

NONSTRUCTURAL Component



NONBUILDING Structure?

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How should the determination be made whether an item is treated as a nonstructural component or a nonbuilding structure for purposes of seismic design? The following guidelines will help, but—as shall be seen—necessarily involve many generalizations, so common sense must be exercised.

Nonstructural Components

Traditionally, nonstructural components have been identified as architectural, mechanical and electrical components found in buildings. Prior to the *International Building Code* (IBC), the focus had been on the design of anchorage and bracing of these components and not the components themselves. The components had been treated as “black boxes” and whatever was inside the boxes was

not required to be designed for seismic loads. Exceptions to this approach were items such as towers on tops of buildings (radio and cell towers), heavy cladding, battery racks, billboards and signage attached to buildings.

Since the 2000 IBC, when components were determined to have an importance factor of 1.5, they generally needed to be designed or qualified to resist the effects of seismic forces. Current IBC seismic requirements for anchorage and bracing of nonstructural components are given in



Nonbuilding structure similar to a building.

American Society of Civil Engineers (ASCE) 7-05, *Minimum Design Loads for Buildings and Other Structures*, Chapter 13.

Nonbuilding Structures

Nonbuilding structures are self-supporting structures other than buildings that carry gravity loads and resist the effects of earthquakes. The concept of providing specific seismic design requirements for nonbuilding structures was first introduced into the model codes in the 1988 *Uniform Building Code*. The most current seismic design requirements for nonbuilding structures are given in ASCE 7-05 Chapter 15.

There are two types of nonbuilding structures. One type has a structural system similar to buildings, and the other type has a structural system that is not similar to buildings. This article pertains to nonbuilding structures which are not similar to buildings and focuses on the determination of when the design rules of ASCE 7-05 Chapter 15 or ASCE 7-05 Chapter 13 apply.

Figure 1 provides a visual illustration that shows:

- items which should be treated as nonstructural components,
- items which should be treated as nonbuilding structures and
- items which appear to be ambiguous because they are permitted to be treated either way.

Note that most, if not all, nonbuilding structures support attached nonstructural components of some type. One item of interest not shown is skid-mounted equipment modules (to be addressed later.)

Differentiating between Nonstructural Components and Nonbuilding Structures

There are several general ways to differentiate between nonstructural components and nonbuilding structures. The first is size. Stated simply: nonstructural components are typically small and nonbuilding structures are typically large. What do we mean by “small” and “large”? Mechanical and electrical equipment components are typically small enough to fit within a building; something on the order of less than 10 feet tall. There are, of course, exceptions such as signs attached to



Nonbuilding structure not similar to a building.

buildings and very large generators and turbines. Although somewhat arbitrary, our basis for selecting 10 feet in height is twofold: (1) it represents a story height which will allow installation within a building, and (2) the weight of a component that height or less is likely to be small relative to the weight of the supporting structure.

Another way to differentiate between nonstructural components and nonbuilding structures is whether they are factory assembled or field erected. Nonstructural components are typically factory assembled: transported to the jobsite in one piece and requiring no assembling. There obviously are many nonstructural components that are assembled on the site, such as ceilings; partition walls; exterior curtain walls; exterior siding; masonry veneer; cable trays; piping systems; ductwork; large, roof-mounted roof handlers; elevators; etc. Fortunately, there is no question that these should be treated as nonstructural components and that the design criteria of ASCE 7-05 Chapter 13 apply. Nonbuilding structures are most likely field erected. Exceptions include large vertical vessels, hoppers and bins which can be shipped on trucks or railcars to the jobsite, but essentially every other type of nonbuilding structure is erected in the field.

The last major difference between a nonstructural component and a nonbuilding structure is the basis for design and construction. Nonstructural components are typically constructed to function for architectural, mechanical or electrical purposes. The primary function of nonbuilding structures is to maintain structural

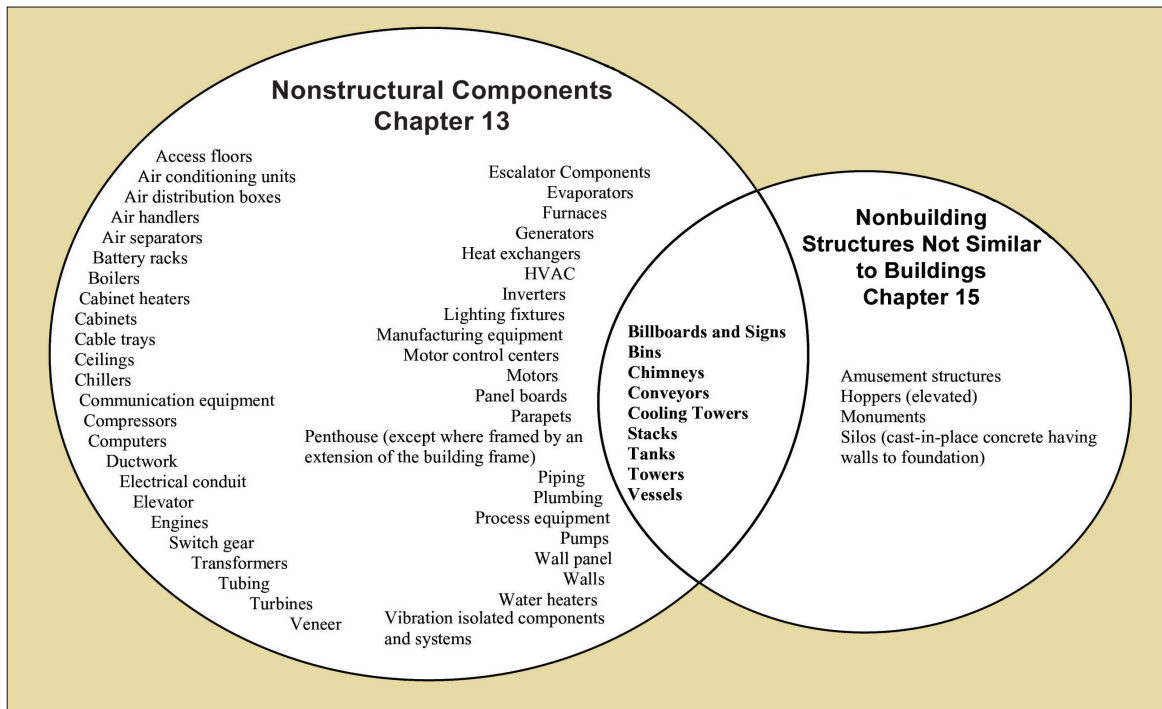


Figure 1. Intersection of nonstructural components and nonbuilding structures.

stability: they are typically constructed to resist gravity and lateral loads, and the structural system is typically very carefully designed for seismic loads. For example, a communications tower is designed to maintain structural stability, whereas a motor is primarily designed for mechanical functionality—seismic design may be inherent and therefore not rigorously evaluated (other than for anchorage).

Another Design Option

When in doubt, the designer always has the option of calculating the force demand in accordance with the nonstructural component equation in ASCE 7-05 Chapter 13 and the nonbuilding structure equation in ASCE 7-05 Chapter 15 and using the most conservative design.

The design force equation for nonstructural components is indirectly dependent on the period of the item (is it flexible or rigid?), whereas the design force equation for nonbuilding structures is directly dependent on the period of the structure. For nonstructural components, the period of the item affects the determination of the amplification factor, a_p . Because of differences in the form of the two sets of equations and the defined parameters, they may yield quite different results.

Nonstructural Components

$$F_p = \frac{0.4a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)} \left(1 + 2\frac{z}{h}\right)$$

F_p shall not be taken as less than: $F_p = 0.3S_{DS}I_pW_p$

F_p is not required to be taken as greater than:

$$F_p = 1.6S_{DS}I_pW_p$$

for $T \leq T_s$:

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I}\right)}$$

for $T_L > T > T_s$:

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I}\right)}$$

for $T > T_L$:

$$C_s = \frac{S_{D1}T_L}{T^2\left(\frac{R}{I}\right)}$$

Nonbuilding Structures not Similar to Buildings

For nonbuilding systems that have an R value provided in Table 15.4-2, C_s shall not be taken as less than:

$$C_s = 0.03$$

For nonbuilding structures located where $S_1 \geq 0.6g$, C_s shall not be taken as less than:

$$C_s = \frac{0.8S_1}{\left(\frac{R}{I}\right)}$$

Are Penthouses Really Nonstructural Components?

One of the items listed in Figure 1 as a nonstructural component may come as a surprise: penthouses (except where framed by an extension of the building frame).

A penthouse is typically a structure on a roof for housing elevator machinery, equipment, water tanks, etc. It can easily be more than 10 feet in height and is most likely constructed at the jobsite. Because penthouses are typically located at the roof level and are of a small mass and footprint size compared to the structure as a whole, thus not affecting the dynamics of the entire structure, they are classified as nonstructural components provided they are not part of the building frame. One could argue that their framing system is similar to that of a building; however, they also can be viewed as a small appendage to a structure, similar to a tower. If the penthouse is framed by an extension of the building frame, it needs to be designed as part of the building as a whole.

Nonbuilding Structures Supported within a Building or Other Structures

Sometimes the seismic design forces of a nonbuilding structure need to be determined using the same equations used for a nonstructural component. This happens when, rather than being supported on the ground, the nonbuilding structure is supported within a building or by another nonbuilding structure. ASCE 7-05 Section 15.3 provides clear instructions for this condition.

Where the weight of the supported nonbuilding structure is relatively small compared to the weight of the supporting structure, the assumption is that the supported nonbuilding structure will have a relatively small effect on the overall nonlinear earthquake response of the primary structure during design-level ground motions. (The code equates “relatively small” to weighing less than 25 percent of the combined weight of the nonbuilding structure and supporting structure.) In these cases, the code allows such structures to be considered

as nonstructural components and the requirements of ASCE 7-05 Chapter 13 to be utilized for their design.

When the weight of the supported structure is large as compared to the weight of the supporting structure (greater than or equal to 25 percent of the combined weight of the nonbuilding structure and supporting structure), it is expected that the combined response could be significantly affected by the combined response of the supported and supporting nonbuilding structure. Two analysis options permitted to be used for this situation are set forth in ASCE 7-05 Section 15.3.2.

Equipment Modules (Equipment Skids)

Equipment modules are implicitly, but not explicitly, covered by ASCE 7-05. Sometimes these modules have exterior coverings and one could consider them as very large “black boxes.” Preassembled modular units are typically transported on a truck and therefore must have a certain level of inherent ruggedness to account for transportation loadings. It is the authors’ opinion that such transportation design loads are usually sufficient to assure adequate seismic performance in lower areas of seismicity (structures assigned to Seismic Design Categories A, B or C) if the module is not stiffened or braced in any way for transportation.

In higher areas of seismicity (structures assigned to Seismic Design Categories D, E or F), seismic design of the primary structural frame of the modular unit should be demonstrated. Obviously, if a modular unit does not weigh much—for example, 400 pounds—it does not make sense to require design for seismic loads. However, if a modular unit is of substantial weight—say, 2,000 pounds—the primary support members should be designed in accordance with ASCE 7-05 Chapter 13, and a_p and R_p values should correspond to the ASCE 7-05 Table 13.6-1 entry excerpted in Table 1.

Table 1. ASCE 7-05 Table 13.6-1 excerpt.

Mechanical and Electrical Components	a_p	R_p
Wet-side HVAC, boilers, furnaces, atmospheric tanks and bins, chillers, water heaters, heat exchangers, evaporators, air separators, manufacturing or process equipment, and other mechanical components constructed of high deformability materials.	1.0	2.5

(continued)

Nonstructural/Nonbuilding (continued)

Table 2. ASCE 7-05 Table 13.6-1 Table 2. Discussion of items which can be either nonstructural components or nonbuilding structures.

Item	ASCE 7-05 Ch. 13 R_p Value	ASCE 7-05 Ch. 15 R Value	Discussion
billboards and signs	2.5	3.5	Items attached to a structure are considered nonstructural components and Chapter 13 should be used. If an item is attached and supported by another structure, it may be of such size and weight that it needs to be treated as a nonbuilding structure supported by other structures and the seismic design forces determined in accordance with Section 15.3, which refers back to Chapter 13. If an item is assembled and is a freestanding, ground-supported structure, it should be treated as a nonbuilding structure and Chapter 15 should be used.
bins	1.0	2 or 3	
chimneys	varies	3	There are many types of chimneys, ranging from residential to industrial. A chimney attached to a structure may be of such size and significance that it can be considered an architectural nonstructural component and designed in accordance with Chapter 13. Industrial, institutional and commercial chimneys that are attached and supported by other structures may be of such size and weight that they need to be considered nonbuilding structures supported by other structures, with the seismic design forces determined in accordance with Section 15.3, which refers back to Chapter 13. Freestanding industrial, institutional and commercial chimneys are typically of a size that they are considered nonbuilding structures and should be designed in accordance with Chapter 15.
conveyors	2.5	usually considered "nonbuilding structures similar to buildings" except for their mechanical parts	Support structures for conveyors used in large industrial complexes such as surface mining facilities typically qualify as nonbuilding structures similar to buildings. There are, however, smaller manufacturing, processing and material handling conveyors which can be transported in a truck in one piece and would qualify as nonstructural components. In the case where conveyors are designed as nonbuilding structures in accordance with Chapter 15, the bracing and anchorage for the actual mechanical workings should be designed in accordance with Chapter 13.
cooling towers	2.5 or 1.0	3.5	If a cooling tower is shop-fabricated and transported in a truck, it is considered a nonstructural component and should be designed in accordance with Chapter 13. If it is self-supporting and field erected, it should be considered a nonbuilding structure and designed in accordance with Chapter 15.
stacks	2.5 or 1.0	3	Stacks that are supported by or attached to a structure are considered nonstructural components and should be designed in accordance with Chapter 13. Stacks that are freestanding or guyed-supported at grade are considered nonbuilding structures and should be designed in accordance with Chapter 15.
tanks	1.0	varies	It is recommended that tanks which are small (5 feet or less in diameter), shop-fabricated and transported to the site in one piece be considered nonstructural components and designed in accordance with Chapter 13. It is recommended that tanks which are larger in size (greater than 5 feet in diameter) and constructed at the jobsite be considered nonbuilding structures and designed in accordance with Chapter 15. Should a larger tank be installed within a building or on the roof, design forces may need to be determined in accordance with Section 15.3, which refers back to Chapter 13.
towers	2.5 or 1.0	varies	Towers are typically shop-fabricated and shipped to the site in pieces to be field erected. As such, they are considered nonbuilding structures. However, there are times when a tower is small and transported in one piece so it qualifies as a nonstructural component. If the tower is attached and supported by another structure, it may be of such a size and weight that design forces should be determined in accordance with Section 15.3, which refers back to Chapter 13.
vessels	2.5 or 1.0	varies	If a vessel is less than 10 feet tall, it can typically fit within a building and is considered a nonstructural component. If a vessel is more than 10 feet tall, it most likely should be considered a nonbuilding structure. Power boilers typically qualify as nonbuilding structures. Freestanding vessels should typically be considered nonbuilding structures. If a vessel is attached and supported by another structure, it may be of such a size and weight that design forces should be determined in accordance with Section 15.3, which refers back to Chapter 13.

Design of Items Which Can be either a Nonstructural Component or a Nonbuilding Structure

With the differences between nonstructural components and nonbuilding structures outlined, it is appropriate to take a look at the apparently ambiguous items illustrated in Figure 1. Table 2 provides an overview of these items.

Conclusion

The foregoing provides guidance on how the authors believe items that could be identified as either nonstructural components or nonbuilding structures be treated from a seismic design perspective. Because of the wide variety of real-world items, it is extremely difficult to write all-inclusive code guidelines. Again, the application of a good dose of common sense will lead to the appropriate treatment. ♦

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