Nonbuilding Structures

Same:
• Basic ground motion hazards
• Basic structural dynamics

Different:
• Structural characteristics
• Fault rupture
• Fluid dynamics
• Performance objectives
• Networked systems
Dams with Damage
Dam and Water Treatment Plant
Joints at Long Spans
Elevated Roadways (1)
Elevated Roadways (2)
Tanks

Elephant’s foot buckling
Tanks & Towers
Pipelines
On-Grade and Buried
Electrical Towers and Substations
Nonbuilding Structures in the NEHRP Recommended Provisions

SCOPE of Chapter 14:
- Self supporting structures that carry gravity loads.
- Nonbuilding structures may be supported by earth or by other structures.

EXCLUSIONS:
- Vehicular and railroad bridges
- Nuclear power plants
- Offshore platforms
- Dams
Nonbuilding Structures

TWO CLASSIFICATIONS included in Provisions

1. Nonbuilding structures similar to buildings
   - Dynamic response similar to buildings
   - Structural systems are designed and constructed similar to buildings
   - Use provisions of Chapter 14 and applicable parts of Chapter 5, 7, 8, 9, . . . .

2. Nonbuilding structures not similar to buildings
   - Design and construction results in dynamic response different from buildings
   - Use Chapter 14 and “approved standards” for design
Nonbuilding Structures defined similar to buildings (2000)

Examples:
• Pipe racks
• Steel storage racks
• Electric power generation facilities
• Structural towers for tanks & vessels

(Many of these have changed in the 2003 edition)
Nonbuilding Structures not similar to buildings

• Use “approved standards” for design. Loads and load distributions shall not be less than those given by NEHRP RP.

Examples:
• Earth retaining structures
• Tanks and vessels
• Telecommunication towers
• Stacks and chimneys
• Buried structures (tanks, tunnels, pipes)
Nonbuilding Structures not similar to buildings

Examples of approved design standards:

• Telecommunications structures:

• Steel Stacks and Chimneys:
  – ANSI/ASME STS-1-1992, *Steel Stacks*
Nonbuilding Structures
Design Requirements

• LOADS
  – Weight, $W$, for calculating seismic forces includes all dead loads and all normal operating contents
  – (grain, water, etc. for bins and tanks)

• DRIFT LIMITATIONS
  – Drift limits of Section 5.2.8 do not apply - but must maintain stability. $P-\Delta$ check required.

• FUNDAMENTAL PERIOD
  – Calculate using same methods for buildings (5.3.3)
Nonbuilding Structures
Design Requirements

- **VERTICAL DISTRIBUTION OF SEISMIC FORCES**
  - Use same methods for buildings:
  - ELF or Modal Analysis

- **NONBUILDING STRUCTURES SUPPORTED BY OTHER STRUCTURES**
  - If $W_{nb} < 25\%$ of $W_{tot}$ treat nonbuilding structure as component and design per Chapter 6
  - If $W_{nb} \geq 25\%$ of $W_{tot}$ determine seismic forces considering effects of combined structural systems
Nonbuilding Structures
Design Requirements

- **SEISMIC COEFFICIENTS AND HEIGHT LIMITS**
  
  - Use smaller R factor from Table 5.2.2 or Table 14.2.1.1
  
  - In general, height limits for nonbuilding structures are less stringent than those for buildings
# Nonbuilding Structures Design Requirements

**Table 14.2.1.1: Seismic Coefficients and Height Limits**

<table>
<thead>
<tr>
<th>Structural System</th>
<th>$R$</th>
<th>$\Omega_o$</th>
<th>$C_d$</th>
<th>HL</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel storage racks</td>
<td>4</td>
<td>2</td>
<td>3½</td>
<td>NL</td>
<td>--</td>
</tr>
<tr>
<td>Elevated tanks on braced legs</td>
<td>3</td>
<td>2</td>
<td>2½</td>
<td>NL</td>
<td>--</td>
</tr>
<tr>
<td>Reinf conc tanks (nonsliding base)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>NL</td>
<td>--</td>
</tr>
<tr>
<td>Conc silos, stacks…w/ walls to fdn</td>
<td>3</td>
<td>1 ¾</td>
<td>3</td>
<td>NL</td>
<td>--</td>
</tr>
<tr>
<td>Trussed towers, guyed stacks…</td>
<td>3</td>
<td>2</td>
<td>2 ½</td>
<td>NL</td>
<td>--</td>
</tr>
<tr>
<td>Self-supporting, not covered by other standards and not similar to bldgs</td>
<td>1 ¼</td>
<td>2</td>
<td>2 ½</td>
<td>C</td>
<td>--</td>
</tr>
</tbody>
</table>
Nonbuilding Structures
Design Requirements

• IMPORTANCE FACTOR AND SEISMIC USE GROUP
  – Based on relative hazard of contents and function
  – Use largest value from Table 14.2.1.2 or from approved standard
Nonbuilding Structures
Design Requirements

- Table 14.2.1.2: Importance Factor and SUG

<table>
<thead>
<tr>
<th>Importance Factor</th>
<th>I=1.0</th>
<th>I=1.25</th>
<th>I=1.5</th>
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</thead>
<tbody>
<tr>
<td>Seismic Use Group</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Hazard</td>
<td>H-I</td>
<td>H-II</td>
<td>H-III</td>
</tr>
<tr>
<td>Function</td>
<td>F-I</td>
<td>F-II</td>
<td>F-III</td>
</tr>
</tbody>
</table>

H-I, H-II and H-III: Relative hazard of stored product
F-III: Communication towers, fuel storage tanks, cooling towers etc., required for the operation of SUG III buildings
F-II: Not applicable
Nonbuilding Structures
Chapter 14 Appendix

Additional design procedures and recommendations for:

• Electrical transmission, substation and distribution structures
• Buried structures
• represents current industry accepted design practice
• info not ready for inclusion in main body of chapter