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

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 Ip = 1.0
  3. Architectural in SDC A
  4. Architectural in SDC B if Ip = 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)

Nonstructural Demand
• ASCE 7-05 – Based on 2003 NEHRP

\[ F_p = \frac{0.4w_j S_{sec}}{R/F_j} \left[ 1 + \frac{z}{R} \right] W_p \]

\[ F_p (\text{min}) = 0.3 S_{sec} I_p W_p \text{ for } S_{sec} = 1.00, F_j = 0.30 I_p W_p \]

\[ F_p (\text{max}) = 1.6 S_{sec} I_p W_p \text{ for } S_{sec} = 1.00, F_j = 1.60 I_p W_p \]

Nonstructural Importance Factor - Ip
• ASCE 7-05 has assigned Nonstructural Component Importance Factor, Ip
• The values of Ip is either 1.0 or 1.5
• In ASCE 7-05, the value of Ip 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 Ip = 1.5 are called Designated Seismic Systems.
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.

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.

### Comparison of $a_p$ and $R_p$ values for Selected Architectural Components

<table>
<thead>
<tr>
<th>Architectural Component</th>
<th>2003 NEHRP</th>
<th>ASCE 7-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantilever Parapets</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Exterior Walls (rigid diaph.)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Partitions (rigid diaph.)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceilings</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Penthouse (not an extension)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Signs and Billboards</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Access Floors (special)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Storage Cabinets</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Architectural Component</th>
<th>2003 NEHRP</th>
<th>ASCE 7-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantilever Parapets</td>
<td>0.48</td>
<td>0.40</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Partitions</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Ceilings</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Penthouse (not an extension)</td>
<td>0.20</td>
<td>0.60</td>
</tr>
<tr>
<td>Signs and Billboards</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Access Floors (special)</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Storage Cabinets</td>
<td>0.30</td>
<td>0.40</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Mech./Elect. Component</th>
<th>2003 NEHRP</th>
<th>ASCE 7-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks and Vessels w/o skirts</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Air side equipment</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Wet side equipment</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Emergency Battery Racks</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Stacks, towers braced below cg</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Vibration Isolated Equipment</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Piping – ASME Welded</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Piping – threaded joints</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Mech./Elect. Component</th>
<th>2003 NEHRP</th>
<th>ASCE 7-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks and Vessels w/o skirts</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Air side equipment</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Wet side equipment</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Emergency Battery/Tanks</td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>Stacks, towers braced below cg</td>
<td>0.40</td>
<td>0.33</td>
</tr>
<tr>
<td>Vibration Isolated Equipment</td>
<td>0.40</td>
<td>0.20</td>
</tr>
<tr>
<td>Piping – ASME Welded</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>Piping – threaded joints</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>
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 Ip greater than 1.0.

Except for glazing – no specific acceptance criteria is provided
No requirement to stay within elastic limits or allowables

Load Combinations

• In ASCE 7-05, the redundancy factor, p, is specified as 1.0 for nonstructural components.
• In ASCE 7-05, Qo is not specified and load combinations with Qo 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)

Anchorage of Nonstructural Components

In ASCE 7-05

All anchor forces based on Rp 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 Fp if gap > 0.25”

Load path analysis to primary structure shall be performed.

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

Certification Requirements for Certain Designated Seismic Systems (Ip=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

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 – ASME 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
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

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.