## Workshop Outline

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## Overview

- Codes & Their History
- Conventional vs. Prestressed
- Type I and Type III Tank Projects
- Design Considerations
- Recently Completed Tank Projects
Concrete Tank Design Codes

**ACI 350.3-06**
Used to design conventional and prestressed tanks

**AWWA D110-04**
Used to design prestressed tanks

**Brief Code History**

- **ACI 350.3-06**
  - Main difference from previous version (ACI 350.3-01) are the seismic design parameters
  - ACI 350.3-01 used seismic zones while ACI 350.3-06 uses site specific seismic design parameters

- **AWWA D110-04**
  - Still uses seismic zones for seismic design parameters
  - 2010 CBC adopted ACSE 7-05 which requires site specific seismic design parameters to be used in lieu of seismic zones (ASCE 7-05 Section 15.7.7.3) when designing with AWWA D110

**Result:** All reinforced and prestressed concrete tanks must be designed using site specific seismic design parameters
Comparison of Seismic Design Parameters

<table>
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<tr>
<th>Location</th>
<th>$S_{DS}$</th>
<th>$S_{D1}$</th>
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<tbody>
<tr>
<td>San Francisco, CA</td>
<td>1.0</td>
<td>0.68</td>
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<tr>
<td>Davis, CA</td>
<td>0.69</td>
<td>0.38</td>
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<tr>
<td>Woodland, CA</td>
<td>0.68</td>
<td>0.38</td>
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Structural Difference in Conventional vs. Prestressed Tanks is Mainly in Wall Design

- **Conventionally Reinforced Tanks**: Wall is designed in bending to resist forces on the wall.
- **Prestressed Tanks**: Prestressed cables are designed to resist the forces on the wall.

**Result**: Conventionally reinforced tanks typically will have a thicker wall than prestressed tanks.
Prestressed Concrete Tanks

AWWA D110 – Type I
• Cast-in-place concrete with vertical prestressed reinforcement

AWWA D110 – Type III
• Precast concrete with a steel diaphragm

Type I Tanks
Type I Tanks

Type I Tanks
Type I Tanks

Type I Tanks
Type III Tank

Type III Tank
Type III Tank

Type III Tank
Type III Tank

Standard Steel Diaphragm with Re-Entrant Angles

Type III Tank

Regularly embossed steel diaphragm with re-entrant angles provides an enhanced mechanical connection between concrete to steel diaphragm and shotcrete to steel diaphragm for transferring seismic induced forces.
Design Considerations: Roofs

- Concrete or Aluminum
- Traffic/Heavy Load
- Columns or Dome

Design Considerations: Walls

- Hoop Stress
- Lateral Seismic Force (seismic cables)
- Shear Transfer (cables, embossed diaphragm)
- Overturning
- Sliding (floor slab extension)
Design Considerations: Walls

• 2 DOF system
• Impulsive – constrained
• Convective – sloshes
• Hydrodynamic stresses

Design Considerations: Footings

• Ring Wall (Overturning)
• Column Footing
• Membrane Slab
• Mat Slab
• Deep Pile Foundation
East Area Water Tank – Davis, CA

D Street Reservoir – Hayward, CA
Reed Reservoir – Escondido, CA