engineering evaluation may be required.

The sequence used in this course follows the same logic expected in a reviewable design calculation. The engineer first establishes the code basis and wind inputs, then evaluates velocity pressure at mean roof height, selects the internal pressure coefficient from the enclosure classification, determines the effective wind area for the intended element, identifies the applicable surface zone, selects the external pressure coefficient, and finally calculates the controlling positive and negative C&C pressures. Keeping this sequence visible is important because it allows a reviewer, delegated designer, or product supplier to trace each scheduled pressure back to a code provision and a specific envelope element.

The velocity pressure is evaluated at mean roof height for the low-rise C&C procedure. In SI units, the ASCE 7 velocity pressure expression is written as follows, with wind speed in m/s and pressure in N/m2.

$$q_h = 0.613\, K_h\, K_{zt}\, K_e\, V^2 \quad \text{N/m}^2$$

(ASCE/SEI 7-22 Eq. 26.10-1, SI form)

In this expression, V is the 3-second gust basic wind speed, Kh is the velocity pressure exposure coefficient at mean roof height, K_{zt} is the topographic factor, and K_e is the ground elevation factor. The wind directionality factor, K_d, is applied in the ASCE/SEI 7-22 Chapter 30 C&C pressure equation rather than being included in q_h.

The examples in this course report pressures in kPa because that unit is more convenient for building-envelope schedules.

$p = q_h K_d [(GCp) - (GCpi)]$ *N/m²*

(ASCE/SEI 7-22 Eq. 30.3-1, SI form)

Because K_d is applied in the Chapter 30 pressure equation, the pressure calculations in the examples report both q_h and the product q_hK_d. The product q_hK_d is then multiplied by the algebraic difference between the external and internal pressure coefficients. The sign convention must be maintained throughout the calculation. Positive pressure acts toward the surface. Negative pressure acts away from the surface. For each C&C element, both the maximum positive and maximum negative cases should be evaluated. The internal pressure coefficient is selected from the enclosure classification and used with the sign that produces the controlling algebraic pressure for the element under review.

Unless noted otherwise, the C&C pressures calculated in this course are reported as strength-level ASCE 7 design pressures. Where allowable stress design or allowable product ratings are used, the pressure basis should be clearly identified and converted consistently with the applicable ASCE 7 load-combination provisions.

$p_{min} = 0.77$ *kN/m²*

(ASCE/SEI 7-22 Sec. 30.2.2)

The minimum C&C pressure requirement is not a minor provision. It often controls positive pressure on low-slope roof surfaces and can control other low-magnitude cases where large effective wind area reduces the coefficient. The pressure schedule should clearly state when the minimum pressure controls.

Verification Tip: Before selecting any coefficient, confirm the Chapter 30 part, building height, roof shape, enclosure condition, and intended C&C element.

Table 1. Code provisions used in this course.

Reference	Use in the course
ASCE/SEI 7-22, Chapter 26	General wind parameters, velocity pressure, exposure, enclosure classification, and internal pressure.
ASCE/SEI 7-22, Chapter 30, Part 1	C&C pressures for low-rise buildings and buildings with h <= 18.3 m.
ASCE/SEI 7-22, Chapter 2	Strength and allowable-stress load combinations used to communicate pressure level.
IBC 2024	Building-code framework that adopts and coordinates ASCE 7 wind design.
ASTM E1886 / ASTM E1996	Impact and cyclic pressure performance references for protected openings where required.
ACI 318-19/22	Concrete anchorage checks when cladding support reactions transfer into concrete.

Module 3. Effective Wind Area, Pressure Zones, and Building-Envelope Load Path

Effective wind area is one of the most common sources of error in C&C calculations because it is often confused with gravity tributary area or with the area of the product being purchased. In ASCE/SEI 7-22 C&C design, the effective wind area is used primarily to select the appropriate external pressure coefficient. It is not always the same area used later to convert pressure into force. This distinction is important for panels, secondary framing members, fasteners, windows, doors, and mullions.

For C&C members and panels, the effective wind area is based on the span length multiplied by an effective width that need not be less than one-third of the span length. This rule recognizes that local wind pressure is not transferred to every element over the same physical area. A wall girt spanning between frames, a roof purlin spanning between rigid frames, a wall panel spanning between girts, and a roof panel spanning between purlins may each have a different effective wind area even when they are located on the same wall or roof surface.

Fasteners require separate attention. For cladding fasteners, the effective wind area used for coefficient selection is not taken greater than the area tributary to an individual fastener. In practice, this is why screws, clips, and local attachment points often use coefficients at or near the lower-bound effective wind area shown in the C&C figures. The resulting pressure may be higher than the pressure used for the panel or supporting member, but the force is then applied over the much smaller tributary area assigned to the individual fastener.

This difference between coefficient selection and force conversion should be kept visible in the calculation. A roof purlin may be designed using a pressure associated with a relatively large effective wind area, while the roof panel and fasteners in the same roof corner zone may require higher local pressures. If the purlin pressure is reused for fasteners, the attachment design may be unconservative. If the fastener pressure is applied to the full purlin span without engineering intent, the support-member design may become unnecessarily conservative and may not reflect the actual load path.

Pressure zones are the second major source of C&C error. Walls are separated into field and corner regions, while roofs may include field, edge, and corner zones depending on roof slope, plan dimensions, and the applicable ASCE/SEI 7-22 Chapter 30 figure. The zone boundary is not selected by visual judgment alone. It must be determined from the applicable code figure before pressure coefficients are selected. In design documentation, the zone layout should be shown on roof plans and wall elevations whenever the pressure schedule will be used by a delegated designer, manufacturer, contractor, or plan reviewer.

The building-envelope load path begins at the surface pressure and continues through the cladding element, local attachment, secondary support, primary structure, and final anchorage. A complete C&C calculation therefore does more than report a pressure value. It identifies where the pressure acts, which element it is intended to design, what effective wind area was used to select the coefficient, and how the pressure will be converted into panel demand, fastener force, or member line load. This level of traceability is essential when different elements on the same surface require different pressures.

$$A_e = L_s\, b_e, \quad \text{with } b_e \geq L_s/3$$

(effective wind area for C&C member or panel)

Here, Ls is the span length of the element and be is the effective width used for coefficient selection. For a wall girt spanning between frames, the span may govern the effective width. For a panel spanning between girts, the panel width or one-third span requirement may govern. For a screw, clip, or fastener, the tributary area to the fastener controls the force conversion after the pressure is selected.

$$Ff = |p|\, At \quad kN$$

(Fastener force from tributary area)

Pressure zones are equally important. Walls are separated into field and corner regions. Roofs may include field, edge, and corner zones depending on roof slope and geometry. The zone dimension is not selected by judgment alone; it follows the applicable ASCE 7 figure. In practice, the zone layout should be drawn on roof plans and wall elevations before coefficients are selected.

$$a = \min(0.10\, L_{min}, 0.40h), \text{ but not less than } \max(0.04\, L_{min}, 0.9\text{ m})$$

(Typical low-rise C&C zone dimension form)

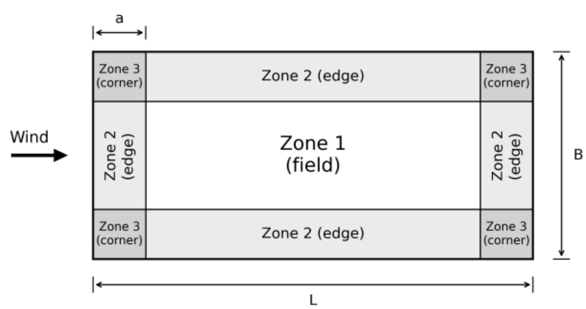

Figure 1- Schematic low-slope roof C&C pressure-zone layout. Final zone dimensions and pressure coefficients shall be selected from the applicable ASCE/SEI 7-22 Chapter 30 roof figure.

The expression above is a common form used in low-rise C&C zoning. The engineer should verify the exact notation, roof-specific dimensions, and limitations in the applicable ASCE 7-22 figure. Some roof figures use additional dimensions such as 0.6h or 0.2h. A coefficient selected without a zone diagram is difficult to review because the location assumption is not visible.

Design Office Note: A pressure coefficient is defensible only when the calculation shows the element, effective wind area, surface zone, and figure used to select the coefficient.

Module 4. Wall Cladding, Openings, and Corner-Zone Pressure Demands

Wall C&C design commonly includes wall panels, girts, studs, masonry wall segments, windows, curtain-wall mullions, personnel doors, overhead doors, louvers, and local fasteners. These elements may appear on the same elevation, but they do not necessarily use the same effective wind area, pressure coefficient, or product-rating basis. A wall girt, a metal wall panel, a storefront mullion, and an overhead door may all be located on the same wall surface while requiring different C&C pressures.

Positive wall pressure is often similar for wall field and wall corner regions, but negative pressure is typically more severe near building corners. This distinction is important because many commercial envelope schedules are prepared too generally. A single wall pressure value may be easy to place on drawings, but it can be misleading when doors, windows, panels, or mullions occur near corners. Zone 4 and Zone 5 should therefore be distinguished whenever an element may be located within the corner region defined by the applicable ASCE/SEI 7-22 Chapter 30 wall figure.

Openings require additional engineering attention because they affect both local pressure resistance and, in some cases, the enclosure classification of the building. A window, storefront system, personnel door, louver, or overhead sectional door is a C&C element that must resist positive and negative pressure normal to the wall surface. At the same time, if the opening is not designed or protected to remain in place during the design wind event, the assumed enclosed condition may no longer be valid. This can increase internal pressure and affect roof uplift, wall suction, fastener demand, and edge securement throughout the building envelope.

Large doors are a common source of coordination problems in low-rise commercial and warehouse buildings. An overhead door may have a large effective wind area and a lower external pressure coefficient than a smaller personnel door, but that does not make it less important. The door panel, guides, jamb supports, track anchorage, and surrounding wall framing must all be consistent with the scheduled pressure and the enclosure assumption. If the product submittal pressure rating is lower than the required C&C pressure, the issue should be resolved before the building is treated as enclosed in the final wind calculation.

The wall pressure schedule should therefore identify more than one value. It should normally distinguish positive and negative pressure, Zone 4 and Zone 5 demand, element type, effective wind area, and pressure level. For openings and storefront systems, the schedule should also make clear whether the pressure applies to glazing, mullions, door leaves, frames, anchors, or the complete assembly. This is particularly important when product data, delegated design submittals, or manufacturer ratings use a different pressure basis than the structural calculation.

In practice, wall C&C design is also a communication problem. The engineer may calculate pressures correctly, but the drawing or schedule may not tell the architect, supplier, or reviewer which pressure applies to a door near a corner, a window in the field zone, or a mullion spanning between floor and roof support lines. A clear schedule reduces this ambiguity and helps prevent a common review comment: "Provide C&C wind pressures for wall panels, openings, and attachments by zone."

$p_{pos} = q_h K_d[(GCp)pos - (-GCpi)]$

(controlling positive wall pressure)

$p_{neg} = q_h K_d [(GCp)_{neg} - (+GCpi)]$

(controlling negative wall pressure)

Openings require an additional layer of judgment. A window, door, or overhead door is a C&C element with its own effective wind area and pressure rating. The same opening may also influence the enclosure classification if it is not designed or protected to remain in place during the design wind event. A warehouse overhead door is therefore not merely a large wall panel. It is a local C&C element, a serviceability-sensitive product, and a possible dominant opening.

Where wind-borne debris requirements apply, pressure resistance and impact resistance should not be confused. ASCE 7 establishes wind pressure demand. ASTM E1886 and ASTM E1996 address impact and cyclic pressure performance for exterior windows, doors, curtain walls, and protective systems where required by the adopted code. A product may need to satisfy both pressure and impact criteria.

Reviewer's Comment: For buildings with large doors or storefront systems, the enclosure classification should be traceable to opening areas, pressure ratings, and protection assumptions.

Module 5. Roof Cladding, Uplift Zones, and Fastener-Level Demand

Roof C&C pressures often govern building-envelope design because suction near corners and edges is amplified by flow separation. In many low-rise commercial and warehouse buildings, the primary frame may have adequate strength for global wind effects while the roof envelope remains the critical vulnerability. The roof field pressure may be moderate, but the edge and corner zones can control panel resistance, deck attachment, clip demand, fastener spacing, perimeter securement, and local support-member design.

The roof should not be treated as one uniform pressure surface unless the applicable ASCE/SEI 7-22 procedure and the design objective justify that simplification. For flat and low-slope roofs, localized corner-zone uplift can be severe even when the mean roof height is modest. For gable and hip roofs, the roof slope, effective wind area, pressure zone, and applicable Chapter 30 figure control the coefficient selection. A roof pressure schedule that reports only a single uplift pressure will usually be incomplete for commercial envelope design, delegated submittals, and plan review.

A frequent design error occurs when the pressure selected for a purlin or joist is reused for roof panels, clips, screws, or other local attachments. This is usually unconservative. A roof purlin or joist typically has a larger effective wind area, which can lead to a lower magnitude pressure coefficient. A roof panel has a smaller effective wind area. A fastener or clip may have an even smaller tributary area and may require a coefficient at or near the lower-bound effective wind area shown in the ASCE C&C figures. The calculation must therefore remain tied to the element being designed.

This distinction is not merely mathematical. It reflects the load path. Wind suction acts first on the roof surface. The panel transfers load to clips, screws, plates, or seams. Those attachments transfer load into purlins, joists, deck supports, or other secondary framing. The secondary framing then transfers force to the primary structure and anchorage system. A pressure that is appropriate for one step in this load path may not be appropriate for another step. For that reason, roof C&C design should separate support-member pressure, panel pressure, and fastener-level demand.

A complete roof C&C schedule should normally include at least three levels of demand. The first is the support-member pressure used for purlins, joists, or roof framing. The second is the panel or deck pressure used for the roof cladding system. The third is the fastener, clip, seam, or local attachment demand. These values can be different on the same roof surface, especially in edge and corner zones. When the same scheduled pressure is used for all roof elements, the engineer should verify that the assumption is intentionally conservative and not the result of overlooking effective wind area.

Perimeter and corner detailing require particular attention. Roof failures frequently initiate at edges, corners, laps, seams, coping interfaces, or local discontinuities where suction and attachment demand are high. Once a local attachment failure occurs, load redistribution can damage adjacent panels and expose the building interior to rain, debris, and internal pressure changes. In partially enclosed or opening-sensitive buildings, roof envelope failure can also alter the pressure environment acting on other surfaces. For this reason, edge securement and corner-zone fastening should be coordinated with the calculated pressure schedule, not left to generic product assumptions.

The engineer should also distinguish pressure demand from product qualification. A calculated roof C&C pressure establishes the demand that the roof assembly or delegated designer must satisfy. Product data, approval reports, manufacturer tables, and tested assemblies must then be checked for the same pressure basis, attachment pattern, substrate condition, and zone application. A product rating that is adequate for a field zone may not be adequate for a corner zone. Similarly, a fastener pattern that works over the main roof area may require increased density or different attachment near corners and edges.

Roof C&C documentation should therefore make the location and intended use of each pressure clear. The schedule should identify roof zone, effective wind area, positive pressure where applicable, uplift pressure, element type, pressure level, and whether the value is intended for support members, panels, or attachments. If the roof system is delegated, the schedule should be clear enough that the specialty engineer can prepare a compliant submittal without guessing which pressure applies to each roof region.

Field Observation: Many roof failures initiate at local attachment points rather than at primary structural members. For that reason, the fastener-level pressure and the connection interpretation can be more important to envelope performance than the average pressure used for the supporting member.

Module 6. Worked Example 1: Low-Rise Retail Building with a Flat Roof

A one-story retail building is used to demonstrate a basic C&C pressure schedule for wall and roof envelope elements. The building is regular in plan, enclosed, and located in an open commercial development where Exposure C is appropriate. The example is not tied to a specific city and is not reproduced from a published example. Its purpose is to show a defensible SI-unit workflow for a common low-rise retail building.

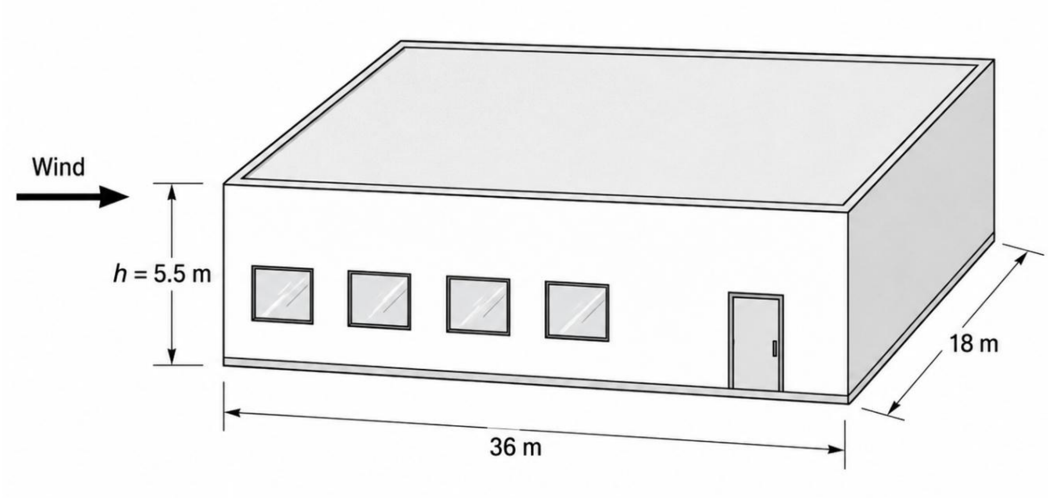

Figure 2-Flat-roof retail building geometry used in Worked Example 1. Building dimensions are 36 m by 18 m, with mean roof height h = 5.5 m.

Table 2. Design data for Worked Example 1.

Parameter	Value used in example
Plan dimensions	18 m x 36 m
Mean roof height, h	5.5 m
Roof type	Flat roof, theta <= 7 degrees
Risk category	II
Basic wind speed, V	58 m/s
Exposure category	C
Velocity pressure exposure coefficient, Kh	0.85
Kzt, Ke, Kd	1.0, 1.0, 0.85
Enclosure classification	Enclosed; GCpi = +/-0.18

The mean roof height is less than 18.3 m and does not exceed the least horizontal plan dimension. The building is therefore within the low-rise scope used in this course. The velocity pressure at mean roof height is calculated as follows.

$q_h = 0.613(0.85)(1.0)(1.0)(58)^2 = 1{,}753\ N/m^2 = 1.75\ kPa$

$q_h K_d = 1.75(0.85) = 1.49\ kPa$

The product $q_h K_d$ = = 1.49 kPa is used in the following pressure calculations.

For maximum positive pressure, negative internal pressure is used. For maximum suction or uplift, positive internal pressure is used. The following tables report strength-level design pressures in kPa normal to the surface.

Table 3. Wall C&C pressures for Worked Example 1.

Wall C&C element	**Ae (m^2)**	**+GCp**	**-GCp Zone 4**	**-GCp Zone 5**	**+p (kPa)**	**-p Zone 4 (kPa)**	**-p Zone 5 (kPa)**
Wall girt	10.1	0.82	-0.92	-1.03	+1.49	-1.64	-1.80
Wall panel / fastener	0.93	1.00	-1.10	-1.40	+1.76	-1.91	-2.35

Table 4. Roof C&C pressures for Worked Example 1.

Roof C&C element	**Ae (m^2)**	**+GCp**	**-GCp Zone 1 prime**	**-GCp Zone 1**	**-GCp Zone 2**	**-GCp Zone 3**	**+p (kPa)**	**-p Zone 3 (kPa)**
Roof support member	12.0	0.20	-0.84	-1.24	-1.71	-2.02	+0.77 min	-3.27
Roof panel / fastener	0.93	0.30	-0.90	-1.70	-2.30	-3.20	+0.77 min	-5.03

The table shows why a single roof pressure is not adequate. The corner-zone uplift for the roof panel and fastener is much larger than the positive minimum pressure and much larger than the support-member pressure. The final roof plan should identify the zone boundaries so that the scheduled pressures can be applied by the delegated designer or product supplier.

Lesson Learned: For flat-roof low-rise commercial buildings, the roof corner zone commonly controls panel and fastener design even when it occupies a limited portion of the roof plan.

Module 7. Worked Example 2: Light-Industrial Warehouse with a Low-Slope Gable Roof

The second example considers a light-industrial warehouse with metal wall panels and metal roof panels supported by secondary framing. This building type is common in U.S. commercial practice and illustrates why C&C schedules should separate girts, purlins, panels, fasteners, openings, and doors.

Table 5. Design data for Worked Example 2.

Parameter	Value used in example
Plan dimensions	42 m x 72 m
Eave height	8.0 m
Roof slope	10 degrees
Mean roof height	9.85 m
Frame spacing	6.0 m
Girt spacing	1.8 m
Purlin spacing	1.5 m
Wall and roof panel module	1.0 m nominal panel width
Basic wind speed, V	49 m/s
Exposure category	C
Kh	0.98
Kzt, Ke, Kd	1.0, 1.0, 0.85
Enclosure	Enclosed; GCpi = +/-0.18

$q_h = 0.613(0.98)(1.0)(1.0)(49)^2 = 1{,}442\ N/m^2 \approx 1.44\ kPa$

$q_h K_d = 1.44(0.85) = 1.22\ kPa$

The product $q_h K_d = 1.22\ kPa$ is used for the wall, roof, opening, panel, and fastener pressure calculations that follow.

The gable roof slope lies in the 7-degree to 20-degree range. The wall girt and purlin span between frames, while the wall panel and roof panel span between secondary members. The fastener demand is evaluated using local tributary area after pressure selection.

Table 6. Effective wind areas for Worked Example 2.

Element	Basis	Effective wind area used
Wall girt	6.0 m span; effective width not less than 2.0 m	12.0 m²
Wall panel	1.8 m span between girts; 1.0 m panel module	1.8 m²
Wall fastener	Fastener tributary area; graph lower-bound coefficient used	0.93 m²
Purlin	6.0 m span; effective width not less than 2.0 m	12.0 m²
Roof panel	1.5 m span between purlins; 1.0 m panel module	1.5 m²
Roof fastener	Fastener tributary area; graph lower-bound coefficient used	0.93 m²

Table 7. Wall pressure schedule for Worked Example 2.

Wall element	Ae (m^2)	+GCp	-GCp Zone 4	-GCp Zone 5	+p (kPa)	-p Zone 4 (kPa)	-p Zone 5 (kPa)
Wall girt	12.0	0.80	-0.90	-1.01	+1.20	-1.32	-1.45
Wall panel	1.8	0.95	-1.05	-1.30	+1.38	-1.51	-1.81
Wall fastener	0.93	1.00	-1.10	-1.40	+1.44	-1.57	-1.93

Table 8. Roof pressure schedule for Worked Example 2.

Roof element	Ae (m^2)	+GCp	-GCp Zone 1	-GCp Zone 2	-GCp Zone 3	+p (kPa)	-p Zone 1 (kPa)	-p Zone 2 (kPa)	-p Zone 3 (kPa)
Purlin	12.0	0.34	-0.87	-1.25	-1.80	+0.64	-1.29	-1.75	-2.42
Roof panel	1.5	0.55	-1.79	-2.43	-3.23	+0.90	-2.41	-3.19	-4.17
Roof fastener	0.93	0.60	-2.00	-2.70	-3.60	+0.95	-2.67	-3.53	-4.63

The purlin Zone 3 pressure is much lower than the roof fastener Zone 3 pressure because the effective wind area is larger. Both values are valid for their intended elements. The purlin pressure should not be used for fastener design, and the fastener pressure should not automatically be applied to the full purlin length unless a conservative design decision is made and documented.

Engineering Judgment: Separate schedules for framing members, panels, and fasteners reduce both unconservative detailing and unnecessary overdesign.

Module 8. Worked Example 3: Windows, Personnel Doors, Overhead Doors, and Internal Pressure

Openings are evaluated as C&C elements using wall coefficients for their effective wind areas and locations. They also influence enclosure classification if they are not designed or protected to remain in place during the design wind event. This example uses the warehouse wind parameters from Worked Example 2 and evaluates common opening types.

Table 9. Opening elements considered in Worked Example 3.

Opening element	Nominal size	Location	Effective area used
Office window	1.5 m x 1.2 m	Wall Zone 4	1.8 m^2
Personnel door	0.9 m x 2.1 m	Wall Zone 5	1.9 m^2
Overhead sectional door	4.8 m x 4.2 m	Wall Zone 5	20.2 m^2

Table 10. Opening design pressures for enclosed condition.

Opening	Ae (m^2)	Wall zone	+GCp	-GCp	+p (kPa)	-p (kPa)
Office window	1.8	Zone 4	0.95	-1.05	+1.38	-1.51
Personnel door	1.9	Zone 5	0.95	-1.29	+1.38	-1.80
Overhead sectional door	20.2	Zone 5	0.76	-0.93	+1.15	-1.36

The overhead door has a larger effective wind area and therefore a lower coefficient than the smaller personnel door. That reduction should not be interpreted as reduced importance. If the door is not rated for the required pressure or is vulnerable to failure during the design event, the building may need to be evaluated as partially enclosed for the relevant wind direction.

p(enclosed) = 1.22(-3.23 - 0.18) = -4.17 kPa

p (partially enclosed) = 1.22(-3.23 - 0.55) = -4.63 kPa

The increase is approximately 11 percent for this roof-panel case. The significance is not the percentage alone; it is the change in envelope reliability assumption. A building treated as enclosed depends on its openings remaining in place. Large overhead doors, storefront systems, and nonrated glazing should therefore be reviewed before the final roof pressure schedule is issued.

Practical Takeaway: A large overhead door is both a C&C element and a potential enclosure-classification trigger; it should be checked early in the wind design workflow.

Module 9. Worked Example 4: Complete C&C Pressure Schedule and Attachment Demand

The preceding examples develop individual pressure calculations. In professional practice, the calculation is complete only when those results are converted into a coordinated pressure schedule that can be placed in a calculation package, transmitted to the architect, and used by delegated designers. This example develops that schedule for a representative low-rise distribution building and converts selected pressures into line loads and fastener-level demands.

Table 11. Design data for Worked Example 4.

Design item	Assumed value	Engineering basis
Building use	Low-rise distribution / light-industrial building	Risk Category II ordinary commercial-industrial occupancy.
Plan dimensions	30 m x 60 m	Regular rectangular plan; least horizontal dimension = 30 m.
Mean roof height	7.5 m	Below 18.3 m and below the least horizontal dimension.
Roof form	Low-slope roof; theta <= 7 degrees	Applicable to low-rise C&C roof provisions.
Basic wind speed, V	54 m/s	Representative U.S. Risk Category II design wind speed in SI units.
Exposure	Exposure C	Open commercial / industrial terrain with scattered obstructions.
Enclosure classification	Enclosed, with large-door assumption documented	Openings are assumed designed to remain in place.
Internal pressure coefficient	GCpi = +/-0.18	Enclosed building internal pressure coefficient.
Kzt, Ke, Kd, Kh	1.0, 1.0, 0.85, 0.85	No topographic speed-up or elevation reduction used.

$q_h = 0.613(0.85)(1.0)(1.0)(54)^2 = 1{,}520\ N/m^2 = 1.52\ kPa$

$q_h K_d = 1.52\ (0.85) = 1.29\ kPa$

The product $q_h K_d = 1.29\ kPa$ is used to prepare the pressure schedule and attachment demand checks.

The pressure-zone width for the low-rise envelope is controlled by the smaller of ten percent of the least horizontal dimension and forty percent of mean roof height. In this example, both ten percent of 30 m and forty percent of 7.5 m equal 3.0 m. The zone width is therefore 3.0 m after checking the lower limits.

$a = \min(0.10(30), 0.40(7.5)) = 3.0\ m$

Table 12. Effective wind and tributary areas for Worked Example 4.

Element	Component geometry used for pressure selection	Area used
Wall girt	6.0 m span; effective width not less than one-third span	Ae = 12.0 m²
Wall panel	1.5 m support spacing by 0.60 m panel module	0.93 m² coefficient lower-bound used
Wall fastener	0.60 m panel module by 0.40 m fastener spacing	At = 0.24 m²; 0.93 m² coefficient lower-bound used
Roof purlin	6.0 m span by 1.50 m spacing; one-third span rule checked	Ae = 12.0 m²
Roof panel	1.50 m support spacing by 0.60 m panel module	0.93 m² coefficient lower-bound used
Roof fastener	0.60 m panel module by 0.30 m fastener spacing	At = 0.18 m²; 0.93 m² coefficient lower-bound used
Personnel door	1.0 m x 2.1 m	Ae = 2.10 m²
Overhead door	4.2 m x 4.8 m	Ae = 20.2 m²

Table 13. Wall and opening C&C pressure schedule for Worked Example 4, kPa.

Wall element	Zone 4 +p	Zone 4 -p	Zone 5 +p	Zone 5 -p	Use in design
Wall girt	+1.34	-1.47	+1.34	-1.67	Secondary wall framing
Wall panel	+1.52	-1.65	+1.52	-2.04	Panel pressure resistance
Wall fastener	+1.52	-1.65	+1.52	-2.04	Panel-to-girt attachment
Personnel door	+1.48	-1.60	+1.48	-1.90	Door product pressure rating
Overhead door	+1.38	-1.50	+1.38	-1.74	Door assembly and guide supports

Table 14. Roof C&C pressure schedule for Worked Example 4, kPa.

Roof element	Positive pressure	Zone 1 uplift	Zone 2 uplift	Zone 3 uplift	Use in design
Roof purlin	+0.77 minimum	-1.81	-2.12	-2.45	Secondary roof framing
Roof panel	+0.77 minimum	-2.42	-3.20	-4.36	Panel pressure resistance
Roof fastener	+0.77 minimum	-2.42	-3.20	-4.36	Panel-to-purlin attachment
Roof edge securement	+0.77 minimum	-2.42	-3.20	-4.36	Perimeter fastening / edge detailing

The roof fastener demand is calculated from the governing roof Zone 3 pressure and the actual tributary area assigned to one fastener. This conversion does not replace product approval or connection resistance checks. It provides the engineering demand that must be resisted by the selected fastener, substrate, and installation pattern.

$At = 0.60(0.30) = 0.18\ m^2$

$Ff = 4.36\ kN/m^2 \times 0.18\ m^2 = 0.78\ kN$ *per fastener*

The roof purlin line load is calculated using the purlin-level pressure and tributary width. If the purlin spacing is 1.50 m, the Zone 3 uplift line load is calculated as follows.

$w = 2.45\ kN/m^2 \times 1.50\ m = 3.68\ kN/m$

Table 15. Review-ready deliverables from Worked Example 4.

Submittal item	Pressure or force to be shown	Common review concern
Metal roof panel	Zone 1, 2, and 3 panel uplift pressures	Panel rating submitted for field zone only.
Roof fasteners	Fastener demand or required design pressure by zone	Uniform fastening used without corner-zone enhancement.
Wall panels	Zone 4 and Zone 5 positive and negative pressures	Corner suction omitted from elevation schedule.
Overhead door	Door assembly pressure and guide/support demand	Door rating based on a different pressure basis or unit system.
Windows and storefront	Positive and negative pressure by wall zone	Mullion pressure not coordinated with glazing pressure.
Delegated design criteria	Ultimate or ASD pressure basis clearly stated	Ultimate ASCE 7 pressure compared directly with allowable data.

The final output is not just arithmetic. It is a set of design values that can be transmitted without ambiguity. The schedule identifies the code basis, pressure level, units, element type, zone, and connection interpretation. This is the level of documentation normally expected when C&C pressures are used by a specialty engineer, product manufacturer, plan reviewer, or forensic reviewer after a wind event.

Engineering Judgment: The most useful C&C calculation is a pressure schedule that a reviewer, manufacturer, or delegated designer can apply without guessing which pressure belongs to which element.

Module 10. Worked Example 5: Members Crossing Multiple Pressure Zones

A practical issue occurs when a continuous girt, purlin, joist, or panel line crosses more than one C&C pressure zone. The ASCE 7 figures define zones on building surfaces, but the structural member may not terminate at the zone boundary. The engineer must decide whether to apply the most severe pressure over the entire member, use separate load segments, or compute a weighted average for member design when that approach is consistent with the actual analysis model and load path.

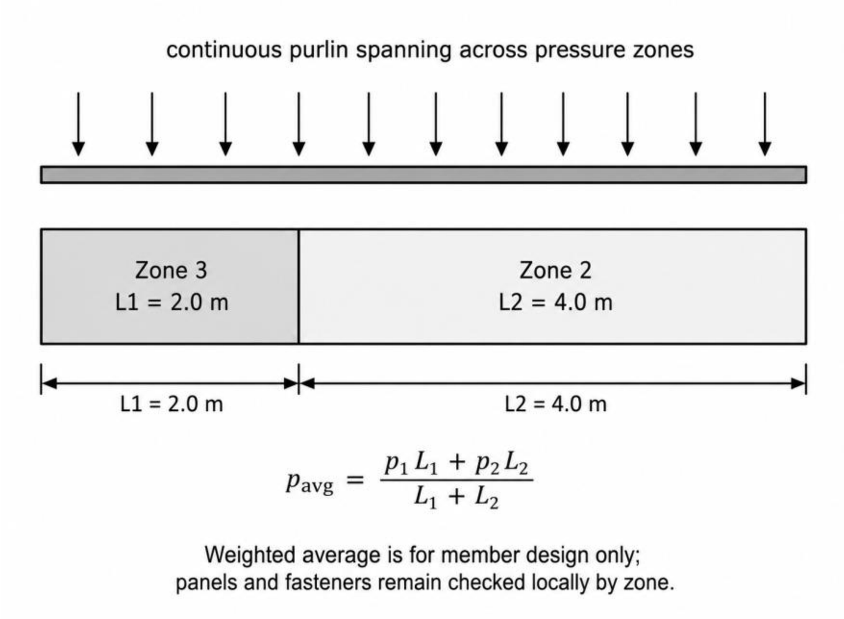

Figure -3 Continuous purlin crossing multiple C&C roof pressure zones. Weighted average pressure may be used for member design only when panels and fasteners are checked locally by zone.

Consider a roof purlin in the warehouse example. The purlin tributary length between frames is 6.0 m. Assume 2.0 m of that length is located in Zone 3 and 4.0 m is located in Zone 2. The purlin-level uplift pressures from the schedule are -2.42 kPa for Zone 3 and -1.75 kPa for Zone 2. A weighted pressure for purlin member design may be calculated as follows.

$pavg = (p_1L_1 + p_2L_2) / (L_1 + L_2)$

$pavg = [(-2.42) (2.0) + (-1.75) (4.0)] / 6.0 = -1.97 \text{ kPa}$

This weighted value applies only to the purlin-level design problem. It should not replace local panel or fastener pressures in the same zones. The roof panel and fastener remain local C&C elements, and their design pressures should still be applied by zone. If the drawing cannot communicate a segmented member load, a conservative alternative is to apply the more severe pressure over the full member length and state that assumption.

Table 16. Acceptable approaches when a member crosses multiple zones.

Approach	When it is appropriate	Documentation requirement
Segmented loading	Analysis model or hand calculation can represent the actual zone lengths.	Show zone lengths, pressure in each segment, and resulting member demand.
Weighted average	Member design is based on overall bending/shear response and local cladding is checked separately.	State that the average applies only to member design, not panels or fasteners.
Governing zone over full length	Simpler conservative design or limited documentation environment.	State that the severe zone pressure is applied conservatively over the full member length.

Design Office Note: Weighted average pressures are useful for member design, but they should not erase local zone pressures required for cladding and fastener design.

Module 11. Documentation Practice, Plan Review Case Studies, and Professional Quality Control

The strongest C&C calculation packages are not necessarily the longest. They are the ones in which every pressure can be traced to a surface, a zone, an element, an effective wind area, a coefficient, an internal pressure assumption, a pressure level, and a code provision. A reviewer should be able to verify the scope, the wind parameters, the enclosure classification, the zone layout, the selected coefficient, and the final pressure schedule without reconstructing the calculation from unrelated notes.

A professional C&C calculation should read as a coordinated design document rather than a collection of isolated pressure values. The calculation begins with the code basis and applicability of ASCE/SEI 7-22 Chapter 30, then moves through wind parameters, effective wind areas, pressure zones, coefficient selection, pressure calculation, and schedule preparation. When that sequence is visible, the calculation can be reviewed efficiently. When that sequence is missing, even correct pressures may be questioned because the reviewer cannot trace how they were obtained.

A common plan-review scenario involves a warehouse where the structural calculations provide MWFRS roof uplift for the primary frame but do not provide separate C&C pressures for roof panels and fasteners. The delegated roof supplier then submits panel data based on a uniform field pressure, while the drawings show no corner-zone fastening requirement. The review comment is not that the building lacks a wind calculation. The comment is that the envelope calculation is incomplete because local C&C demands were not carried into the roof-panel and fastener design criteria.

A second common scenario involves a large overhead door. The building is classified as enclosed, but the door product submittal later shows a pressure rating lower than the required C&C pressure. The engineer should not ignore that discrepancy. Either the door assembly must be upgraded, the door support system must be redesigned, or the enclosure classification must be revisited. The latter option may increase internal pressure and can affect roof panels, purlins, edge securement, wall panels, fasteners, and opening protection throughout the building envelope.

A third scenario occurs when the pressure schedule does not state whether the listed values are ultimate-level ASCE 7 pressures or ASD-level values intended for comparison with allowable product ratings. This issue appears frequently in delegated design and product selection. A roof panel, overhead door, or window may be submitted with an allowable pressure rating, while the structural schedule lists ultimate-level Chapter 30 pressures. If the pressure basis is not stated, the reviewer cannot determine whether the comparison is valid. This is a documentation problem, not only a calculation problem.

Another frequent coordination issue involves effective wind area. The engineer may calculate a pressure for a purlin or girt using a large effective wind area, while the product supplier assumes that same pressure applies to the panel or fastener. That transfer is not automatically valid. The pressure schedule should distinguish support members, panels, fasteners, and openings. The schedule should also state whether the pressure is intended for product resistance, connection design, line-load conversion, or delegated design criteria.

Quality control for C&C design should include a final traceability check. Each scheduled pressure should answer six practical questions: What surface is being designed? What zone applies? What element is intended? What effective wind area was used? What pressure level is being reported? What assumption controls the internal pressure? If any of these questions cannot be answered from the calculation package, the pressure schedule is not ready for review or delegated design.

In professional practice, good C&C documentation reduces both risk and delay. It allows the architect to coordinate notes, the product supplier to select the correct rating, the delegated designer to apply the correct pressure, and the plan reviewer to verify compliance without repeated requests for clarification. It also provides a defensible record if the building envelope is later reviewed after a wind event.

Final Professional Observation: C&C deficiencies are often coordination failures rather than calculation failures. The pressure schedule must be carried into drawings, product selection, delegated design, and construction review.

Table 17. Common C&C review findings and corrective actions.

Review finding	Why it matters	Corrective action
MWFRS pressure used for cladding	MWFRS pressures are not local C&C pressures and may be unconservative for envelope elements.	Calculate C&C pressures using Chapter 30 and the correct effective wind area.
One pressure used for the entire roof	Corner and edge zones may govern cladding and fasteners.	Prepare a roof-zone plan and schedule field, edge, and corner pressures.
Fastener area not evaluated	Fasteners may require the highest coefficient due to small tributary area.	Compute fastener tributary area and select coefficients accordingly.
Door pressure omitted	Large doors may govern envelope reliability and enclosure classification.	Schedule personnel and overhead door pressures by zone and effective area.
Internal pressure assumption unsupported	The difference between enclosed and partially enclosed can affect roof uplift.	Document opening areas, door ratings, and protection assumptions.
Minimum pressure ignored	Low calculated pressures may fall below the ASCE minimum.	Check the 0.77 kN/m² minimum net pressure in both directions.
Coefficient figure not stated	Reviewer cannot verify roof slope, zone, or figure selection.	Reference the ASCE 7 figure, roof slope range, and effective area used.

Table 18. Professional C&C wind design checklist.

Review item	Professional quality-control question
Scope	Is the element a building-envelope C&C item rather than MWFRS, rooftop equipment, canopy, or freestanding structure?
Applicability	Does the building qualify for ASCE/SEI 7-22 Chapter 30 Part 1?
Wind parameters	Are V, exposure, Kzt, Ke, Kd, Kh, and qh documented with units?
Enclosure	Is the enclosed or partially enclosed assumption supported by opening areas and protection assumptions?
Effective wind area	Is the area calculated from actual span, effective width, or fastener tributary area?
Zones	Are roof and wall zones shown on a plan or elevation?
Coefficients	Are coefficient values taken from the figure applicable to the roof slope and surface?
Pressure signs	Are maximum positive and maximum negative cases both evaluated?
Minimum pressure	Has the 0.77 kN/m² minimum net C&C pressure been checked?
Documentation	Can a delegated designer or plan reviewer use the schedule without guessing the intended element?

Appendix A. Sample Calculation Report Structure

A professional calculation report for C&C wind design should be organized so that the reviewer can follow the calculation without searching through unrelated wind-design material. The structure below is suitable for a low-rise commercial or warehouse building and may be adapted to office standards.

Table A1. Suggested structure for a C&C wind calculation report.

Report section	Content expected
Project and code basis	Project description, ASCE 7 edition, IBC edition, risk category, and units.
Building applicability	Mean roof height, least horizontal dimension, roof form, and Chapter 30 part selected.
Wind parameters	V, exposure, Kzt, Ke, Kd, Kh, qh, enclosure classification, and GCpi.
Zone diagrams	Roof zones and wall zones shown on plan and elevations.
Effective wind areas	Area calculations for members, panels, fasteners, openings, and mullions.
Coefficient selection	ASCE 7 figure and coefficient values for each surface and element type.
Pressure calculations	Positive and negative pressures with units and sign convention.
Pressure schedule	Final table for drawings, delegated design, and review.
Attachment interpretation	Pressure-to-force conversions where required.
Quality-control review	Minimum pressure, enclosure classification, and zone checks.

Design Office Note: A calculation report should be organized around decisions and load path, not only around arithmetic.

Appendix B. Sample Drawing Notes for C&C Wind Design

The following notes are written in a style suitable for adaptation to project drawings. They are not project specifications and should be reviewed by the responsible design professional before use.

Components and cladding wind pressures are based on ASCE/SEI 7-22, Chapter 30, Part 1, for a low-rise enclosed building unless noted otherwise. Pressures are reported as ultimate-level design pressures in kPa acting normal to the surface. Positive pressures act toward the surface and negative pressures act away from the surface. Roof and wall cladding, supports, fasteners, windows, doors, overhead doors, and mullions shall be designed for the scheduled pressures applicable to their location, pressure zone, and effective wind area.

Delegated design submittals shall identify the pressure schedule used, the applicable element, the effective wind area or tributary area, the resistance basis, and the connection layout. Product approvals or manufacturer data shall be consistent with the scheduled design pressure and the required pressure level. Where product data are based on allowable pressures, conversion from ultimate-level ASCE 7 pressures shall be documented.

Openings used to justify an enclosed building classification shall be designed or protected for the applicable design wind pressures. If large doors, storefronts, or glazing systems are not designed to remain in place for the design wind event, the building enclosure classification shall be reevaluated and partially enclosed pressures shall be considered.

Practical Takeaway: Drawing notes should make the pressure schedule enforceable and understandable to the delegated designer.

Appendix C. Strength Design, ASD Use, and Pressure Level

ASCE 7-22 Chapter 30 pressures are commonly used as strength-level design pressures. Chapter 2 then controls how wind load W is combined with other loads for strength design or allowable stress design. The pressure schedule should state the pressure level being reported. Ultimate-level pressures should not be compared directly with allowable product capacities without the correct conversion or load-combination basis.

Table C1. Communicating pressure level in design documents.

Use condition	Pressure communication issue	Recommended note
Structural steel or concrete support design	Strength design may use ultimate pressure directly in load combinations.	State that scheduled pressures are ultimate-level ASCE 7-22 pressures.
Manufacturer allowable capacity	Product data may be ASD-based or allowable-pressure based.	Confirm whether conversion from ultimate to ASD pressure is required.
Delegated cladding design	Specialty designer needs the pressure basis.	State pressure level, units, zones, and applicable ASCE 7 edition.
Plan review	Reviewer needs traceability.	Include Chapter 30 part, figure, and internal pressure assumption.

Reviewer’s Comment: The pressure level should be stated on every C&C pressure schedule; otherwise, the schedule may be misused during delegated design or product selection.

Appendix D. Air-Permeable Cladding and Product-Specific Behavior

Some cladding systems do not behave as fully air-impermeable plates. Pressure-equalized rainscreens, shingles, tiles, vegetative roof trays, and other air-permeable systems may experience pressure distribution through multiple layers of the envelope. ASCE 7-22 recognizes this issue and permits approved test data or recognized literature when lower loads are justified for the specific cladding system. In the absence of such documentation, a conservative approach applies the Chapter 30 pressure to the cladding layer designed to carry load.

The engineer should not reduce C&C pressure for a ventilated or air-permeable product without project-specific support. If a manufacturer provides tested design pressures, the test configuration should be compared with the project condition, including substrate stiffness, cavity depth, compartmentalization, fastener pattern, and edge conditions. Pressure equalization is a system behavior, not a generic material property.

Verification Tip: Do not reduce wind demand for air-permeable cladding unless the reduction is supported by approved test data or recognized literature for the actual envelope assembly.

Appendix E. Worked Example 6: ASD-Level Pressure Communication for Product Selection

Product data for wall panels, roof panels, windows, and doors may be reported as allowable pressure, test pressure, design pressure, or ultimate pressure depending on the product standard and the procurement documents. A technically correct C&C pressure can still be misused if the pressure level is not stated. This short example illustrates how pressure communication should be handled when ultimate-level ASCE 7 pressures are used to coordinate an ASD-based product submittal.

Assume the roof panel Zone 3 uplift pressure from Worked Example 4 is 4.36 kPa as an ultimate-level ASCE 7 pressure. If a delegated product submittal reports allowable pressure capacity, the design team must verify the required comparison basis. A common communication approach is to report the ultimate pressure in the structural schedule and, where requested by procurement, also provide an ASD-level reference pressure based on the wind-load factor used in ASCE 7 allowable stress design combinations.

pASD = 0.6 pultimate

pASD = 0.6(4.36) = 2.62 kPa

This conversion does not replace the product standard, manufacturer test protocol, or authority having jurisdiction requirements. It simply prevents a common coordination error: comparing an ultimate-level pressure directly with an allowable product rating. The calculation package should state whether the listed values are ultimate-level or ASD-level and should not mix both values in the same column without labels.

Table E1. Example pressure-level communication for roof panel product selection.

Pressure item	Value	How it should be used
ASCE 7 ultimate C&C pressure, roof Zone 3	4.36 kPa uplift	Use in strength-level design and as the basis for delegated design criteria.
ASD reference pressure, if required	2.62 kPa uplift	Use only when the product rating or specification is explicitly ASD/allowable based.
Submittal review requirement	Pressure basis stated by supplier	Reviewer verifies that the product rating basis matches the schedule basis.

Professional Consideration: Pressure-level notation is a design responsibility, not a clerical detail. Mislabeling ultimate and allowable pressures can lead to either unsafe product selection or unnecessary rejection of acceptable products.

References and Technical Resources

1) ASCE/SEI 7-22, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, 2022. Chapter 26 is used for general wind parameters, Chapter 30 is used for components and cladding wind pressures, and Chapter 2 is used for load combinations.
2) International Building Code (IBC), 2024 edition, International Code Council. The IBC provides the adopted building-code framework used with ASCE 7 wind provisions.
3) ASTM E1886, Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.
4) ASTM E1996, Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.
5) ANSI/DASMA 115, Standard Method for Testing Sectional Doors, Rolling Doors, and Flexible Doors: Determination of Structural Performance under Missile Impact and Cyclic Wind Pressure, where applicable to door performance requirements.
6) ACI 318-19/22, Building Code Requirements for Structural Concrete, American Concrete Institute. This reference is relevant where cladding supports, embeds, or delegated attachments transfer C&C wind forces into concrete members.
7) FEMA wind and building-envelope guidance documents, for supplementary discussion of observed wind damage, opening protection, roof performance, and building-envelope mitigation in severe wind events.
8) ASCE 7 Hazard Tool, for project-specific wind speed and hazard information used by engineers to verify design wind speed inputs.