Prestressed and Cast-in-Place Concrete Water Storage Reservoir Seismic Design

Overview

- Seismic Loads on your Reservoir
- Features to Reduce Seismic Risk
- Additional Detailing for Seismic
- Applicable Codes and Standards
- Future Seismic Considerations
- Design Philosophies
- Seismic Parameters

DISASTER!!!!

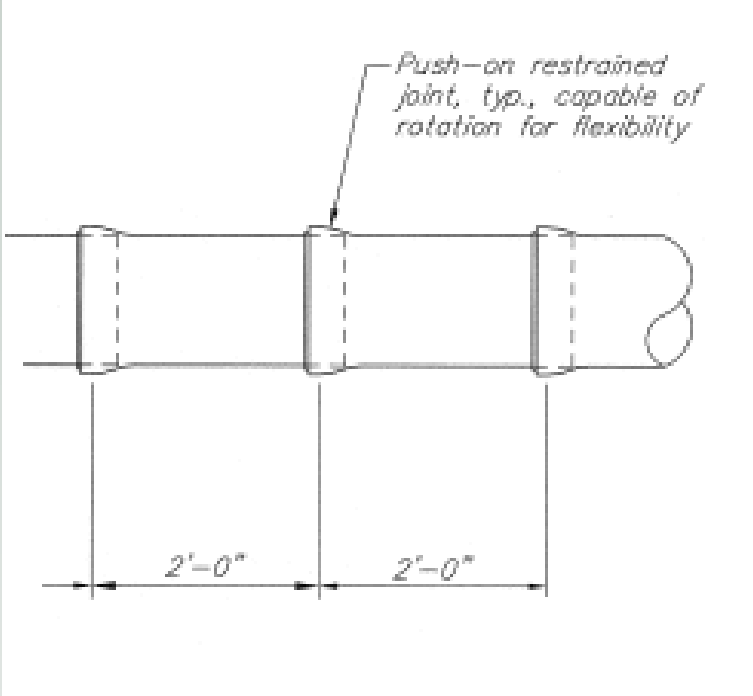
Don’t underestimate Nature

Seismic Loads on Your Reservoir

- Tank, anchorage and foundation under distress.
- Possible failures: anchorage breakage, buckling, pipe connections and soil liquefaction
- Older reservoirs are under capacity for current Code levels.
- Taller, narrower and unburied tanks have more issues.

Features to Reduce Seismic Risk

Flexible piping connections to tank.



Multiple, closely spaced joints

Features to Reduce Seismic Risk

Expansion/rotation joints

EBBA Flextend connection between tank and yard piping

Features to Reduce Seismic Risk

The inlet and outlet piping should have seismically activated closure valves

Seismically actuated valve

Features to Reduce Seismic Risk

- The tank floor, walls, and roof are interconnected to prevent displacement of any structural element from another.

Features to Reduce Seismic Risk

The tank is founded as required to avoid lateral spreading, liquefaction, and landslides by bearing on rock or deep foundations as required

Additional Detailing

- Crack Prevention: Small spacing for primary reinforcing (ACI 350 => tighter spacing and smaller bar is rewarded)
- Two curtains of reinforcing when economical
- Partially buried tank when possible
- Fibers in slabs and shotcrete cover
- Shrinkage reducing admixtures

Applicable Codes and Standards

- ACI 350
- ASCE 7
- NSF
- AWWA

Future Seismic Considerations

- Design code –Account for changes in future IBC codes and other standards
- Example= New dome roof seismic load combination

Design Philosophies

- Different design philosophies
- Seismic criteria for certain elements of different types of tanks are not equal.
- The tank industry has written special exceptions for various types of tanks.
- Slabs are examples

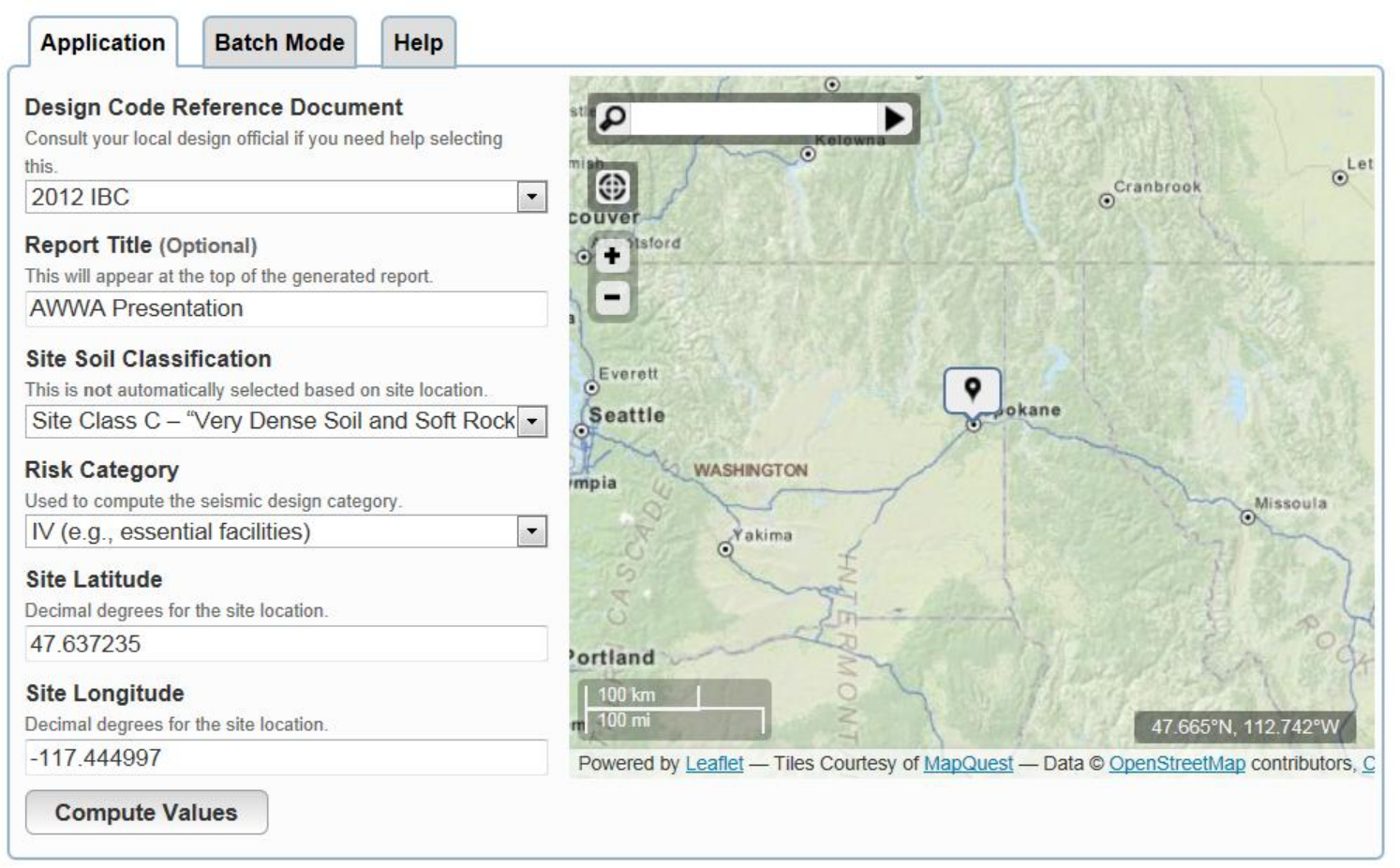
Seismic Parameters

- Seismic Accelerations, based on USGS Maps
- Tank Restraint Coefficients are based on Tank Type and Applicable AWWA Code
- Site Class= Determined by Geotech. Based on borings and subsurface investigations
- I= Importance Factor

Seismic Accelerations

- 2% probability in 50 years
- No more Zones (now categories)
- Published maps by USGS are used
- Geotechnical Input

USGS Earthquake Hazards Program



http://geohazards.usgs.gov/designmaps/us/application.php

USGS Earthquake Hazards Program

USGS Design Maps Summary Report

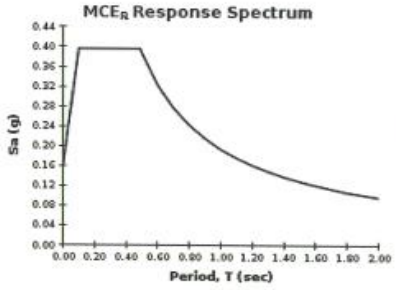
User–Specified Input

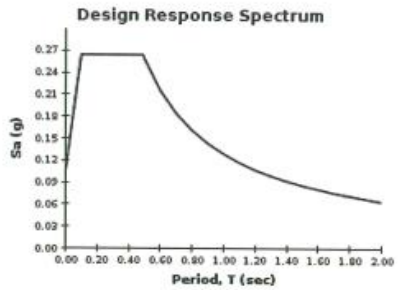
Report Title	AWWA Presentation Wed March 27, 2013 14:50:09 UTC
Building Code Reference Document	2012 International Building Code (which makes use of 2008 USGS hazard data)
Site Coordinates	47.63724°N, 117.445°W
Site Soil Classification	Site Class C – "Very Dense Soil and Soft Rock"
Risk Category	IV (e.g. essential facilities)

USGS–Provided Output

S_S =	0.330 g	S_{MS} =	0.396 g	S_{DS} =	0.264 g
S_1 =	0.115 g	S_{M1} =	0.193 g	S_{D1} =	0.129 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





Importance Factors

IBC/ASCE

- I= 1.5 = “Essential Facility”
- I = 1.25 = “Risk to human life” and “disruption to civilian life”
- I = 1.0 = lower risk categories

ACI 350.3-06

- I = 1.5 = “containing hazardous materials
- I = 1.25 = “tanks tend to be usable for emergency purposes after quake”
- I = 1.0 = other

Discuss with Owner

Elements Effected by “I”

Impacts:

- Amount of prestressing or tendons
- Amount of base seismic restraints
- Size of foundation or burial
- Thickness of wall
- Amount of slosh and freeboard

Seismic Slosh

- Seismic Slosh and Required Freeboard
- Based on maximum operating elevation not cresting overflow event
- What causes larger slosh?
  - Location
  - Diameter of Tank
  - Importance Factor
  - Height
- Designed to keep roof from uplifting/floating

Questions?