Design Example 1
Enclosure Classification

OVERVIEW

An enclosure classification is a way of assigning a classification to a building to determine the appropriate amount of internal pressure generated. Internal pressure is a significant phenomenon that can easily be understood by drawing parallels in everyday events. The inflation of a balloon or an air mattress is a good example.

When an air mattress is inflated, a pump is usually attached to an opening on one end of the mattress. Assuming there are no other valves open, the air mattress quickly inflates when the pump is turned on. This action matches that of a *partially enclosed building*, where very large pressures are exerted on the inside of the structure.

However, if the air mattress has a hole or a release valve on one of the other sides of the mattress and the pump is turned on, air will go into the mattress but will flow out the other side. While some internal pressures inflate the air mattress, most of the air is able to escape, thus not fully inflating the mattress. This phenomenon closely matches that of an *enclosed building*: the air is able to get into the building but also able to escape so that lower internal pressures are generated.

If the air mattress has significant holes on all sides (exceeding 80 percent of the air mattress) it is easy to imagine that there would be no inflation as the air would escape as quickly as it could be pumped into the mattress. This phenomenon represents the *open building* classification.

OUTLINE

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Definitions — ASCE 7

OPEN BUILDING: A building that has each wall at least 80 percent open.

This condition is expressed for each wall by the equation

$A_o \geq 0.8A_g$ §26.2, Table 26.13-1

A_o = total area of openings in a wall that receives positive external pressure, in ft^2

A_g = the gross area of that wall in which A_o is identified, in ft^2

PARTIALLY ENCLOSED BUILDING: A building that complies with both of the following conditions:

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.

2a. The total area of openings in a wall that receives positive external pressure exceeds 4 ft^2 or 1 percent of the area of that wall, whichever is smaller, and

2b. The percentage of openings in the balance of the building envelope does not exceed 20 percent.

These conditions are expressed by the following equations:

$A_o > 1.10A_{oi}$ §26.2, Table 26.13-1

$A_o > 4\ ft^2$ or $> 0.01\ A_g$ (whichever is smaller)

and $A_{oi}/A_{gi} \leq 0.20$

A_{oi} = sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft^2

A_{gi} = sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft^2

ENCLOSED BUILDING: A building that has the total area of openings in each wall, that receives positive external pressure, less than or equal to 4 ft^2 or 1 percent of the area of that wall, whichever is smaller.

This condition is expressed for each wall by the following equation:

$A_o < 0.01A_g$, or 4 ft^2 (whichever is smaller) §26.2, Table 26.13-1

PARTIALLY OPEN BUILDING: A building that does not comply with the requirements for an *open building*, *partially enclosed building*, or *enclosed building*.

1. Enclosure Classifications

The porosity for an *enclosed building* is such that there are not sufficient openings in the exterior building envelope to allow significant air flow into the building. The porosity of a *partially enclosed building* is such that there are sufficient openings in the building envelope windward wall to allow for wind to enter the building; however, there are not sufficient openings in the remaining portions of the building envelope to allow air flow out of the building without a buildup of internal pressure. The porosity for a *partially open building* is such that there exist sufficient openings in the building envelope windward wall to allow for air flow into the building, and sufficient openings exist in the remaining portions of the building envelope to allow for some air flow out of the building but with some buildup of internal pressure. The porosity for the *open building* is such that air can enter and exit the building without a significant buildup of internal pressure. The classification of a *partially open building* has been added to the ASCE 7-16 standard to help the user understand that a building with openings and significant porosity (such as an open parking garage, for example) that fails to meet the requirements of the *partially enclosed building* classification does not automatically classify the building as an *open building*. Once the enclosure classification is known, the designer refers to Table 26.13-1 to select the appropriate internal pressure coefficient.

ASCE 7 Table 26.13-1. Main Wind Force Resisting System and Components and Cladding (All Heights): Internal Pressure Coefficient, (GC_{pi}), for Enclosed, Partially Enclosed, Partially Open, and Open Buildings (Walls and Roof)

Enclosure Classification	Criteria for Enclosure Classification	Internal Pressure	Internal Pressure Coefficient, (GC_{pi})
Enclosed buildings	A_o is less than the smaller of $0.01A_g$ or 4 sq. ft. and $A_{oi}/A_{gi} \leq 0.2$	Moderate	$+0.18$ -0.18
Partially enclosed buildings	$A_o > 1.1A_{oi}$ and $A_o >$ the lesser of $0.01A_g$ or 4 sq. ft. and $A_{oi}/A_{gi} \leq 0.2$	High	$+0.55$ -0.55
Partially open buildings	A building that does not comply with Enclosed, Partially Enclosed, or Open classifications	Moderate	$+0.18$ -0.18
Open buildings	Each wall is at least 80 percent open	Negligible	0.00

Notes

1. Plus and minus signs signify pressures acting toward and away from the internal surfaces, respectively.
2. Values of (GC_{pi}) shall be used with q_z or q_h as specified.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition:
   a. A positive value of (GC_{pi}) applied to all internal surfaces, or
   b. A negative value of (GC_{pi}) applied to all internal surfaces.

1.1 DEFINITIONS OF OPENINGS

In order to determine an enclosure classification, a determination must be made on the number of openings in the building envelope.

Openings are defined as apertures or holes in the building envelope that allow air to flow through the building envelope and that are designed as open during design winds. Examples include doors, operable windows, air intake exhausts for air conditioning or ventilation systems, gaps around doors, deliberate gaps in cladding, and flexible and operable louvers.

Non-operable glazing in hurricane zones generally need not be considered an opening due to the requirements for impact-resistant glazing. See Design Example 6 for a discussion of these requirements for high-wind regions.

1.2 PROBLEM STATEMENT

This example shows the application of enclosure classifications, including distinction between *open buildings*, *enclosed buildings*, *partially open buildings*, and *partially enclosed buildings*.

2. Design Example Problem 1a

Enclosure classification on an agricultural building with large openings.

This agricultural building has several large openings in the building envelope. On the windward wall, there is a large 200-foot-wide by 25-foot-tall opening. On the two side walls, there are matching 100-foot-wide by 30-foot-tall openings. The leeward wall and roof have no openings.

Is this building an *enclosed building*, *partially enclosed building*, *partially open building*, or *open building*?

2.1 DETERMINATION OF ENCLOSURE

Step 1: Identify the openings

	Opening Size, A_o
Windward wall	$200' \times 25' = 5{,}000$ ft^2
Side walls (2)	$2 \times (100' \times 30') = 6{,}000$ ft^2
Leeward wall	0 ft^2
Roof	0 ft^2

For simplification, the pitch of the roof is not considered in this problem and is approximated using a single height; also, the structural member sizes are ignored.

Step 2: Check *Open Building* Requirements

An open building is one in which each wall is at least 80 percent open.

	Opening Size, A_o	Gross Area, A_g	Percentage of Wall Open, A_o/A_g	80% Open?
Windward wall	$200' \times 25' = 5{,}000$ ft^2	$200' \times 25' = 5{,}000$ ft^2	100	Yes
Side walls (2)	$2 \times (100' \times 30') = 6{,}000$ ft^2	$2 \times (100' \times 30') = 6{,}000$ ft^2	100	Yes
Leeward wall	0 ft^2	$200' \times 25' = 5{,}000$ ft^2	0	No

In order to check this condition, we should compare the percentage of openings in each wall. However, it is immediately clear that the leeward wall does not meet this requirement, as it has no openings. Thus, this building cannot be classified as an *open building*. In other words, this building will generate some internal pressures. We must now determine if those internal pressures are "moderate" or "high" as defined by Table 26.13-1.

Step 3: Check *Partially Enclosed Building* Requirements

A partially enclosed building has a three-part definition. The building must comply with both of the following conditions:

1. The total area of openings in a wall must exceed the sum of the areas in the balance of the building envelope by more than 10 percent.

2a. The total area of openings in a wall must exceed the lesser of

  a. 1 percent of the area of the wall.

  b. 4 square feet

2b. The percentage of openings in the balance of the building envelope does not exceed 20 percent.

In order to check the first requirement, we must compare the windward wall openings with the sum of the remainder of the openings.

Equation: Windward wall openings > 1.10 × (leeward wall openings + side wall openings + side wall openings + roof openings)

$$5{,}000 \text{ ft}^2 \ngtr 1.10\,(3{,}000 \text{ ft}^2 + 3{,}000 \text{ ft}^2) = 6{,}600 \text{ ft}^2$$

In this case, the openings in the windward wall do not exceed the balance of the building by 10 percent. As a result, this building cannot be classified as a *partially enclosed building*.

We are not required to check condition 2a or 2b, as a *partially enclosed building* classification must meet both condition 1 and conditions 2a and 2b. See problem 1b for a check of conditions 2a and 2b.

Step 4: Check *Enclosed Building* Requirements

In previous versions of ASCE 7, the definition for an enclosed building was one that did not comply with that of an open building or a partially enclosed building. In ASCE 7-16, there is a more explicit definition:

Enclosed Building: A building that has the total area of openings in each wall that receives positive external pressure less than or equal to 4 square feet or 1 percent of the area of that wall, whichever is smaller.

	Opening Size	Gross Area, A_g	Percentage of Wall Open	$< 4\text{ft}^2$ or 1% of Wall?
Windward wall	$200' \times 25' = 5{,}000 \text{ ft}^2$	$200' \times 25' = 5{,}000 \text{ ft}^2$	100	No
Side walls (2)	$2 \times (100' \times 30') = 6{,}000 \text{ ft}^2$	$2 \times (100' \times 30') = 6{,}000 \text{ ft}^2$	100	No
Leeward wall	0 ft^2	$200' \times 25' = 5{,}000 \text{ ft}^2$	0	Yes

Due to the large openings in the windward and side walls, this building does not classify as an enclosed building or partially enclosed building.

Step 5: Check *Partially Open Building* Requirements

New to ASCE 7-16 is the partially open building classification. It is defined as a building which does not comply with open building, partially enclosed building, or enclosed building guidelines.

2.2 SUMMARY

Because this structure doesn't fall under the classification of an open building, partially enclosed building, or enclosed building, this building would be classified as a partially open building, using an internal pressure coefficient of $GC_{pi} = \pm 0.18$.