

## conference preview

# NONBUILDING STRUCTURES AND NONSTRUCTURAL COMPONENTS

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Knowing the differences between the two will enhance the design experience and outcome for both.

**STRUCTURAL ENGINEERING DESIGN** typically falls under one of the following three categories: building structures, nonbuilding structures or nonstructural components.

While the majority of structural engineering encompasses building structures, most designers will also deal with nonbuilding structures and nonstructural components throughout their careers. And it's important to recognize the differences between the latter two categories.

ASCE 7: *Minimum Design Loads for Buildings and Other Structures* defines a *nonbuilding structure* as a "self-supporting structures that carry gravity loads that may be required to resist the effects of earthquake." *Nonstructural components* are defined as architectural, mechanical, plumbing or electrical components "that are permanently attached to structures." Oftentimes a component may actually be categorized as either a nonbuilding structure or a nonstructural component (see Figure 1).

### Nonbuilding Structures

In addition to knowing which elements are nonbuilding structures and which are nonstructural components, it's also important to understand how both categories compare to building structures.

While nonbuilding structures are similar to buildings in terms of basic structural dynamics and ground motion hazards, they have different structural characteristics and performance objectives. In addition, the design of nonbuilding structures often requires additional considerations such as fluid dynamics and networked systems. Nonbuilding structures fall into

one of two classifications: similar to buildings or not similar to buildings.

Nonbuilding structures meeting the first of these two classifications have structural systems that are designed and constructed similar to those for buildings in addition to having a similar dynamic response. Examples of nonbuilding structures that are similar to buildings include pipe racks, steel storage racks, power generation facilities and towers for tanks or vessels. The design of these structures follows the requirements of Chapter 15 and applicable parts of Chapters 11, 12 and 14 of ASCE 7.

Examples of nonbuilding structures that are not similar to buildings include earth-retaining structures, tanks and vessels, telecommunication towers, stacks and chimneys. The dynamic response of these structures is different than that of buildings and often requires specialty design guides and standards. Chapter 15 of ASCE 7 provides direct references to many of these standards (e.g., API 620, API 650, AWWA D100, etc.), but regardless of what is obtained from these standards, the design loads shall not be less than what is provided in ASCE 7.

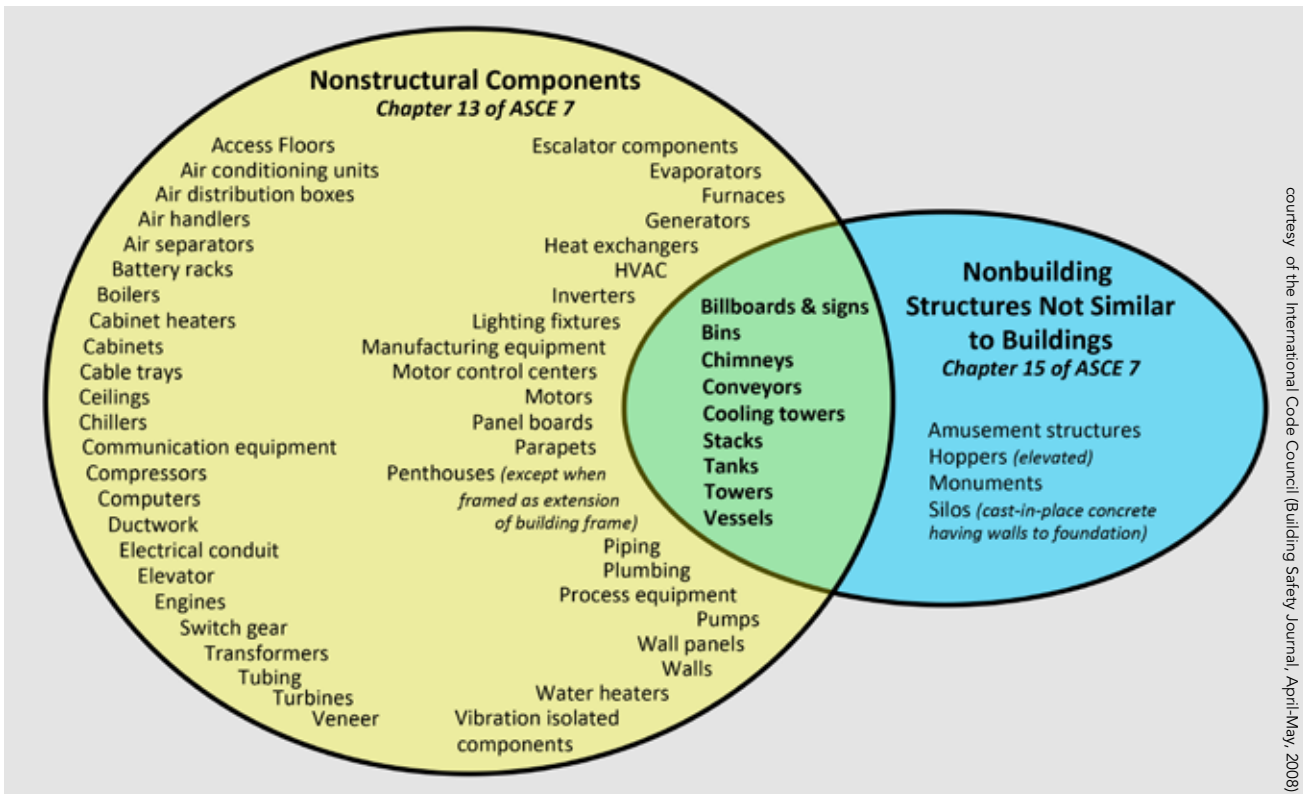
When it comes to design loads for nonbuilding structures, they must take into account the dead load of the structure in addition to the weight of the normal operating contents. While the drift limitations of Chapter 12 do not apply, a rational analysis must be performed showing that structural stability and attached components are not adversely affected. The approximate period provided in Chapter 12 of ASCE 7 cannot be used for nonbuilding structures, therefore requiring the period to be substantiated by means of analysis. In addition, the importance factor used in the design of nonbuilding structures should be the largest value obtained from applicable referenced standards, such as Table 11.5-1 of ASCE 7 or as elsewhere specified in Chapter 15 of ASCE 7.

Nonbuilding structures that are supported by other structures must meet the requirements of Section 15.3 of ASCE 7. In following this section, there are three possible outcomes:

1. If the nonbuilding structure weighs *less than 25%* of the combined seismic weight of the nonbuilding structure and the supporting structure, it should be considered a nonstructural component and designed in accordance with Chapter 13 of ASCE 7.



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▲ Figure 1. Intersection of nonstructural components and nonbuilding structures.

2. If the nonbuilding structure weighs 25% or more of the combined seismic weight and has a period of less than 0.06 seconds:
  - ▶ The nonbuilding structure is considered a “rigid” element
  - ▶ Analysis shall use the  $R$  factor of the supporting structure
  - ▶ It shall meet the design requirements of Chapter 13 of ASCE 7 but use the response modification factor ( $R_p$ ) obtained from Table 15.4-2 and an amplification factor ( $a_p$ ) of 1.0
3. If the nonbuilding structure weighs 25% or more of the combined seismic weight and has a period equal to or greater than 0.06 seconds:
  - ▶ The nonbuilding structure and the supporting structure must be modeled together
  - ▶ The nonbuilding structure shall use the lesser response modification factor ( $R_p$ ) of the nonbuilding structure and the supporting structure
  - ▶ It shall meet the design requirements of Section 15.5 of ASCE 7

### Nonstructural Components

Nonstructural components consist of architectural, mechanical, plumbing and electrical components that are permanently attached to structures. There is often debate as to who is responsible for the anchorage and restraint of nonstructural components. Is it the structural engineer, architect, mechanical engineer, etc.? Chapter 12 of FEMA 389 discusses how a unified approach can be used by the design team to ensure that a scope of work is provided for each element thus clarifying who in the design team is responsible for that item. FEMA 389 also includes sample checklists to aid in this endeavor.

Concerning forces and displacements, Chapter 13 of ASCE 7 provides clear guidance on how to calculate the seismic design force for each component. Separate response modification and component amplification factors are provided in Table 13.5-1 for architectural components and in Table 13.6-1 for mechanical, plumbing and electrical components. If the component has multiple connection points, the design must also take into account displacement that can occur within the structure or displacements that could occur between separate structures.

When not exempt by Chapter 13 of ASCE 7, the construction documents must show the seismic restraint requirements for nonstructural components and their supports and attachments. They shall also note the special inspection requirements for their installation per Section 13.2.7 of ASCE 7. In addition, Section 1705.12.3 of the *International Building Code (IBC)* requires that the design professional list on the construction documents the certification requirements for designated seismic systems. Section 202 of the *IBC* defines designated seismic systems



as “those nonstructural components... for which the component importance factor is greater than 1”. Chapter 13 of ASCE 7 then clarifies that the following conditions would result in an importance factor of greater than 1:

- ▶ The component is required to function for life-safety purposes after an earthquake
- ▶ The component conveys, supports or otherwise contains hazardous, highly toxic or explosive substances and can pose a threat to the public
- ▶ The component is in or attached to a Risk Category IV structure, and failure could impair the continued operation of the facility

In essence, designated seismic systems are those nonstructural components that are most likely to affect life-safety after a seismic event. Section 1705.11.4 of the *IBC* also requires that special inspection be provided for designated seismic systems.

When it comes to supports and anchorage, nonstructural components shall be “bolted, welded or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.” This anchorage shall be provided for not only the component but also its support. A good example would be of a rooftop unit. While appropriate anchorage may be provided for the unit to the

rooftop curb, the curb itself must also be properly anchored to the supporting structure. Per Section 13.4.2 of ASCE 7, anchors in concrete are to comply with Appendix D of ACI 318, anchors in masonry are to meet TMS 402/ACI 530/ASCE 5, post-installed anchors are to be prequalified for seismic applications and power-actuated fasteners resisting sustained tension loads or friction clips are not allowed in high-seismic regions.

A quick note on seismic design requirements: The current requirements for nonbuilding structures are found in Chapter 15 of ASCE 7 while the requirements for nonstructural components are located in Chapter 13 of ASCE 7. For nonbuilding structures such as vehicular bridges, electrical transmission towers, hydraulic structures, buried utility lines and their appurtenances, nuclear reactors and piers or wharves, the seismic design requirements are not provided in ASCE 7 but rather in industry standards specific to the element type. ■

*This article is a preview of Session N43 “Nonbuilding Structures and Nonstructural Components” at NASCC: The Steel Conference, taking place April 13–15 in Orlando. Learn more about the conference at [www.aisc.org/nascc](http://www.aisc.org/nascc).*