

SEISMIC VULNERABILITY AND MITIGATION OF WATER SYSTEM COMPONENTS

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Components

- Tanks
- Treatment
- Wells
- Pump Stations
- Administration and Maintenance
- Pipelines (next presentation...)

Tanks – Ground Support Steel

- Anchorage
- Pipe Flexibility
- Freeboard
- Steel Plate and Foundation Adequacy

Inadequate Anchorage



Elephant's Foot Buckling



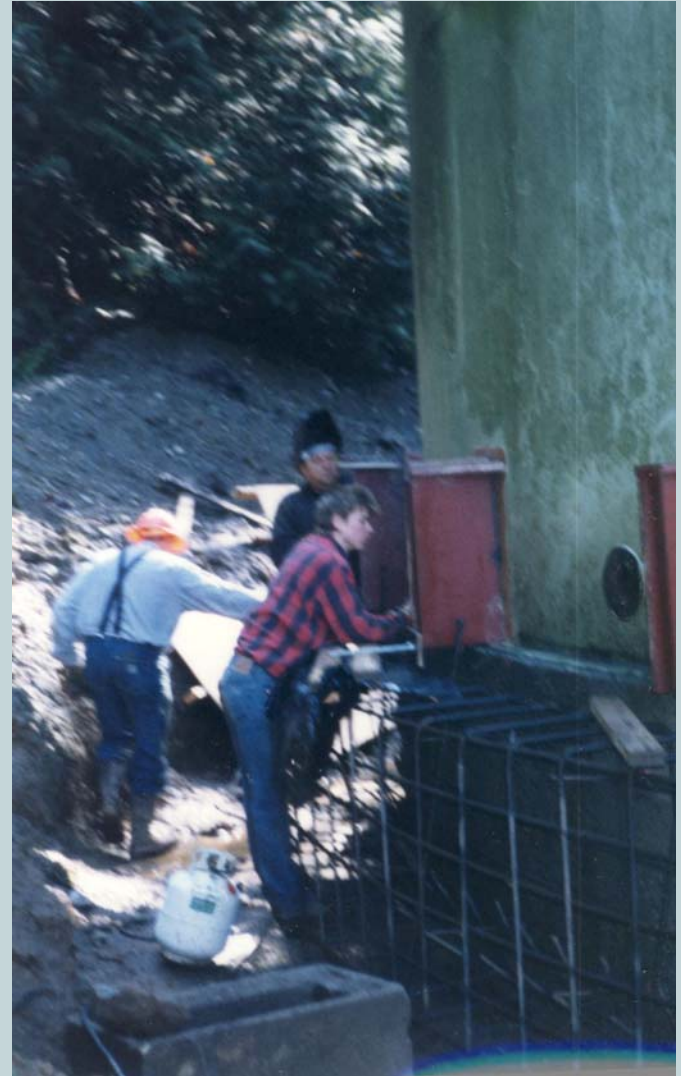
Tank Anchorage Upgrade Solutions

- Add Anchorage
 - External to Tank
 - Internal with Concrete Pour
- Limit Water Level

Little Mountain Reservoir Seismic Upgrade



Little Mountain Reservoir Seismic Upgrade



Tanks - Pipe Flexibility

- Side Connections Preferable to Bottom Connections
- AWWA D100-05 Minimum Design Displacement Requirements for Anchored Tanks
 - Upward Vertical: 1-inch relative to foundation
 - Downward Vertical and Horizontal: 0.5 inches relative to foundation
- Self-Anchored Values
 - Upward Vertical: 1-inch or 4-inches
 - Downward Vertical: 0.5 inches or 1-inch
 - Horizontal: 2 inches

Inadequate Pipe Flexibility



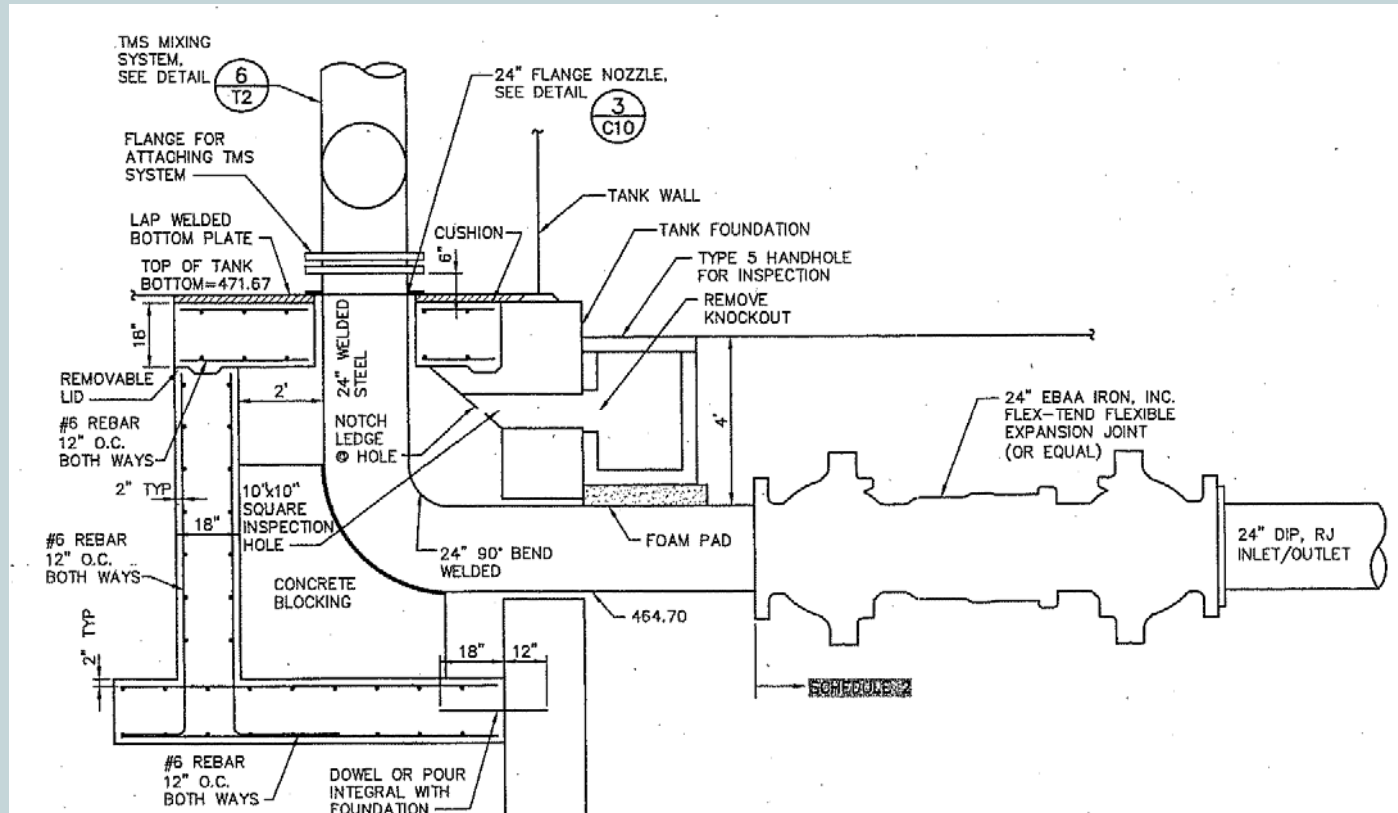
Flexible Connections



Flexible Connections (Cont)



Flexible Connection (Bottom Connection)



Steel Tanks – Freeboard

			Wave Height (ft)	
Dia (ft)	Height (ft)	Vol (MG)	Bellevue, WA	Spokane, WA
75	60	2.0	5.3	2.0
55	60	1.1	4.6	1.8
80	40	1.5	5.4	2.1
160	40	6.0	4.6	2.5
80	80	3.0	5.5	2.1
40	55	0.5	3.9	1.5
50	70	1.0	4.4	1.7

Steel Tank Structural Strength



Tanks – Prestressed Concrete

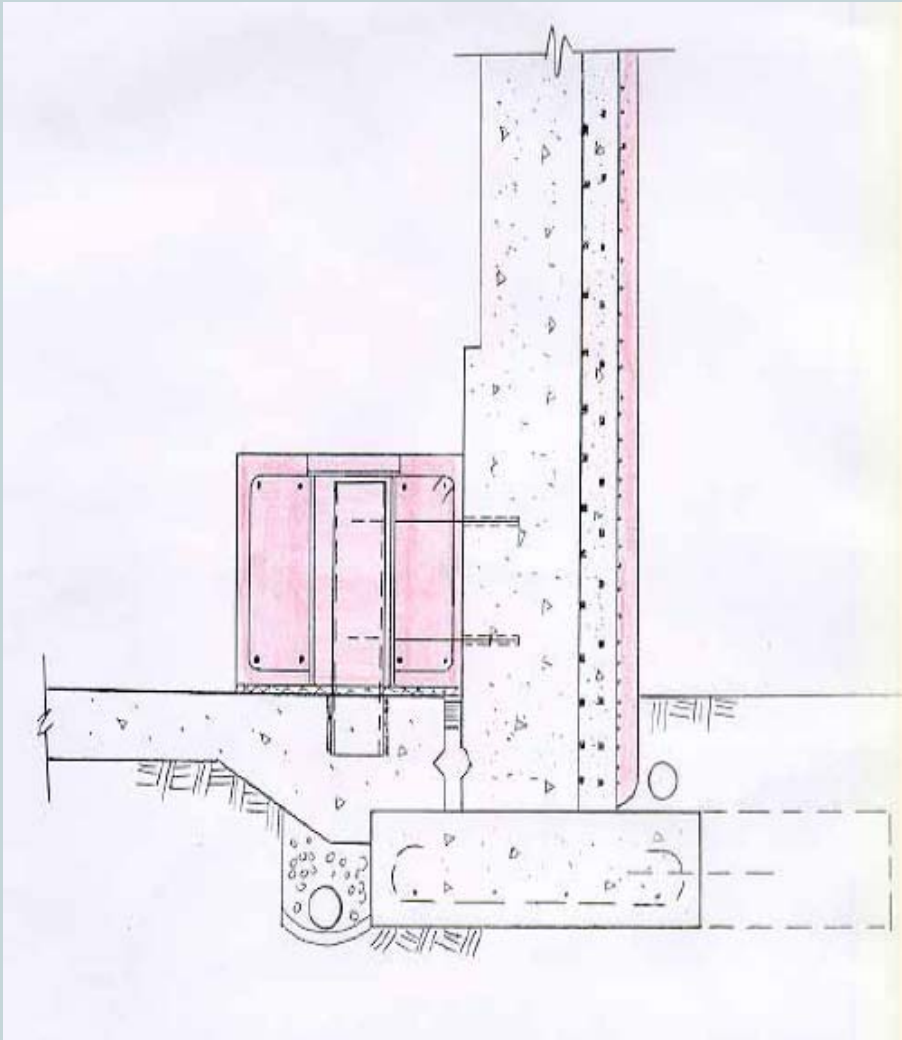
- Lateral Restraint (Seismic Cables)
- Wall Hoop Stresses/Condition



Wire Wrapped Concrete Tanks - Condition



Concrete Tanks – Sliding



Concrete Tanks

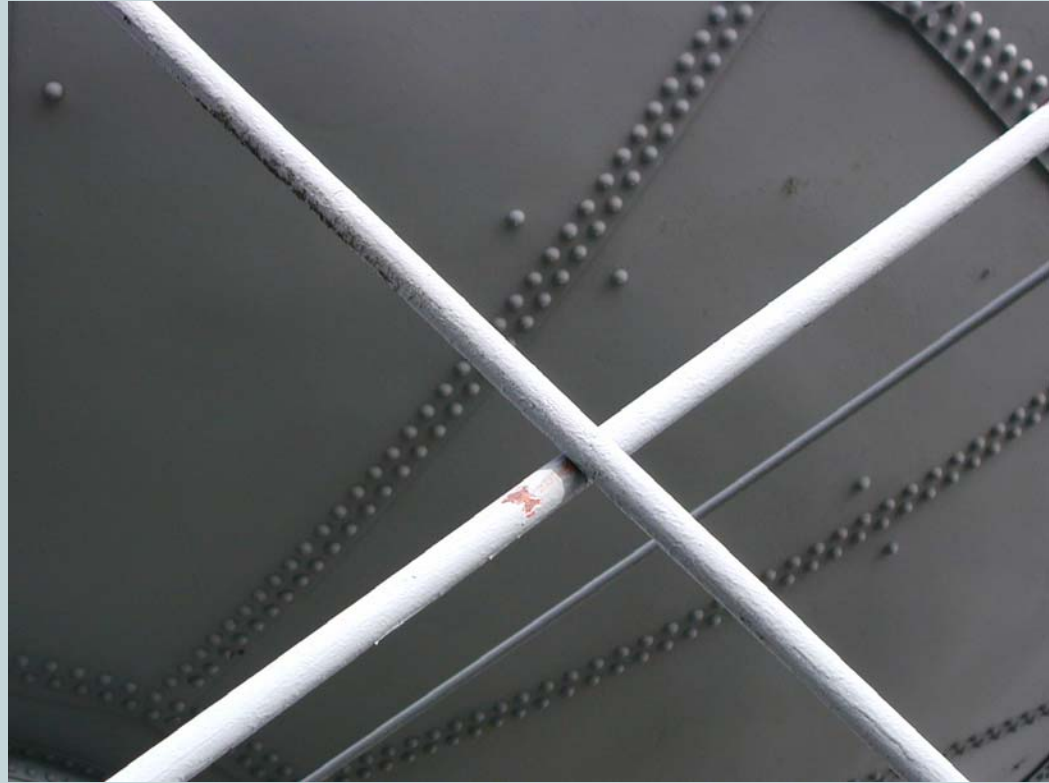
– Hoop Stress



TANKS – ELEVATED STEEL

- Bracing Adequacy
- Grade Beams

Elevated Steel Tanks



Elevated Steel Tank Upgrade Solutions

- Strength Approach – Structure and Foundation
- Seismic Isolation
- Energy Dissipation

Elevated Tank Seismic Isolation/Structural Upgrade



Before

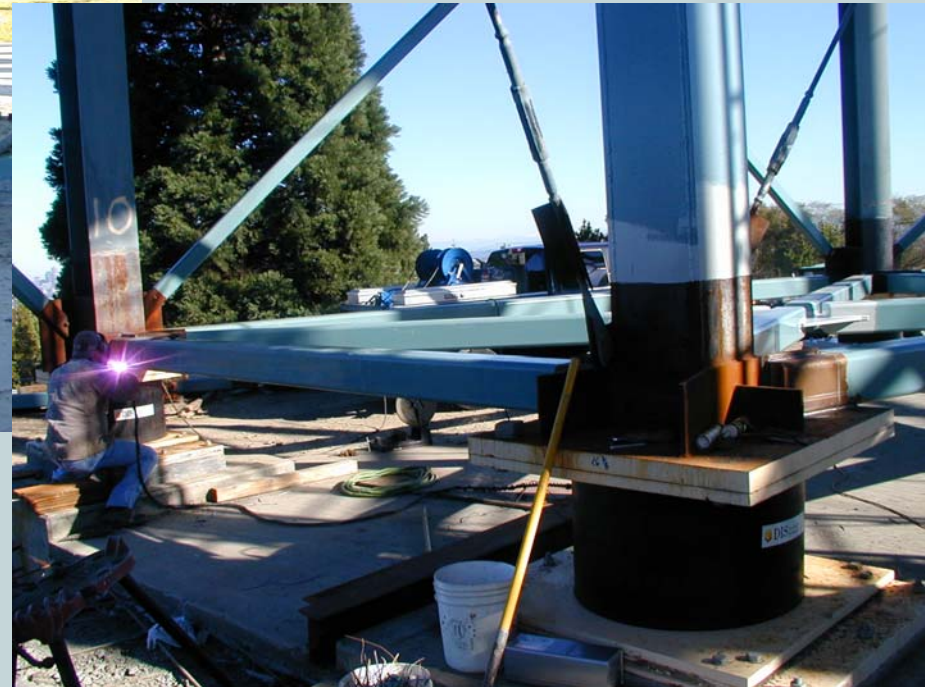


After

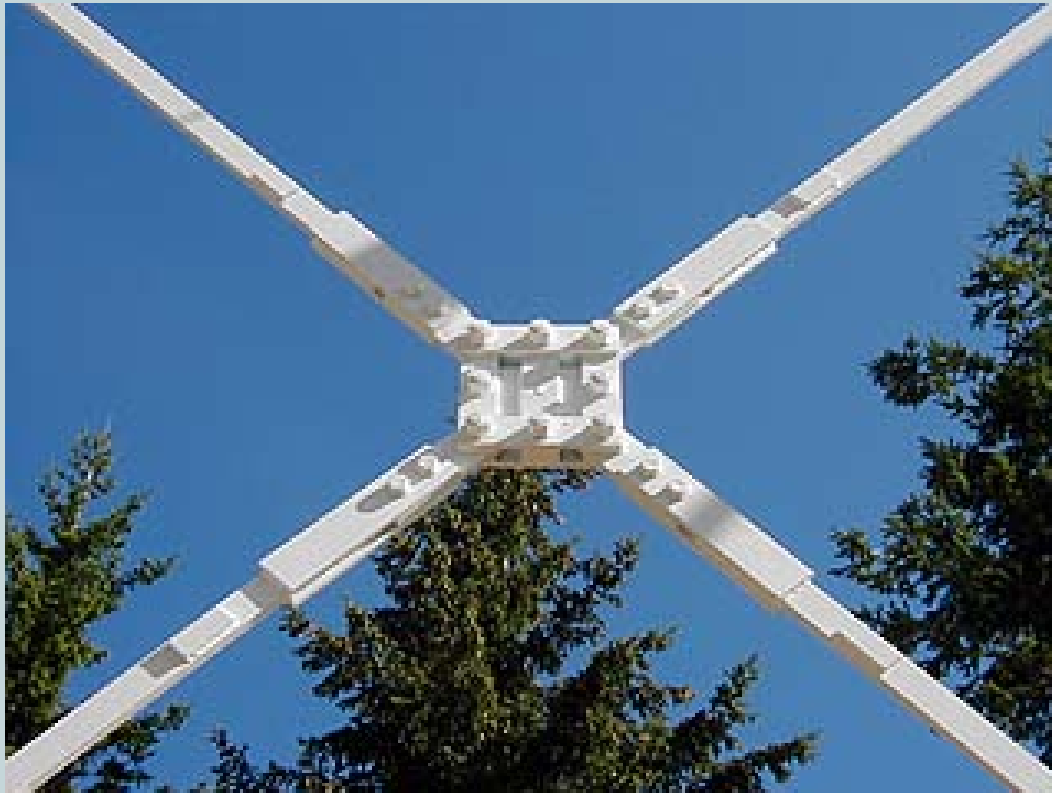
Elevated Tank Seismic Isolation/Structural Upgrade (cont)



Elevated Tank Seismic Isolation/Structural Upgrade (cont)



Elevated Tank Upgrade – Energy Dissipation



Elevated Timber Water Tanks



TREATMENT FACILITIES – CLARIFIERS AND SEDIMENTATION BASINS

- Sloshing
- Geotechnical Conditions



TREATMENT FACILITIES – EQUIPMENT

- Chlorine cylinders and compressed gas cylinders
- Process piping bracing and flexibility
- Protective measures to prevent inundation

Chlorine Cylinders



Not Good



Better

Gas Cylinders (cont)



Not Good



Good

Hazardous Materials Storage



Not Good

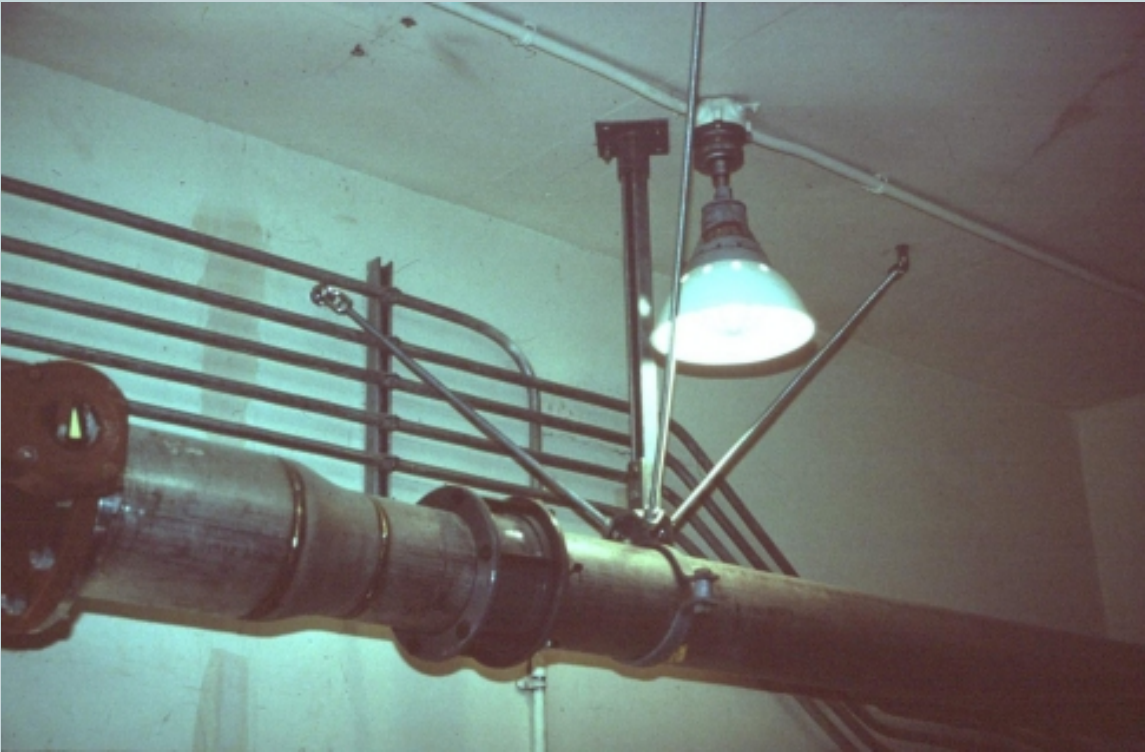


Better

Plant Piping



Plant Piping (cont)



Wells

- Bent Casings
- Sanding
- Submerged Pumps
- Aquifer Problems
- Structure and nonstructural components

Pump Stations

- Anchor pump and motor to common base
- Sloshing (submerged pumps)
- Power supply
- Structure and nonstructural components

Administration and Maintenance Facilities

- Administration Facilities
- Storage Racks
- “General” Building Contents

Administration Facilities



Office Equipment



Electrical Cabinets



Not Good



Good

Storage Racks



Miscellaneous Hazards



Not Good



Good

Miscellaneous Hazards (cont)



Miscellaneous Hazards (cont)



A map of the United States with a grid overlay. Numerous small circles of varying sizes are scattered across the map, representing earthquake epicenters. A prominent red line with a jagged, oscillating pattern, resembling a seismic wave, runs horizontally across the lower portion of the map. The text is overlaid on the map in a bold, red, sans-serif font.

Minimizing Earthquake Damage

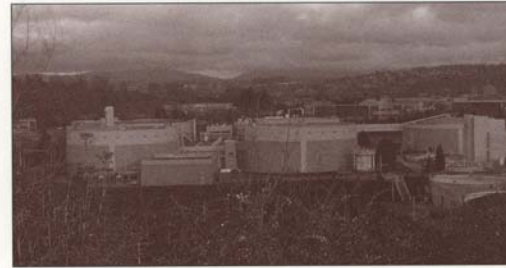
A Guide for Water Utilities



American Water Works Association

SEISMIC SCREENING CHECKLISTS FOR WATER AND WASTEWATER FACILITIES

Edited by William F. Heubach



Technical Council on Lifeline Earthquake Engineering
Monograph No. 22
September 2002

ASCE



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Any Answers?