

## NONBUILDING STRUCTURES



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## Nonbuilding Structures

Same:

- Basic ground motion hazards
- Basic structural dynamics

Different:

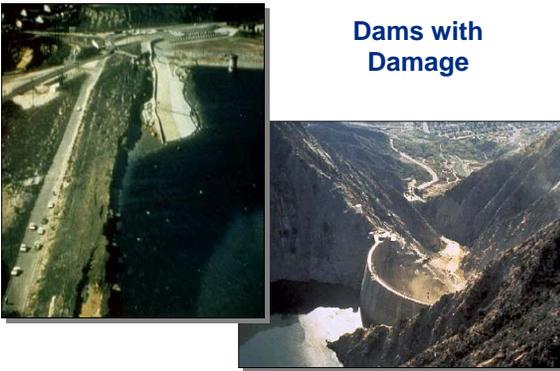
- Structural characteristics
- Fault rupture
- Fluid dynamics
- Performance objectives
- Networked systems



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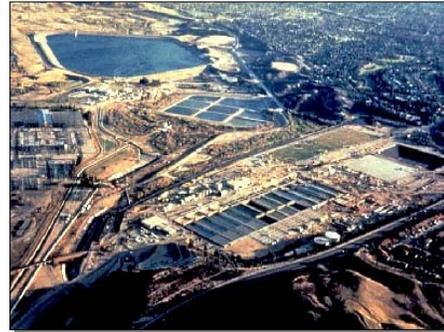
## Dams with Damage



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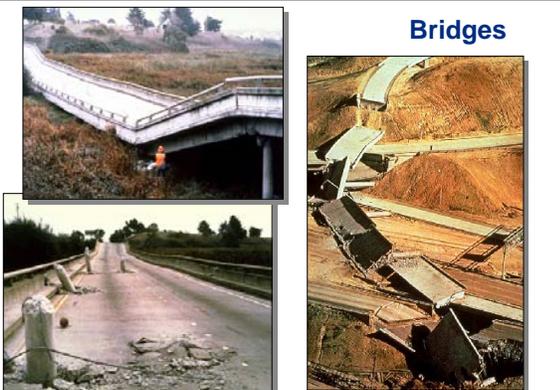
## Dam and Water Treatment Plant



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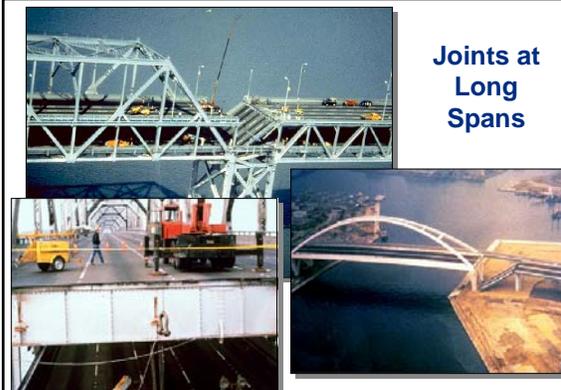
## Bridges



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## Joints at Long Spans



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## Elevated Roadways (1)



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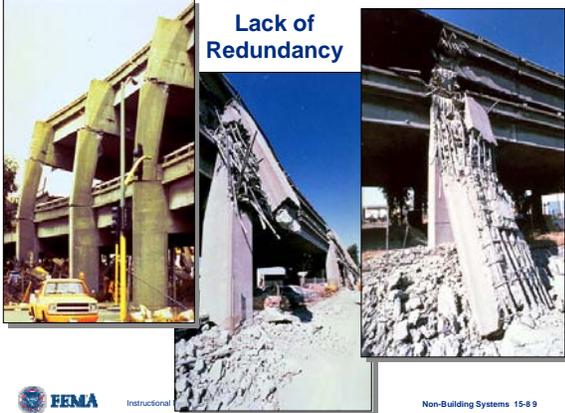
## Elevated Roadways (2)



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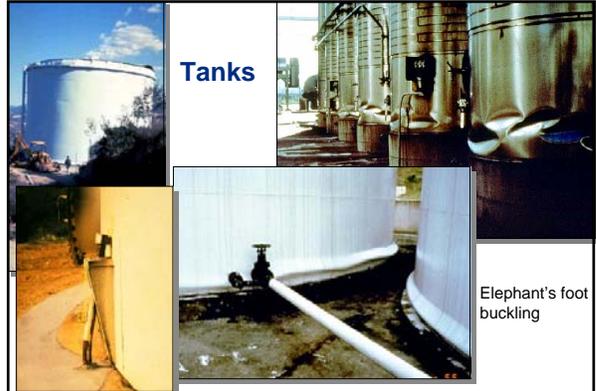
## Lack of Redundancy



Instructional

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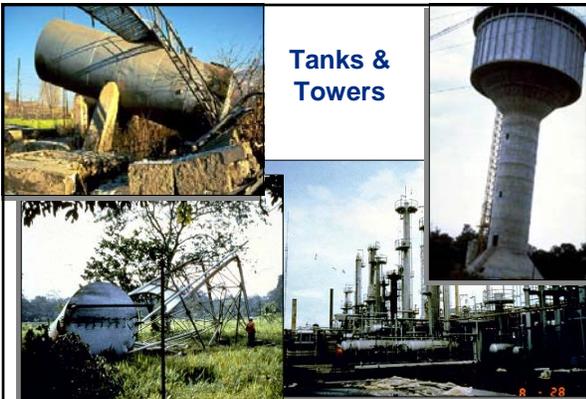
## Tanks



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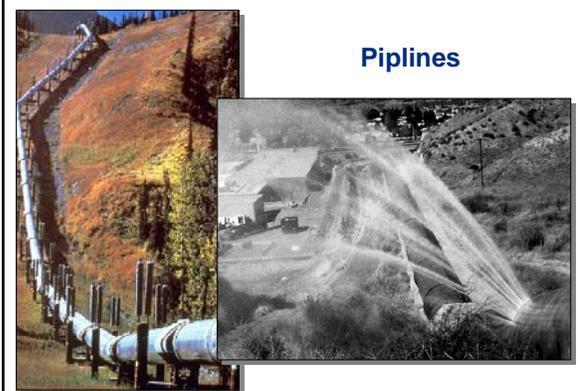
## Tanks & Towers



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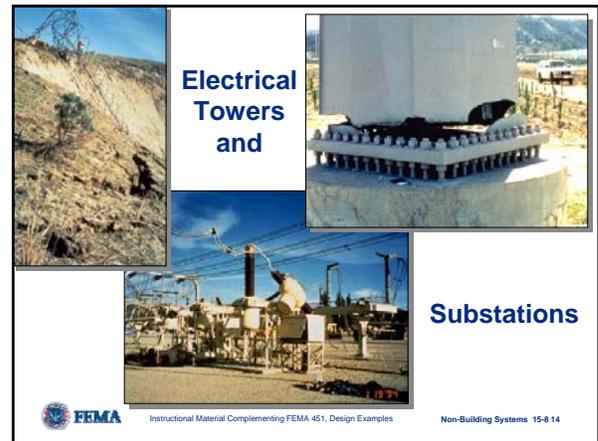
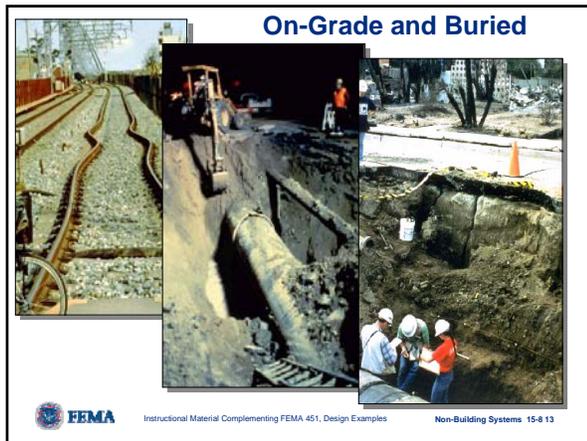
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## Pipelines



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### 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

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### 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

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### 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)

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### 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)

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## Nonbuilding Structures not similar to buildings

Examples of approved design standards:

- Telecommunications structures:
  - ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, 1995.
  - TIA/EIA 222F, *Structural Standards for Steel Antenna Towers and Antenna Supporting Structures*, 1996.
- Steel Stacks and Chimneys:
  - ANSI/ASME STS-1-1992, *Steel Stacks*



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## 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)



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## 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



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## 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



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## Nonbuilding Structures Design Requirements

Table 14.2.1.1: Seismic Coefficients and Height Limits

Structural System	$R$	$\Omega_o$	$C_d$	HL	X
Steel storage racks	4	2	3½	NL	--
Elevated tanks on braced legs	3	2	2½	NL	--
Reinf conc tanks (non-sliding base)	2	2	2	NL	--
Conc silos, stacks...w/ walls to fdn	3	1¼	3	NL	--
Trussed towers, guyed stacks...	3	2	2½	NL	--
Self-supporting, not covered by other standards and not similar to bldgs	1¼	2	2½	C	--



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## 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



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## Nonbuilding Structures Design Requirements

• **Table 14.2.1.2: Importance Factor and SUG**

Importance Factor	I=1.0	I=1.25	I=1.5
Seismic Use Group	I	II	III
Hazard	H-I	H-II	H-III
Function	F-I	F-II	F-III

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

