# *Is It a Nonstructural Component or a Nonbuilding Structure?*

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This article provides guidance to code users on how to determine whether or not an item should be treated as a nonstructural component or a nonbuilding structure for purposes of seismic design. In order to explain the differences between nonstructural components and nonbuilding structures, many generalizations need to be made so that the discussion can be simplified as much as possible. Common sense also needs to be exercised, as these generalizations don't always apply. Also, it should be noted, that the guidance provided herein represents only the collective opinion of the authors at this point in time. It is hoped that as the nonstructural component and nonbuilding structure code provisions evolve, some of these guidelines will become obsolete as the code will directly address these issues.


*Figure 1: Nonbuilding Structure Similar to Building.*

*Figure 2: Nonbuilding Structure Not Similar to Building.*

## Nonstructural Components

Traditionally, nonstructural components have been identified as architectural, mechanical and electrical components found in buildings. Prior to adoption of 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 themselves had been treated as a "black box" and whatever was inside the "black box" was not required to be designed for seismic loads. Exceptions to this "black box" approach were items such as towers on tops of buildings (radio and cell towers), heavy cladding, battery racks, billboards and signage attached to buildings. Current IBC seismic code requirements for anchorage and bracing requirements for nonstructural components are found in ASCE 7-05 Chapter 13. It should be noted that, starting with the 2000 IBC, when the component is determined to have an importance factor of 1.5, the "black box" itself now generally needs to be designed, or qualified, to resist the effects of seismic forces.

## Nonbuilding Structures

Self-supporting nonbuilding structures are 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 code requirements in the *1988 Uniform Building Code* (UBC). The most current seismic design requirements for nonbuilding structures are found 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 (*Figures 1* and *2*). The focus of this article is on nonbuilding structures which are not similar to buildings, and the determination of when the design rules of ASCE 7-05 Chapter 15 apply and when the design rules of ASCE 7-05 Chapter 13 apply.

*Figure 3* provides a visual illustration that shows:

1) those items which should be treated as nonstructural components;
2) those items which should be treated as nonbuilding structures; and
3) those items, such as tanks, that appear to be ambiguous since they are permitted to be treated either way.

It should be noted that most, if not all, nonbuilding structures support attached nonstructural components of some type. One item not shown on the list that is of interest is skid mounted equipment modules.

## Differentiating Between Nonstructural Components and Nonbuilding Structures

There are a number of obvious differences between nonstructural components and nonbuilding structures. First is size. To say it simply, nonstructural components are typically small, and nonbuilding structures are typically big. "Small" and "big" now need to be described in a more definitive way. 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 to the 10 feet, such as signs attached to buildings and very large generators and turbines. The 10-foot height is obviously an arbitrary height. The basis for selecting 10 feet is twofold:

1) it represents a story height which will allow installation within a building, and
2) the weight of the component is likely small relative to the weight of the supporting structure.

Another obvious difference between nonstructural components and nonbuilding structures is whether they are factory assembled or field erected. Nonstructural components are typically factory assembled in that they are transported in one piece on a truck and require no assembling at the jobsite. Obviously there are many nonstructural components that are assembled on the site in pieces 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

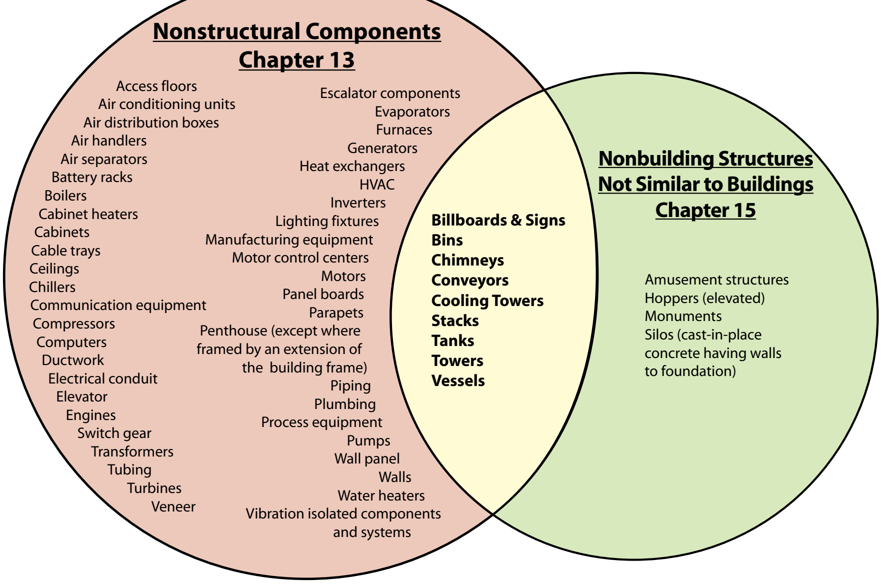


*Figure 3: Intersection of Nonstructural Components and Nonbuilding Structures.*

that these all should be treated as nonstructural components and the design criteria in ASCE 7-05 Chapter 13 apply. Nonbuilding structures are most likely field erected, as they are constructed at the jobsite. Exceptions to this rule would be large vertical vessels, hoppers and bins which can be shipped on trucks or railcars to the site. Essentially every other type of nonbuilding structure is constructed at the jobsite.

Another major difference between a nonstructural component and a nonbuilding structure is the basis for its 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 stability, and 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 and seismic design may be inherent and therefore not rigorously evaluated (other than for anchorage).

## Designer's 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 non-building structures is directly dependent on the period of the structure. For nonstructural components, the period of the item affects the determination of the $a_p$ factor. Because of differences in the form of the two sets of equations and the defined parameters, as shown in the box below, they may yield quite different results.

*Nonstructural Components:*

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

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

$F_p$ is not required to be taken as greater than: $F_p = 1.6 S_{DS} I_p W_p$

*Nonbuilding Structures Not Similar to Buildings:*

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I}\right)} \text{ for } T \leq T_s$$

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I}\right)} \text{ for } T_L \geq T > T_s$$

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

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:

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

## Penthouses: Are They Really a Nonstructural Component?

There is one item listed as a nonstructural component in *Figure 3* that 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 it is most likely constructed at the jobsite. Because penthouses are typically located at the roof level, 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, then it needs to be designed as part of the building as a whole.

## Nonbuilding Structures Supported Within a Building or Other Structures

Sometimes a nonbuilding structure needs to have its seismic design forces determined using the same equations used to determine forces as specified 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. In these cases, the code allows such structures to be considered as nonstructural components and they can therefore utilize the requirements for Chapter

13 for their design. The code equates "relatively small" to weighing less than 25 percent of the combined weight of the nonbuilding structure and supporting structure.

Where 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. There are two analysis options that are permitted to be used for this situation, and they are set forth in ASCE 7-05 Section 15.3.2.

## Equipment Modules (Equipment Skids)

Equipment modules are currently not explicitly (but implicitly) covered by ASCE 7-05, and therefore a suggested seismic design approach is provided in this article. Sometimes these modules have exterior coverings and one could consider them as very large "black boxes". There's a certain inherent ruggedness of equipment modules because these preassembled modular units are typically transported on a truck and therefore must have a certain level of inherent ruggedness because of transportation loadings. It is the authors' opinion that 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 anyway 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 doesn't weigh much, for example 400 pounds, it does not make sense to require a design. On the other hand, if a modular unit weighs 2000 pounds, it is prudent to design for seismic loads. In such a case, the primary support members should be designed in accordance with ASCE 7-05 Chapter 13, and $a_p$ and $R_p$ values should be the same as that for the entry from ASCE 7-05 Table 13.6-1 shown in *Figure 4*.

| 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 |

*Figure 4: From ASCE 7-05 Table 13.6-1*

## Design of Items Which Can Be Either a Nonstructural Component or a Nonbuilding Structure

Now that the differences between nonstructural components and nonbuilding structures have been described, it is appropriate to take a look at the apparently ambiguous items (the overlap items in *Figure 3, page 19*). *Table 1* provides discussion on these items.

## Conclusion

The foregoing article provides guidance on how the authors believe items that could be identified as either nonstructural components or nonbuilding structures can be treated from a seismic design perspective. Because of the wide variety of items, it is extremely difficult to write all-inclusive definition rules within the code. It is hoped that the guidance provided along with the application of a good dose of common sense will lead users to the appropriate treatment.▪

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*Table 1: Discussion of Items Which Can Be Either Nonstructural Components or Nonbuilding Structures.*

| Item | Ch 13 $R_p$-value | Ch 15 R-value | Discussion |
|---|---|---|---|
| Billboards and Signs | 2.5 | 3.5 | If the item is attached to a structure, then it is considered a nonstructural component and Chapter 13 is used. If the item is attached and supported by another structure, it may be of such a size and weight that it needs to be treated as a nonbuilding structures supported by other structures with the seismic design forces determined in accordance with Section 15.3 which refers back to Chapter 13. If the item is assembled and is a free standing, ground-supported structure, then 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 chimneys. A chimney attached to a structure may be of such a 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 a 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, on the other hand, are typically of a size that they are considered nonbuilding structures and designed in accordance with Chapter 15. |
| Conveyors | 2.5 | They are usually considered "nonbuilding structures similar to buildings" except for the mechanical parts. | The support structures for conveyors which are 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 a nonstructural component. 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 Tower | 2.5 or 1.0 | 3.5 | If the cooling tower is shop fabricated and transported in a truck, it is considered a nonstructural component and designed in accordance with Chapter 13. If it is self-supporting and field erected, then it is 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 are designed in accordance with Chapter 13. Stacks that are free standing or guyed-supported at grade are considered nonbuilding structures and 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 such a larger tank be installed within a building or on the roof, then 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 | A tower is typically shop fabricated and shipped to a site in pieces to be field erected. As such, they are considered nonbuilding structures. But there are times when a tower is small enough and transported in one piece that 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 may need to be determined in accordance with Section 15.3 which refers back to Chapter 13. |
| Vessels | 2.5 or 1.0 | varies | If the vessel is less than 10 feet tall, it can typically fit within a building and is considered a nonstructural component. If the vessel is more than 10 feet tall, it most likely should be considered a nonbuilding structure. Vessels that are power boilers typically qualify as a nonbuilding structure. Free standing vessels should typically be considered nonbuilding structures. If the vessel is attached and supported by another structure, it may be of such a size and weight that design forces may need to be determined in accordance with Section 15.3 which refers back to ASCE 7-05 Chapter 13. |

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