

Nonstructural Components

Architectural, Mechanical and Electrical Components supported by or located within buildings or other structures.

In 2003 NEHRP Recommended Provisions:

- Chapter 6 – Architectural, Mechanical, and Electrical Component Design Requirements

In ASCE 7-05:

- Chapter 13 – Seismic Design Requirements for Nonstructural Components
- Section 12.11.2 Anchorage of Concrete and Masonry Structural Walls

See also Chapter 13 of FEMA 451, NEHRP Recommended Provisions: Design Examples



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ASCE 7 Chapter 13 Nonstructural Components

1. Scope and Application
2. Design Requirements
3. Seismic Force and Imposed Displacements
4. Component Anchorage
5. Architectural Components
6. Mechanical and Electrical



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Nonstructural Limits of Applicability

- ASCE 7-05 – Applies throughout the United States with following exceptions:
 1. Mechanical and Electrical Components in SDC A and B
 2. Mechanical and Electrical in SDC if $I_p = 1.0$
 3. Architectural in SDC A
 4. Architectural in SDC B if $I_p = 1.0$ except certain parapets
- Other exceptions for light items, piping and ductwork in both

There is an important errata regarding this section.
See: www.seinstitute.org/pdf/erratasheet7-05.pdf
(these changes are not in the 2003 Provisions)



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Nonstructural Demands

- Equivalent Static Forces – F_p Equation – Independent of building structural properties
 1. Strength Level Forces in both codes
 2. ASCE 7-05 provides building dependent option of determining.
- Relative Displacements for Selected Components
 1. Anticipated Relative Displacements at Design Earthquake Level in both codes (Δ_m or D_p).
 2. ASCE 7-05 provides explicit equations and option of determining using building structural properties.



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Nonstructural Force Demand

- ASCE 7-05 – Based on 2003 NEHRP

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

$$F_p (\text{min}) = 0.3 S_{DS} I_p W_p \text{ for } S_{DS} = 1.00, F_p = 0.30 I_p W_p$$

$$F_p (\text{max}) = 1.6 S_{DS} I_p W_p \text{ for } S_{DS} = 1.00, F_p = 1.60 I_p W_p$$



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Nonstructural Importance Factor - I_p

- ASCE 7-05 has assigned Nonstructural Component Importance Factor, I_p
- The values of I_p is either 1.0 or 1.5
- In ASCE 7-05, the value of I_p is based
 1. Requirements of the component to function after a DBE or
 2. Occupancy Category of the structure or facility
- In ASCE 7-05, nonstructural components/systems which are assigned an $I_p = 1.5$ are called *Designated Seismic Systems*.



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Nonstructural Component a_p and R_p Factors

- ASCE 7-05 have a_p and R_p factors assigned in tables that are used in F_p equation.
- The values of a_p range from 1.0 to 2.5 in both codes and values of a_p can be taken as less than 2.5 based on dynamic analysis.
- In ASCE 7-05, R_p values range from 1.0 to 12.0.
- The values of R_p can be assigned based on the ductility and deformability capacity.
- In ASCE 7-05 there only 2 footnotes to the a_p and R_p tables.



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Changes in Nonstructural Component a_p and R_p Factors

- Many values of a_p and R_p for equipment and distributed systems in ASCE 7-05 differ from those in the NEHRP *Provisions*
- Changes are highlighted in the following Tables



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Comparison of a_p and R_p values for Selected Architectural Components

Architectural Component	2003 NEHRP		ASCE 7-05	
	a_p	R_p	a_p	R_p
Cantilever Parapets	2.5	2.5	2.5	2.5
Exterior Walls* (rigid diaph.)	1.0	2.5	1.0	2.5
Partitions* (rigid diaph.)	1.0	2.5	1.0	2.5
Ceilings	1.0	2.5	1.0	2.5
Penthouses (not an extension)	2.5	3.5	2.5	3.5
Signs and Billboards	2.5	2.5	2.5	2.5
Access Floors* (special)	1.0	2.5	1.0	2.5
Storage Cabinets	1.0	2.5	1.0	2.5



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Comparison of F_p/W_p values for Architectural Components for $C_a = 0.40$, $S_{DS} = 1.0$, $I_p = 1.0$

Architectural Component	2003 NEHRP		ASCE 7-05	
	$z = 0$	$z = h$	$z = 0$	$z = h$
Cantilever Parapets	0.40	1.20	0.40	1.20
Exterior Walls	0.30	0.48	0.30	0.48
Partitions	0.30	0.48	0.30	0.48
Ceilings	0.30	0.48	0.30	0.48
Penthouses (not an extension)	0.30	0.86	0.30	0.86
Signs and Billboards	0.40	1.20	0.40	1.20
Access Floors (special)	0.30	0.48	0.30	0.48
Storage Cabinets	0.30	0.48	0.30	0.48



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Comparison of a_p and R_p values for Selected Mechanical and Electrical Components

Mech./Elect. Component	2003 NEHRP		ASCE 7-05	
	a_p	R_p	a_p	R_p
Tanks and Vessels w/o skirts	1.0	2.5	1.0	2.5
Air side equipment	1.0	2.5	2.5	6.0
Wet side equipment	1.0	2.5	1.0	2.5
Emergency Battery Racks	1.0	2.5	1.0	2.5
Stacks, towers braced below cg	2.5	2.5	2.5	3.0
Vibration Isolated Equipment*	2.5	2.5	2.5	2.0 - 2.5
Piping - ASME Welded	1.0	3.5	2.5	12.0
Piping - threaded joints	1.0	2.5	2.5	4.5



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Comparison of F_p/W_p Values for Mech./Elect. Components for $C_a = 0.40$, $S_{DS} = 1.0$, $I_p = 1.0$

Mech./Elect. Component	2003 NEHRP		ASCE 7-05	
	$z = 0$	$z = h$	$z = 0$	$z = h$
Tanks and Vessels w/o skirts	0.30	0.48	0.30	0.48
Air side equipment	0.30	0.48	0.30	0.50
Wet side equipment	0.30	0.48	0.30	0.48
Emergency Batteries/Tanks	0.30	0.48	0.30	0.48
Stacks, towers braced below cg	0.40	1.20	0.33	1.00
Vibration Isolated Equipment*	0.40	1.20	0.40-0.50	1.20-1.50
Piping - ASME Welded	0.30	0.34	0.30	0.30
Piping - threaded joints	0.30	0.48	0.30	0.67



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Nonstructural Relative Displacement Demand

- ASCE 7-05 – Maximum Relative Displacements for DBE level motions are to be considered
 - In ASCE 7-05
 - Required for Architectural Components which pose a life safety hazard including exterior wall elements and glazing
 - Required for Mech/Elect components and systems where I_p greater than 1.0.
- Except for glazing – no specific acceptance criteria is provided
No requirement to stay within elastic limits or allowables



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Load Combinations

- In ASCE 7-05, the redundancy factor, ρ , is specified as 1.0 for nonstructural components.
- In ASCE 7-05, Ω_o is not specified and load combinations with Ω_o are not used with nonstructural components (including penthouses)
- Vertical seismic forces need not be considered for lay-in access floor panels and lay-in ceiling panels (exception is not in the *Provisions*)



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Anchorage of Nonstructural Components

In ASCE 7-05

All anchor forces based on R_p of 1.5 unless:

- Anchorage governed by ductile steel element or
- Post installed for Seismic Applications per ACI 355.2 or
- Anchors design in accordance with ACI 318-05, App. D

Additional 1.3 factor or maximum transferable force

Special requirement – vibration isolated equipment –
 $2 F_p$ if gap > 0.25"

Load path analysis to primary structure shall be performed.



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Design and Detailing Requirements of Architectural Components

In ASCE 7-05:

- Specific demands exterior walls and connections
- Suspending Ceilings – CISCA & ASTM standards
- Glazing – Drift capacity AAMA 501.6
- Access Floors – special access floor details
- Tall Partitions – independent bracing



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Design and Detail Requirements for Mechanical and Electrical Equipment

In ASCE 7-05:

- Sprinkler systems – NFPA 13 with amendments
- Escalators and Elevators – ASME A17.1
- Vessels – ASME B&PV
- Piping – ASCE B 31.1
- HVAC Ducting – (SMACNA not specifically referenced)
- Lighting fixtures – Prescriptive detail requirements
- Many specific prescriptive details for Mechanical and
- Electrical Equipment – Section 13.6.5.5



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Certification Requirements for Certain Designated Seismic Systems ($I_p=1.5$) in the 2003 *Provisions*

- Testing permitted in lieu of analysis methods to determine the seismic capacity of components and their supports and attachments.
- Certification Requirements are found in Section 2.4.5
 - Registered design professional in responsible charge must state the applicable requirements on the construction documents.
 - Each manufacturer of designated seismic system components must test or analyze the component and its mounting system or anchorage
 - Evidence of compliance must be submitted for review and acceptance by the registered design professional and for approval by the authority having jurisdiction.
 - The evidence of compliance shall be by
 - Actual test on a shake table, or
 - Three-dimensional shock tests, or
 - Analytical methods using dynamic characteristics and forces, or
 - Use of experience, or
 - Rigorous analysis providing for equivalent safety



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ASCE 7-05 Special Certification Requirements for Certain Designated Seismic Systems ($I_p=1.5$)

- In ASCE 7-05 - Seismic qualification required for
 1. Active mechanical and electrical equipment that are required to function following a DBE
 2. Components containing hazardous contents
- Qualification to demonstrate functionality after being subject to a DBE to be determined by either:
 1. Shake table testing – ICC-ES AC-156 , 2004
 2. Experience Data
 3. Analysis (extremely difficult for active equipment)
- Certification required by supplier indicating compliance



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Final Comments about Nonstructural Components

- Much implementation detail in ASCE 7-05
- Additional documentation requirements in ASCE 7-05
- Much more QA requirements in ASCE 7-05. Note there are specific requirements for supports and attachments to be shown on the construction documents.



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