

**WABO/SEAW
Liaison Committee**

Washington Association of
Building Officials and
Structural Engineers Association
of Washington

WHITE PAPER 7-2011

Seismic Design and Gravity Support Requirements for Nonstructural Components

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Abstract:

This white paper establishes recommendations and guidelines for building officials, design professionals, contractors and building owners relating to seismic anchorage and support of “nonstructural (NS) components” regulated by IBC Chapter 16 and Chapter 13 of ASCE 7-05.

Commentary related to practical consideration of the application of code requirements is provided in Section III. References to additional design guidelines, code citations and in-depth engineering for NS components are located in Section IV of this report.

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Committee Mission Statement:

- *Improve communications between the public jurisdictions that administer building codes and the engineering design community that prepares construction documents.*
- *Improve consistency and quality of engineering submittals and project reviews.*
- *Build consensus between the engineering design community and building officials with regard to code interpretation and submittal requirements.*

I. Introduction

The requirements of IBC Section 1613 and ASCE 7-05 Chapter 13 are applicable to seismic design requirements for nonstructural (NS) components permanently attached to the interior or exterior of a building or located such that structural failure could compromise public safety. NS components include items such as prefabricated or factory-assembled components or equipment brought to the jobsite that is typically installed in one piece, including rooftop and suspended HVAC equipment, water heaters, boilers, electrical transformers and generators, light fixtures, etc. Also included are site-assembled NS components, such as Type 1 hoods, ductwork, piping, access floors, stairs, storage racks, suspended ceilings, elevators, exterior veneer, cladding and exterior curtain walls. The NS component category does not typically include furniture or other items of a temporary or portable nature.

There is a public expectation that our buildings will remain standing after an earthquake or high wind storm and that NS components, including critical life safety systems, will remain in place to provide the function for which they were designed. For this reason, building codes specify lateral and gravity forces that the designer must use to reduce the risk of structural failure.

There are multiple reasons for requiring NS components to be adequately anchored and supported to resist lateral and gravity forces, including the fact that the leading cause of injury during an earthquake is falling objects that either strike occupants or obstruct egress. Also, failure of NS components may hinder recovery efforts after an earthquake, with potentially significant property loss and negative impacts on the community. In many cases, the cost to repair or replace NS components after an earthquake exceeds the cost of repairs to the building in which they are located. The cost to repair or replace NS components after an earthquake can amount to 75% of the overall value of the building improvements.

Requirements found in Chapter 13 of ASCE 7-05 for NS components are based on the 1994, 1997 and 2000 NEHRP provisions. The performance goals of these provisions are intended to avoid serious injury or loss of life, avoid loss of function of critical facilities ($I_p = 1.5$) and minimize repair costs to the extent practical.

II. Recommendations and Guidelines

All new installations of NS components must meet current building code requirements. Building officials commonly respond to client inquires about whether or not a building permit and engineering documentation are needed in order to proceed with the installation of NS components. After considering the nature of the installation, the local building official is responsible to determine the need for a building permit and engineering. Separate mechanical, electrical or plumbing (MEP) permits (whichever is applicable) are typically required even though a building permit may not be required. MEP permits should be withheld for components weighing more than 400 lbs. until the structure supporting the equipment is shown to comply with the building code.

Although every case is unique, there are similarities that provide opportunities to “categorize” types of work to help maintain consistency and predictability for clients and building department personnel. There are 3 main categories as follows:

A. Building Permit Not Typically Required – NS Components Exempt from Seismic Design Requirements – (ASCE 7-05 Sections 13.1.4 and 13.6)

1. Mechanical, electrical and architectural components in seismic design category B, other than parapets supported by bearing walls or shear walls, with an importance factor, I_p of 1 (See Sec. 13.1.3 of ASCE 7 05 to determine the importance factor).
2. Mechanical and electrical components in seismic design category C with an importance factor, I_p of 1.
3. Base-mounted mechanical and electrical components in seismic design categories D, E and F with an importance factor, I_p of 1, weighing less than 400 lbs., mounted at 4'

- or less above the floor and provided with flexible connections between the components and associated ductwork, piping and conduit.
4. Distribution systems (such as piping or ducting) weighing 5 lbs./ft. or less and other *suspended* mechanical and electrical components in seismic design categories D, E and F with an importance factor, I_p of 1, weighing less than 20 lbs. and provided with flexible connections between the components and associated ductwork, piping and conduit.
 5. Although not specified in the code, many jurisdictions do not require a separate building permit or seismic design for hot water tanks 60 gallons or less installed in commercial or residential occupancies if they are strapped to resist horizontal displacement per UPC Section 508.2. A mechanical, electrical or plumbing permit, as applicable, is typically required to install a hot water tank. Reference IAPMO Guide Criteria (IGC's) 202-2004a.

B. Building Permit and Inspection Are Typically Required – Design and Installation Without Engineering Documentation

1. Sprinkler systems installed per NFPA 13. Note that ASCE 7-05 requires that force and displacement requirements of Sections 13.3.1 and 13.3.2 be satisfied, but ASCE 7-10 does not.
2. HVAC ductwork installed in accordance with an approved standard such as from ASHRAE or SMACNA. Reference Section 13.6.7 of ASCE 7-05.
3. Mechanical components weighing 75 lbs. or less installed in line with a duct system. Reference Section 13.6.7 of ASCE 7-05.
4. Suspended ceilings installed in compliance with applicable subsections of ASCE 7-05 Section 13.5.6, and references to the ASTM C635, C636 and CISCA documents.
5. Hanging architectural, mechanical and electrical components if (1) a 1.4 load factor is applied simultaneously vertically and horizontally, (2) the designer considers the potential damage to adjacent components, and (3) the component allows a 360-degree range of motion in a horizontal plane. Reference Sections 13.5.1 and 13.6.1 of ASCE 7-05.
6. When approved by the building official, reference documents may be used for seismic design as long as the design earthquake forces meet the provisions of Section 13.3.1 and seismic interaction with adjacent components are evaluated. Examples of recognized reference documents include the International Seismic Application Technology (I.S.A.T) for restraint and attachment of NS components and the Northwest Wall and Ceiling Bureau Document #401 for installation of suspended ceilings. Reference Section 13.1.6 of ASCE 7-05.

C. Building Permit, Plan Review and Inspection Are Typically Required – Design and Installation With Engineering Documentation

1. NS components assigned with an importance factor, I_p of 1.5, are considered crucial for public safety. There are 3 criteria in Section 13.1.3 of ASCE 7-05 used to determine the higher importance factor. (1) Is the component needed for life safety after an earthquake event? Examples include smoke control fans, emergency generators, stairways, etc. (2) Are there hazardous materials that could spill? Examples include battery storage racks, chemical storage racks, etc. (3) Is the

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component in an Occupancy Category IV building and is needed for the continued operation of the facility (see table 1604.5 of the 2009 IBC)? If the answer to any of these questions is yes, then the component has an I_p of 1.5 and a building permit, engineering and plan review should be required.

2. Mechanical and electrical equipment weighing more than 400 lbs. mounted 4' or more above the deck.
3. Mechanical and electrical equipment mounted on a wall or suspended from the structure and weighing more than 20 lbs.
4. Whenever, in the opinion of the building official, engineering is needed to address attachment or support of NS components due to size, shape, weight, location or other considerations.

III. Commentary

A. Practical Considerations

Because resources are typically limited, most building officials must prioritize enforcement objectives. There are several factors to consider when deciding what level of scrutiny to apply to the anchorage and support of NS components. These include but are not limited to:

1. Variation in the size, shape, weight and aspect ratio of nonstructural components
2. Importance of the equipment under consideration relative to life safety (e.g., roof-mounted smoke control fan vs. a toilet exhaust fan)
3. Risk of injury
4. Occupancy category of the building (e.g., critical facility vs. warehouse)

B. Gravity Loads

It is critical that floors, roofs, raised platforms, sidewall/hanging installations, hanging installations and any structures supporting nonstructural components be designed for the anticipated loads per IBC Chapter 16. IBC Section 3403.3 allows an existing gravity load-carrying element to support an additional 5% of the design gravity load before it must be strengthened or replaced. Elevated structures supporting nonstructural components weighing more than 400 lbs should be designed and checked for gravity loading by a Washington State licensed engineer and a building permit obtained if new or additional improvements are necessary to accommodate this additional load.

For new components weighing more than 400 lbs. and for replacement components exceeding 5% of the original unit weight, building officials should consider withholding MEP permits until the structure supporting the equipment is shown to comply with the building code for the gravity loading. Multiple or ganged components in close proximity should be analyzed to confirm that the structure will not become overloaded. Power-actuated fasteners for hanging components are not typically permitted in seismic design categories D, E and F. Reference ASCE 7-05 Sec. 13.4.5.

C. Lateral Loads

NS components, unless exempt, must be effectively anchored to the structure with detailed connections shown in the construction documents. A complete load path is required and must be verified. To maintain public safety it is critical that a 1.5 importance factor be used for individual NS components to ensure they will continue to function when subjected to anticipated earthquake motions.

The Seismic Design Category (SDC) for NS components, consistent with that of the building in which it is located, must be determined. Reference Section 13.1.2 of ASCE 7-05.

An importance factor (I_p) must also be established. Components that are required to function after an earthquake for life-safety purposes or components containing hazardous materials are of high importance and must be designed with an I_p of 1.5. Section 13.1.3 of ASCE 7-05 requires that the supports for these NS components be designed with an importance factor of 1.5 for lateral loads. All other components are given an I_p of 1.0.

Each NS component located in an Occupancy Category IV building must be evaluated to determine if its function is critical for the continued operation of the facility. Improper seismic design or installation of NS components located in essential facilities such as hospitals, police stations, schools, and emergency shelters all considered Occupancy Category IV buildings per IBC Table 1604.5, may negatively impact the entire community if structural failure occurs.

Sliding of NS components due to earthquake loads should also be considered when evaluating whether engineering design is required. Heavy components with a low height-to-width ratio (e.g., 1 or less) may not fail due to overturning but may be at risk of sliding and could cause injury or damage to adjacent components or building elements. Building officials may consider waiving lateral engineering if equipment has a height-to-width ratio of 1 or less and the weight or geometry of the component is not conducive to sliding.

IV. Appendix/Additional information – Reference Documents, Codes Citations, Examples

1. Factors related to code enforcement for nonstructural mechanical components per City of Seattle Director's Rule 29-2005 may be found at <http://www.seattle.gov/dpd/codes/dr/DR2005-29.pdf>.
2. Information, survey checklists and examples of seismic protection of vulnerable nonstructural components in existing buildings may be found in Chapter 6 of FEMA E 74 at <http://www.fema.gov/plan/prevent/earthquake/fema74/chapter6.shtm>.
3. Guidelines for seismic and gravity design criteria for nonstructural components may be found at www.mybuildingpermit.com.

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4. For an article written by Robert Bachman, S.E. and Susan Dowty, S.E. on determining the differences between nonstructural components and nonbuilding structures referenced in ASCE 7-05 Section 13.1.5, go to:
http://www.skghoshassociates.com/sk_publication/Bachman,Dowty_reprint.pdf
5. Special inspection by a WABO-approved agency may be required for the installation of NS components. See IBC Sections 1705.5, 1705.6, 1705.7 and 1705.8.
6. Special seismic certification is required for NS components with an I_p of 1.5 in seismic design category C, D, E & F that: (1) must remain operable following an earthquake, or (2) for components with hazardous contents, as specified in Section 13.2.2 of ASCE 7-05. Shake table testing is typically required. The design may also be approved by submittal and analysis of “experience data.” The State of California has issued Code Application Notice (CAN) number 2-1708A.5 that attempts to clarify the requirements for Special seismic certification of NS components. Go to:
www.oshpd.ca.gov/FDD/Regulations/CANs/2007/2-1708A.5.pdf.
7. The NW Wall and Ceiling Bureau have consolidated all applicable codes related to the installation of suspended ceilings. For suspended acoustical lay-in ceiling installations, go to Document #401 found in the “Technical Documents” section at:
<http://www.nwcb.org/resource.php>.