Elements of 2012 IBC / ASCE 7-10 Nonstructural Seismic Provisions: Bridging the Implementation Gap

J. A. Gatscher, Fellow Engineer
Schneider Electric

R. E. Bachman, S.E.
R. E. Bachman Consulting Engineer

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ABSTRACT:
This paper highlights key seismic requirements defined in the ASCE 7-10 standard (ASCE/SEI 2010) for important nonstructural components. The model building code used in the United States, and elsewhere, that is linked to ASCE 7-10 standard is the 2012 International Building Code—IBC (ICC 2011). Of particular interest are the nonstructural building systems and active equipment where ASCE 7-10 requires special seismic certification. The discussion will focus on code intent, since this perspective is the primary vehicle to transform code language into implementation practices necessary for establishing earthquake protective measures. The code is divided into its functional elements. Each element is presented independently with the goal of working through the code using the basic elements as building blocks. The following code elements are discussed: construction types, construction importance, performance objectives, compliance expectations, site assessment, earthquake static and dynamic demands. The approach taken decouples the discussion from formal and prescriptive code language, such that one's attention can be better directed on intent-based implementation.

Keywords: nonstructural, equipment, systems, seismic requirements, building codes

1. ELEMENTS OF MODEL BUILDING CODES

Nonstructural building code provisions in the United States have adopted sweeping changes over the last decade. One motivation for this significant code evolution is to better assure operational performance of critical nonstructural systems. Stated simply, the code's compliance expectations have expanded beyond just maintaining position retention (i.e., anchorage) to now also include active operation performance at design-level earthquake demands. This requires suppliers and manufacturers of essential nonstructural components—designated as requiring special seismic certification—to treat compliance validation as a product development activity that involves implementation of advanced analytical and testing techniques.

Stakeholders new to nonstructural earthquake protection may perceive modern-day code provisions as complex. The underlying theme of this paper is to transform perceived complexities into tangible implementation practices compatible with new code expectations. Because the perceived complexity of modern-day codes may be a barrier to effective nonstructural earthquake protection, in this paper we have divided the code into its fundamental parts. In fact, these core elements can be found in most modern building codes and standards used around the world. While it is true that nations have evolved their own seismic codes and standards independently, there is similarity when considering the core elements contained within these codes and standards.

1.1. Construction Category

The code (i.e., 2012 IBC / ASCE 7-10) includes provisions for five types of construction categories: (1) buildings, (2) nonstructural components, (3) nonbuilding structures, (4) seismically isolated structures, and (5) structures with damping systems. Each of these categories has its own set of seismic design provisions. The nonstructural components category is divided into two subcategories: (1) architectural components, and (2) mechanical and electrical components. The mechanical and electrical components category includes both equipment and distribution systems and is the focus of this paper. Nonbuilding structures include all self-supporting structures that carry gravity loads and that may be required to resist the effects of earth shaking. Differentiation between nonstructural and nonbuilding categories is not always straightforward. 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. The latter type can be occasionally difficult to distinguish from nonstructural systems since it's possible an item could be classified as either. Figure 1-1 (taken from Bachman and Dowty, 2008) illustrates items which are defined as nonstructural components or nonbuilding structures and highlights where overlaps occur. Perhaps, the easiest way to distinguish between nonstructural or nonbuilding is by size. Stated simply, nonstructural components are typically small and nonbuilding structures are typically large. Nonstructural systems are typically small enough to fit within a building, something on the order of 3 m (10 ft) tall. There are, of course, exceptions such as very large generators and turbines.

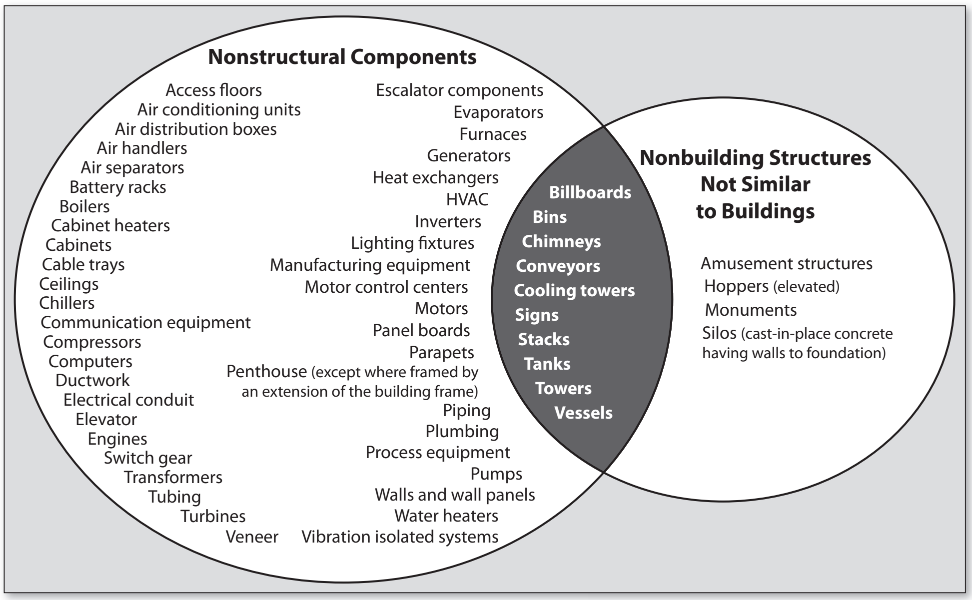

Figure 1-1. Overlap of nonstructural components and nonbuilding structures

1.2. Construction Importance Classifications

In ASCE 7-10 the concept of a construction *risk category* was first introduced. Risk category is a top-level importance classification based on the intended use or occupancy of the construction type. The risk category associates the degree of risk of structural failure with construction performance under environmental demands (e.g., earthquake). There are four risk categories, from I to IV—the higher the category ranking, the higher the expectation for acceptable performance during and after earth shaking with a lower risk of structural failure. Table 1-1 summarizes the four risk categories for various situations. Based upon the risk category, code ground motion levels at the building site and site soil classification, a *seismic design category* is assigned to the building or structure. A high-ranked risk category building (i.e., III and IV) that is located in a high seismic area is assigned the higher seismic design category (and more stringent requirements) compared with similar high-ranked risk category buildings that are located in less seismically active areas. There are six possible seismic design categories: A-B-C-D-E-F. Depending on the code ground motion site values and risk category, the building structure is assigned one of the six rankings, with category F having the most stringent requirements. Nonstructural systems inherit the same seismic design category as the structure that they occupy or to which they are attached.

Each structure and nonstructural component are also assigned a *seismic importance factor*. For buildings and other structures, the seismic importance factor, I_e, is assigned a value of 1.0, 1.25 or 1.5 and is based directly upon the assigned risk category. The nonstructural importance factor, I_p, only includes two classification rankings: $I_p = 1.0$ and $I_p = 1.5$. A nonstructural importance factor of $I_p = 1.5$ is assigned if any of the following conditions apply:

- The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems and egress stairways.
- The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances exceeding a threshold quantity limit and is sufficient to pose a threat to the public if released.
- The component is in or attached to a risk category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.
- The component conveys, supports, or otherwise contains hazardous substances and is attached to a structure classified as a hazardous

All other nonstructural components and systems are assigned a component importance factor of $I_p = 1.0$. There are several exemptions to these rules that are identified in the code. The nonstructural importance factor, I_p, represents the greater of the life-safety risk of the system and the hazard exposure importance of the structure.

Table 1-1. Risk Categories for Buildings and Other Structures

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent a low risk to human life in the event of failure.	I
All buildings and other structures except those listed in Risk Categories I, III, and IV.	II
Buildings and other structures, the failure of which could pose a substantial risk to human life. Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure. Buildings and other structures not included in Risk Category IV containing toxic or explosive substances where their quantity exceeds a threshold quantity established by the AHJ and is sufficient to pose a threat to the public if released.	III
Buildings and other structures designated as essential facilities. Buildings and other structures, the failure of which could pose a substantial hazard to the community. Buildings and other structures containing sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the AHJ to be dangerous to the public if released and is sufficient to pose a threat to the public if released. Buildings and other structures required to maintain the functionality of other Risk Category IV structures.	IV

1.3. Performance Objectives

Our interpretation of the code's implied nonstructural performance objectives related to seismic performance are summarized in Table 1-2. The nonstructural importance factor, I_p, is used to differentiate between the objectives for nonstructural applications in designated seismic systems and those applications deemed less essential. The performance objectives for building structures are related to structural integrity and acceptable structural performance under design-level earthquake demands. Suffice it to say, the inherent assumption regarding nonstructural seismic performance is that the building structure has to perform as intended. The obvious manifestation of this concept results from the secondary nature of nonstructural systems. Without a standing structure, there can be no nonstructural seismic performance, or any performance for that matter. For all performance objectives, the demand motions are presumed to be those associated with the Design Earthquake.

Table 1-2. Nonstructural Seismic Performance Objectives

Nonstructural Importance Factor, I_p	Performance Objective	Design Objective Description
1.0	Position retention	Maintain positive retention of nonstructural position, under design-level earthquake demands, without consideration of frictional resistance produced by the effects of gravity. This includes position retention of nonstructural anchorage, attachments and the force resisting skeleton.
	Systems interaction avoidance	Account for unwanted interaction, under design-level earthquake demands, between nonstructural systems and anything else that might be located in the immediate vicinity of the nonstructural installation, so that failure of one system or contact between systems does not cause Consequential Damage of an essential system. The "anything else" could be building elements or other installed nonstructural systems.
1.5	Position retention	Maintain positive retention of nonstructural position, under design-level earthquake demands, without consideration of frictional resistance produced by the effects of gravity. This includes position retention of nonstructural anchorage, attachments and the force resisting skeleton.
	Systems interaction avoidance	Account for unwanted interaction, under design-level earthquake demands, between nonstructural systems and anything else that might be located in the immediate vicinity of the nonstructural installation, so that failure of one system or contact between systems does not cause Consequential Damage of an essential system. The "anything else" could be building elements or other installed nonstructural systems.
	Active operation	Maintain active operation functionality of mechanical and electrical equipment and distribution systems following (i.e., not during) application of design-level earthquake demands.

1.4. Compliance Expectations

Table 1-3 summarizes our interpretation of the code's compliance expectations to validate that nonstructural performance objectives have been satisfied by employing various validation methods. The process of compliance validation is commonly referred to as *seismic qualification*. Nonstructural qualification is concerned with establishing seismic capacity levels which can be compared with demands to determine compliance. The validation methods used to establish capacity include analysis, testing, earthquake experience data, and comparative assessment using combined methods.

The code requires submittal of appropriate construction documents for nonstructural systems that are designated seismic systems (I_p = 1.5). The construction documents are prepared by the building design professional for use by the building owner, the authority having jurisdiction (AHJ), and inspectors. The acceptance of nonstructural compliance validation is dependent on approval by the AHJ for the project-specific application. Different jurisdictions could have different approval processes and could pose different expectations for compliance. For example, an essential nonstructural application (i.e., a designated seismic system) for a hospital located in the state of California, U.S.A. will pose higher compliance expectations compared with similar applications in other U.S. states. The approval process for designated seismic systems in jurisdictions that require special enforcement needs to be clearly understood well in advance. Inadequate compliance documentation can create major problems during the approval process for such nonstructural applications.

Table 1-3. Nonstructural Seismic Compliance Methods and Expectations

Performance Objective	Validation Method	Compliance Expectation
Position retention	Analysis	Structural analysis can be used to validate that nonstructural anchorage, force resisting skeleton and attachments have position retention capacity equal to or greater than the project-specific design-level demand for the application installation location. Both strength design and allowable stress design approaches are accepted.
	Experience data	The use of earthquake experience data, based upon nationally recognized procedures, can be used to establish nonstructural position retention capacity provided that the substantiated seismic capacities equal or exceed the project-specific design-level demand for the application installation location.
	Testing	The use of seismic simulation testing, based upon a nationally recognized testing standard procedure, such as ICC-ES AC156, can be used to establish nonstructural position retention capacity provided that the seismic capacities equal or exceed the project-specific design-level demand for the application installation location.
Systems interaction avoidance	Inspection	Visual inspection of the nonstructural installation is performed to validate that no unwanted system interactions may result under the project-specific design-level earthquake demands.
Active operation	Experience data	The use of earthquake experience data, based upon nationally recognized procedures, can be used to establish nonstructural active operation capacity provided that the substantiated seismic capacities equal or exceed the project-specific design-level demand for the application installation location.
	Testing	The use of seismic simulation testing, based upon a nationally recognized testing standard procedure, such as ICC-ES AC156, can be used to establish nonstructural active operation capacity provided that the seismic capacities equal or exceed the project-specific design-level demand for the application installation location.
	Combined testing and analysis	The use of combined structural analysis and seismic simulation testing can be used to establish nonstructural active operation capacity for physically massive systems (i.e., large-class) that are impractical to test as complete systems. The testing aspects need to conform with nationally recognized testing standard procedures, such as ICC-ES AC156. The established active operation capacity, using combined testing and analysis, is to equal or exceed the project-specific design-level demand for the application installation location.

1.4. Site Assessment

The building site soil properties are classified based on analysis of the upper 30 m (100 ft) of the site soil profile. The code's site classification options include Site Class A through F. In cases where site-specific data are not available to a depth of 30 m, appropriate soil properties are permitted to be estimated by the registered design professional preparing the soil investigation report based on known geologic conditions. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D is permitted to be used as the default, unless the AHJ or geotechnical data determines that Site Class E or F soils are present at the site. The code provides a section describing the requirements to conduct a site-specific geotechnical survey. Site-specific surveys are common for risk category III and IV buildings located in seismic-prone areas and for many risk category II buildings and other structures.

1.5. Earthquake Demands

Earthquake loads, called demands, for the code's construction types share common ground motion parameters. The first step in establishing earthquake demands is to evaluate the building structure demands and then next determine the nonstructural demand requirements. Nonstructural earthquake demands cannot be fully understood until the building structure demand requirements are reviewed.

1.5.1. Building Structure Demands

A key element in determining the code's earthquake demands are the code seismic ground motion hazard maps. The maps provide both short-period, S_S, (i.e., 0.2 sec) and long-period, S_1, (i.e., 1 sec) spectral response accelerations—so-called two-factor mapped acceleration parameters for a given geographic location. All of the code's construction types utilize the mapped ground motion parameters to define earthquake demands. Note that the hard-copy maps contained in the ASCE/SEI 7-10 standard are often difficult to work with because of the map scale. A U.S. Geological Survey website (USGS 2010) provides digital map tools that access the data behind the maps. These tools are free and quite useful and were intended by the code writers to be typically employed on building projects.

The code's acceleration maps provide values for the risk-targeted maximum considered earthquake (MCE_R), which is defined as the ground motion with a uniform probability of being exceeded at least once in 2,475 years (2% in 50 years adjusted to provide a uniform probability of collapse). Thus, these maps are often referred to as probabilistic seismic hazard maps. The design maps do not reflect how many earthquakes will occur in the return period or their associated magnitudes—only the ground motion intensity that is likely to be exceeded at least once in the MCE_R return period. The ground motion intensity is defined in terms of 5% damped, spectral response acceleration for Site Class B. The first step in determining the demand is to define the two mapped acceleration parameters, S_S and S_1, for a given building site location. The next step is to use the site class designation, which is assigned from the building site assessment, in conjunction with the MCE_R mapped parameters to calculate adjusted MCE_R acceleration parameters as follows:

$$S_{MS} = F_a\, S_S \tag{1-1}$$
$$S_{M1} = F_v\, S_1 \tag{1-2}$$

where S_{MS} = MCE_R, 5% damped, spectral response acceleration at short periods adjusted for site class effects; S_{M1} = MCE_R, 5% damped, spectral response acceleration at a period of 1 sec adjusted for site class effects; F_a = short-period site coefficient (at 0.2-s period); and F_v = long-period site coefficient (at 1.0-s period). The two site coefficients, F_a and F_v, are determined from tables in the code based upon the site class designation and the MCE_R acceleration parameters, S_S and S_1. Site class adjustment is necessary since the mapped hazard values represent Site Class B data. If the building site happens to be a Site Class B, then the site coefficients, F_a and F_v, are unity and no adjustment results.

The code's design-level acceleration parameters are defined as simply a two-thirds ratio of the adjusted MCE_R response acceleration parameters. Thus, the design earthquake spectral response acceleration parameter at short period, S_{DS}, and at 1-s period, S_{D1}, are defined as

$$S_{DS} = \frac{2}{3} S_{MS} \tag{1-3}$$

$$S_{D1} = \frac{2}{3} S_{M1} \tag{1-4}$$

These two response acceleration parameters are used to define design-level earthquake demands at the ground level for building structures. The building structure demand requirements are implemented via the code's ground motion design response spectrum, as shown in Fig. 1-2. The two design-level acceleration parameters, S_{DS} and S_{D1}, and the long-period transition point, T_L, feed into defining this design spectrum. Thus, by definition of S_{DS}, S_{D1}, and T_L, the design response spectrum is fully captured, including all spectrum breakpoints (the T_L transition point is also based on geographic location taken from a map and site soil conditions). The design response spectrum is the cornerstone of the code's seismic demand requirements.

There is an interesting aspect of the design spectrum that has direct bearing on nonstructural requirements. At zero period (i.e., $T = 0$) the design response acceleration is defined by the equation

$$S_a \Big|_{T=0} = S_{DS}\left(0.4 + 0.6\frac{T}{T_0}\right) = S_{DS}\left(0.4 + 0.6\frac{0}{T_0}\right) = 0.4\, S_{DS} \tag{1-5}$$

This acceleration is the zero period acceleration (ZPA) and represents the effective horizontal peak ground acceleration (PGA). The quantity $\left(0.4\, S_{DS}\right)$ is directly incorporated into the nonstructural demand requirement.

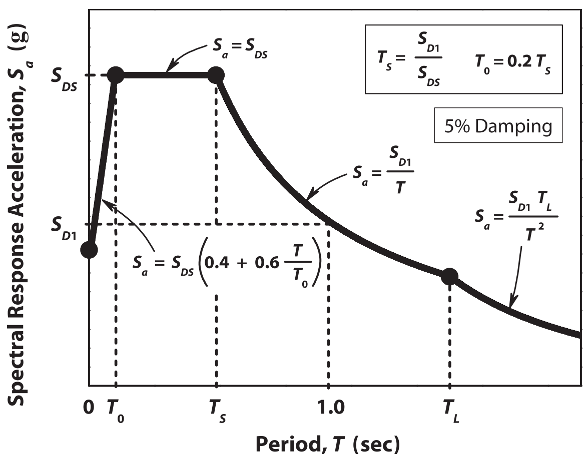

Figure 1-2. 2012 IBC and ASCE 7-10 design earthquake response spectrum that define the seismic ground motion demand requirements for building structures

1.5.2. Nonstructural Static Demands

The code's nonstructural demands are defined as static design forces and, unlike buildings, are not fully described in terms of response spectrum parameters. The code's adoption of nonstructural design force equations follows a long history of U.S. building codes that have employed equivalent lateral force to prescribe seismic design requirements. Equivalent static forces are likely perceived by many stakeholders as easier to implement. This perception is quite accurate when nonstructural systems are treated as black-box building components. However, if the intent is to treat nonstructural components as functioning building systems, then the static force approach leaves room for misinterpretation when nonstructural dynamic approaches are needed. This topic is discussed in the next section.

The building code's horizontal seismic design force, F_p, is defined as

$$F_p = \left(0.4\, S_{DS}\right)\frac{\left(a_p\right)}{\left(\dfrac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right)W_p \tag{1-6}$$

where F_p = seismic design force centered at the component's center of gravity and distributed relative to the component's mass distribution; S_{DS} = design earthquake spectral response acceleration at short period; a_p = component amplification factor; R_p = component response modification factor; I_p = component importance factor; z = height in structure at point of attachment of component; h = average roof height of structure relative to the base elevation; and W_p = component operating weight. Additional code stipulations are defined for allowable maximum and minimum values for F_p:

$$F_p\big|_{\text{MAX}} = 1.6\, S_{DS}\, I_p\, W_p \tag{1-7}$$
$$F_p\big|_{\text{MIN}} = 0.3\, S_{DS}\, I_p\, W_p \tag{1-8}$$

The quantity $\left(0.4\, S_{DS}\right)$ in Eqn. 1-6 has already been identified as the design earthquake zero period acceleration and represents the peak ground-level design acceleration. If we wanted to create the simplest of force equations, starting with the peak ground acceleration is a good choice. For example, if our nonstructural component was literally a solid black box made of lead and was anchored to a concrete pad at ground level, the earthquake inertial force experienced during earth shaking would be the ZPA design acceleration times the box weight. This is $F = m\,a$ in the purest sense. Considering this trivial example we would have

$$F_p = \left(0.4\, S_{DS}\right) W_p \tag{1-9}$$

But if we need to install our solid black box inside a building structure at some floor elevation above grade level, how does that affect our simple force Eqn. 1-9? Common sense tells us that the building will most likely amplify the ground acceleration and we need to somehow account for this building amplification effect in our force equation. The quantity [1 + 2(z/h)] is the needed building height factor to amplify the ground acceleration, accounting for building amplification as we move up in building floor height. This amplification was determined based on observations of building responses in past earthquakes. Now we can modify our simple force equation to include building amplification effects:

$$F_p = \left(0.4\, S_{DS}\right)\left(1 + 2\,\frac{z}{h}\right) W_p \tag{1-10}$$

But what if our solid black box was not solid after all and instead was packaged full of "functioning stuff" that is supported by a box structural system (i.e., a force-resisting skeleton—FRS)? How does that affect our new simple force Eqn. 1-10? Common sense again tells us that because the box is not a rigid block of lead, there will be some flexibility in the box FRS, and dynamic response to the amplified building ground acceleration is likely. The flexible response of the box FRS depends on both the dynamic characteristics of the box system and the building structure. When the dynamics of the box and building are closely tuned, vibration resonance occurs in the box system and box FRS dynamic amplification results. Thus, we need to modify our new simple force equation to account for possible dynamic tuning between building and box system by inserting a component amplification factor, a_p:

$$F_p = \left(0.4\, S_{DS}\right)\left(a_p\right)\left(1 + 2\,\frac{z}{h}\right) W_p \tag{1-11}$$

Eqn. 1-11 is starting to look similar to the code's force requirement, but there is something missing. We have recognized that our black box is not a solid lump of dead weight, but a complex dynamic system in its own right, with functional devices packaged into an FRS. With almost all ductile FRS assemblies there is inherent capacity to absorb some of the energy imparted during earth shaking as inelastic response. A structural system, whether it is a building skeleton or a nonstructural FRS, can absorb and dissipate applied loading through the process of inelastic resistance. Buildings could not be designed (at least for a reasonable cost) without accounting for inelastic response. We need to modify Eqn. 1-11 to account for the inelastic resistance capacity of the nonstructural FRS by inserting a response modification (i.e., reduction) factor, R_p, into the equation. However, the amount of reduction permitted is limited by the importance rating of the nonstructural system, the logic being that for essential nonstructural systems the amount of response reduction is limited by the ratio $1/I_p$. Thus, for essential nonstructural systems (i.e., designated seismic systems) the response modification factor, R_p, is decreased by dividing by 1.5. Now we can modify Eqn. 1-11 by inserting the response reduction ratio, (R_p/I_p), into the denominator:

$$F_p = \left(0.4\, S_{DS}\right) \frac{\left(a_p\right)}{\left(\dfrac{R_p}{I_p}\right)} \left(1 + 2\,\frac{z}{h}\right) W_p \tag{1-6}$$

Our simple force equation now matches the code's nonstructural seismic design requirement, Eqn. 1-6.

Placing the response reduction ratio under the amplification factor is not coincidental. The grouping of these factors together serves a purpose. Both the response reduction ratio, (R_p/I_p), and the amplification factor, a_p, are dependent quantities of the particular nonstructural system. Stated simply, the effects these parameters have on the overall force magnitude are entirely dependent on the type of nonstructural system in question. The code provides options for a_p and R_p coefficients to cover many different nonstructural types. If a specific type is not listed, the default options can be assumed, which include $a_p = 2.5$ and $R_p = 1.5$ for flexible systems (i.e., maximum FRS amplification and minimum inelastic reduction). The other parameter groupings in Eqn. 1-6 of (0.4 S_{DS}) and $[1 + 2(z/h)]$ are independent of the nonstructural system and represent building floor-level demands. In other words, the ground-level static acceleration and the building height amplification factors are applicable regardless of what type of nonstructural is installed. The distinction between nonstructural dependent and independent force parameters may not be important at this juncture, but this distinction is fundamental when there is a need to use dynamic nonstructural procedures.

One conclusion that can be drawn from this discussion is that the design force equation is a generic construct to account for building amplification, nonstructural FRS amplification, and inelastic reductions. The design force is independent of building structural properties. This makes the Eqn. 1-6 nonstructural design force fully uncoupled from building dynamics. However, the code does provide an option to calculate design force by employing modal analysis procedures used in conjunction with a building-specific structural model. In lieu of forces determined using Eqn. 1-6, accelerations at any building elevation can be calculated via modal analysis, and nonstructural design force is calculated as

$$F_p = \frac{a_i\, a_p\, W_p}{\left(\dfrac{R_p}{I_p}\right)}\, A_x \tag{1-12}$$

where a_i = acceleration at building height i obtained from modal analysis procedure; and A_x = torsional amplification factor as defined in the code's "Amplification of Accidental Torsional Moment" section. Maximum and minimum values for design force (Eqns. 1-7 and 1-8) are still applicable using this alternative design force method.

Code acceptance of alternative procedures for determining seismic design force is a welcome step. This procedure is highly useful when nonstructural static demands are needed to address project- and building-specific application needs. There is, however, a much greater need to address generic nonstructural dynamic demands. This need is precipitated by the nonstructural performance objective of active operation for designated seismic systems and the exclusion of analytical means for compliance validation (see Table 1-3). Stated simply, nonstructural active operation compliance requires dynamic demands in order to test and analyze equipment platforms using dynamic techniques. While static demands are more than adequate for our dead-weight black-box example, when our black box is a functioning building system the static requirements are much less useful.

1.5.1. Nonstructural Dynamic Demands

The reality of modern-day seismic provisions makes dynamic testing a key enabler for nonstructural compliance. Without the ability to test and analyze using dynamic demands, many essential nonstructural systems (i.e., designated seismic systems) would not be available to populate essential building structures. There is a gap in current code requirements without direct inclusion of nonstructural dynamic requirements alongside static demands.

In the absence of code-specified dynamic demands, stakeholders are forced to interpret dynamic requirements as best they are understood. Even with existing dynamic interpretation protocols that are already code-referenced and readily available, such as ICC's AC156 standard (ICC ES 2010), many stakeholders are either unaware of this protocol or simply do not recognize this interpretation as a code dynamic demand requirement. In either case, elimination of all misinterpretations can be readily accomplished with explicit code adoption of a generic nonstructural response spectrum demand. This demand would represent building floor motion spectra requirements independent of building dynamics and independent of nonstructural-type classification.

For the time being, the ICC's AC156 test protocol serves this purpose. The technical merit of AC156 development is clearly discussed in Gatscher et al. 2012 and will not be presented here. The need for nonstructural dynamic demand provisions will only increase in the future as more systems require active operation compliance. In the end, it will be inevitable for the code to include these needed provisions. Our position is that sooner is better than later to clarify this gray area and thus remove an existing barrier to effective implementation of nonstructural protective measures.

2. ASCE 7-10 SEISMIC REQUIREMENTS SUMMARY

The continually transforming content of seismic design codes reflects the evolution of design practice as it takes place in changing technical and political contexts. The seismic building code provisions for the United States have undergone considerable growing pains over the last couple of decades. The previous region-based codes have been replaced with a unified national code. The old zone system has been abandoned for probabilistic ground motion hazard maps. And the code's seismic provisions have become much more comprehensive and unfortunately are perceived to be much more complex.

The goal for this paper is to cut through the clutter of code prescriptive language and get to the core of code intent. The code is divided into basic elements that are needed to form a cohesive whole. Nonstructural performance objectives have been identified and include position retention, systems interaction avoidance, and active operation for designated seismic systems. Compliance methods and expectations regarding meeting these objectives are delineated by employing analytical, experimental, comparative experience, or combined procedures. Model code complexity is a perception some stakeholders have that hinders implementation. The code is not complex when viewed as a necessary foundation to support both basic (e.g., lateral force) and advanced (e.g., response spectrum) treatment of nonstructural systems to mitigate the risk of earthquake damage. The nonstructural seismic provisions contained in ASCE/SEI 7-10 become enablers to carry out earthquake protective measures using either basic or advanced techniques.

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