You Just Got the Geotech Report. Now What?

PNWS-AWWA

Water Infrastructure Seismic Design Considerations

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Four key steps guide the implementation of geotechnical seismic considerations

1. Review and dissect the report
2. Communicate information, options, and implications
3. Determine design criteria
4. Incorporate approach into design

REVIEW AND DISSECT

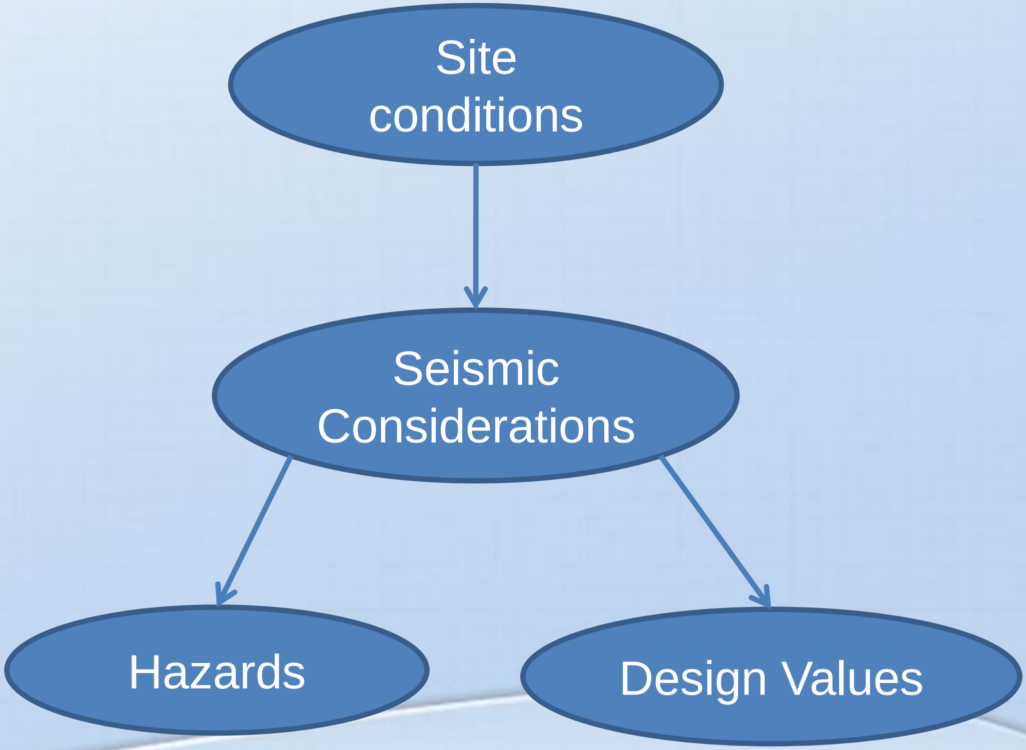
Seismic considerations include three key items:

- Liquefaction
  – Potential for liquefying and consolidation of soils
- Seismic movement
  – Shaking motion during a quake
- Ground displacement
  – Location of ground features following a quake

Dissection of the geotech report is critical to identifying key seismic design influences

The Geotechnical Report

What the designer needs to know



The geotech report contains essential information for proper facility design

- Seismic demand (lateral and vertical accelerations)
  - Soil type
  - Site specific analysis
- Foundation system (deep, mat, shallow)
- Slope stability and excavation protection recommendations
- Anticipated settlement (piping flexibility requirements)
- Wall and foundation sizing
  - Lateral pressure based on soil type and acceleration

COMMUNICATE INFORMATION

Communication of geotech considerations is critical to decision-making

- Project owner – cost implications
- Design team
  - Structural
  - Civil – site layout
  - Electrical – conduit runs
  - Mechanical – equipment anchorage

Communication of geotech considerations is critical to decision-making

Ground displacement

Sloshing

Liquefaction

Anchorage

Sloshing develops significant forces that can result in tank failures

Sloshing can lead to various types of tank wall failure

Haiti 2010
San Fernando 1971
Long Beach 1933

Courtesy of the National Information Service for Earthquake Engineering, EERC, University of California, Berkeley

Liquefaction can lead to extensive settlement and pipeline damage

- Title: Liquefaction and lateral spread around tanks
- Creator(s): unknown
- Date: 1995
- Source: (Copyright restricted)
- Location: Eastern Asia/Japan/ASIA/Kobe
- Earthquake: Kobe, Japan earthquake, Jan. 17, 1995 Magnitude: 6.69

Ground displacement causes pipe failures

Liquefaction can also lead to structures floating upward

- Title: Manhole raised by liquefaction
- Creator(s): Bardet, Jean-Pierre
- Date: 2004-10-31
- Location: Eastern Asia/Japan/ASIA
- Earthquake: Niigata-Ken Chuetsu, Japan earthquake, Oct. 23, 2004 Magnitude: 6.8

DETERMINE CRITERIA

Final level of design is based on requirements ***<u>and</u>*** policy

- Building/seismic code requirements
- State/local resiliency standards and goals
- ASCE
- American Lifelines Alliance
- Practical system vulnerability
  - Existing redundancy within a system
  - Historical challenges with system components

The design team needs to account for the extent and types of risks identified

- Primary goals:
  - Safe environment for operators
  - Continued water flow following a quake
  - Continued functionality
- Design requirements:
  - Foundation stability
  - Pipeline flexibility
  - Equipment anchorage

INCORPORATE INTO DESIGN

Each project component must be designed to address all seismic concerns

- Liquefaction
  - Threat: Infrastructure sinks, floats, or settles differentially
  - Solution: Remediate, support and/or anchor
- Seismic movement
  - Threat: Sloshing or differential motion
  - Solution: Adequate design and connection flexibility
- Ground displacement
  - Threat: Differential settlement
  - Solution: Proper sizing and flexibility

Treatment plant features require multi-faceted seismic design

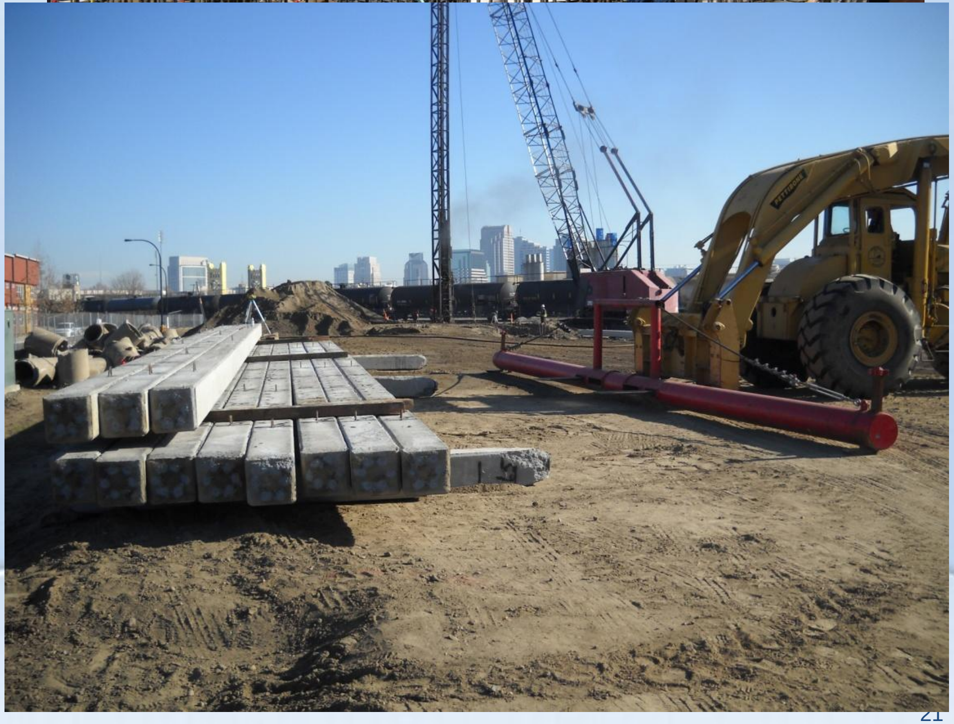
Remediation is often a viable option for addressing liquefaction

- Remediate soils
  - Vibro-compaction
  - Dynamic Compaction
  - Stone Columns
  - Soil Mixing
  - Grouting
- Remove and replace
  - Granular
  - CLSM
  - Lighter, cellular concrete
- Dewater
- Pile support protects the structure but not the connections

- Title: Gap beneath tank mat
- Creator(s): unknown
- Date:
- Location: Eastern Asia/Japan/ASIA/Kobe
- Earthquake: Kobe, Japan earthquake, Jan. 17, 1995 Magnitude: 6.69

Examples of foundation designs that address liquefaction include…

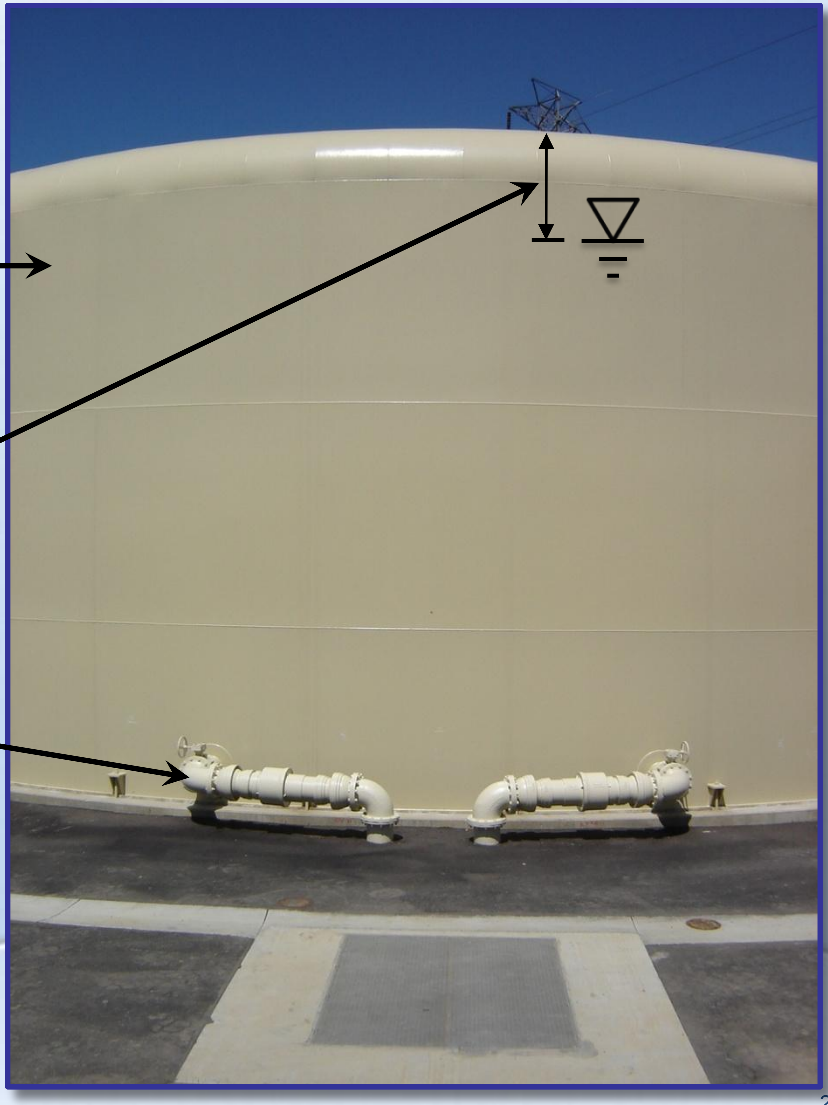
- Shallow foundation on remediated soil
- Mat foundation
  - Large/spread, thickened slab
- Deep foundation
  - Piles



Tank seismic design incorporates criteria determined early in project

Life Safety =
Strength

Continued Operation =
Freeboard
Flexibility

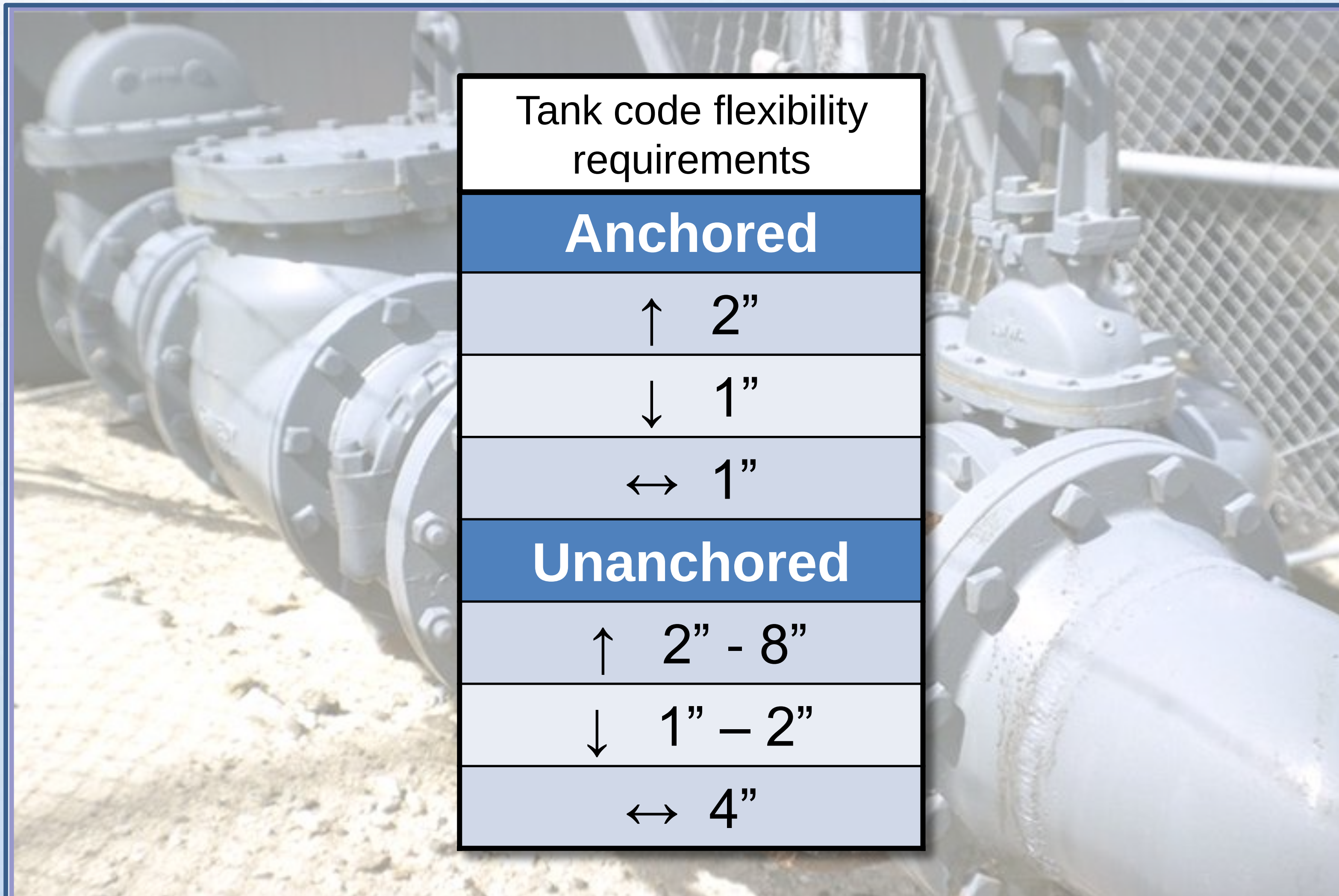


Accommodating sloshing in a tank requires additional freeboard

Water Reservoir Freeboard, ft					
Aspect Ratio D/H	Dia. (ft)	Los Angeles	Bakersfield	Portland	Seattle
5	150	7’	12’	8’	7’
2	60	6’	10’	6’	5’
0.5	15	3’	5’	3’	2’

Side water Depth: 30 ft

All seismic design concerns require piping connection flexibility



Tank code flexibility requirements
Anchored
↑ 2”
↓ 1”
↔ 1”
Unanchored
↑ 2” - 8”
↓ 1” – 2”
↔ 4”

Courtesy of the National Information Service for Earthquake Engineering, EERC, University of California, Berkeley

Design of piping flexibility is dictated by geotech report design values

Critical piping flexibility needs to be accounted for in cost estimates

More pipe in galleries introduces more risk for failures

Pipe supports that incorporate seismic design loads require significant space

In summary, implementation of geotechnical criteria follows four steps…

1. Review and dissect the report
2. Communicate information, options, and implications
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Questions?

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