



# Reservoir Inspection and Structural Analysis

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Why is this important? See anything?







- Safety
- What are we looking for?
- Steel vs. concrete
- Interior vs. exterior
- How do we get a good look at the roof?





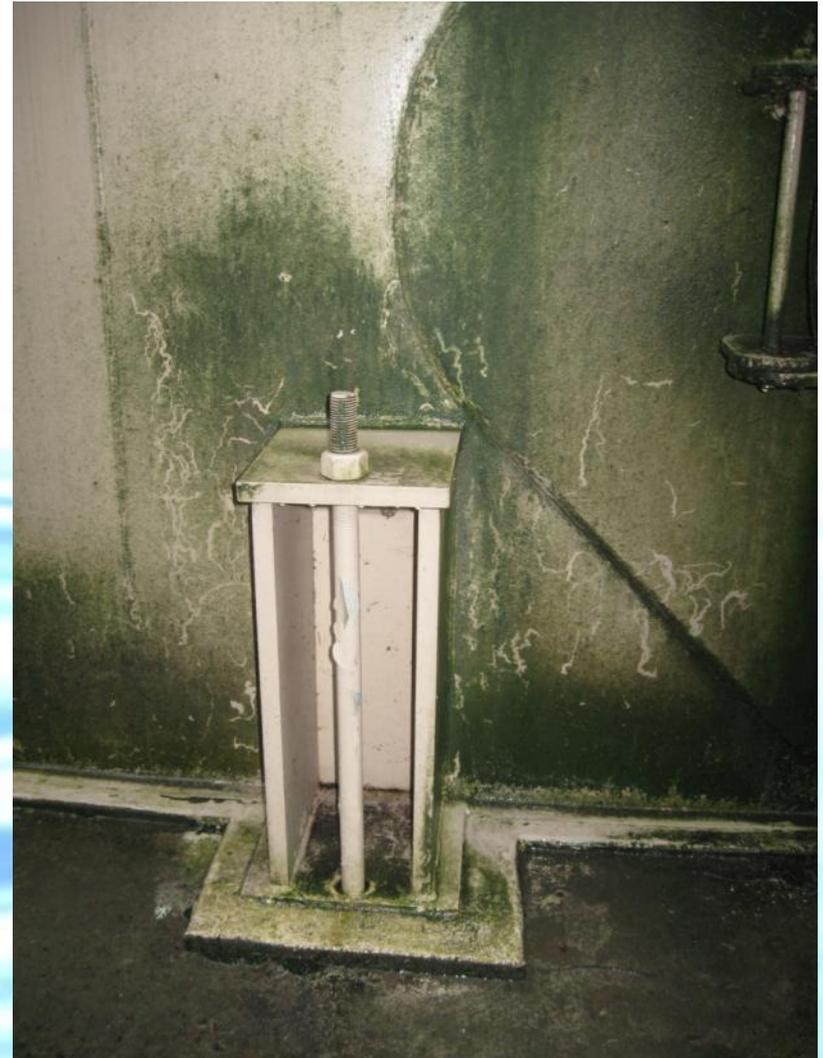
- Confined space entry
- Fall hazard
- Water hazard





## What are we looking for?

- Steel tanks
  - Paint failures
  - Corrosion
  - Algae
- Concrete tanks
  - Cracks and crumbles
  - Exposed rebar
  - Rock pockets
- All tanks
  - Ladders
  - Piping
  - Hatches
  - Vents



**Things that look bad**



## Full Reservoir

- Roof inspection by boat

## Drained reservoir

- Wash down walls and floor
- Visual inspection from floor





## Safety considerations

- Lockout/tag out for reservoir valves
- Air monitor and radio communication
- Retrieval system and harnesses
- Lifejackets and second raft deployed
- Rescue plan and coordination with local fire dept.





# Boat inspections





# Boat inspections



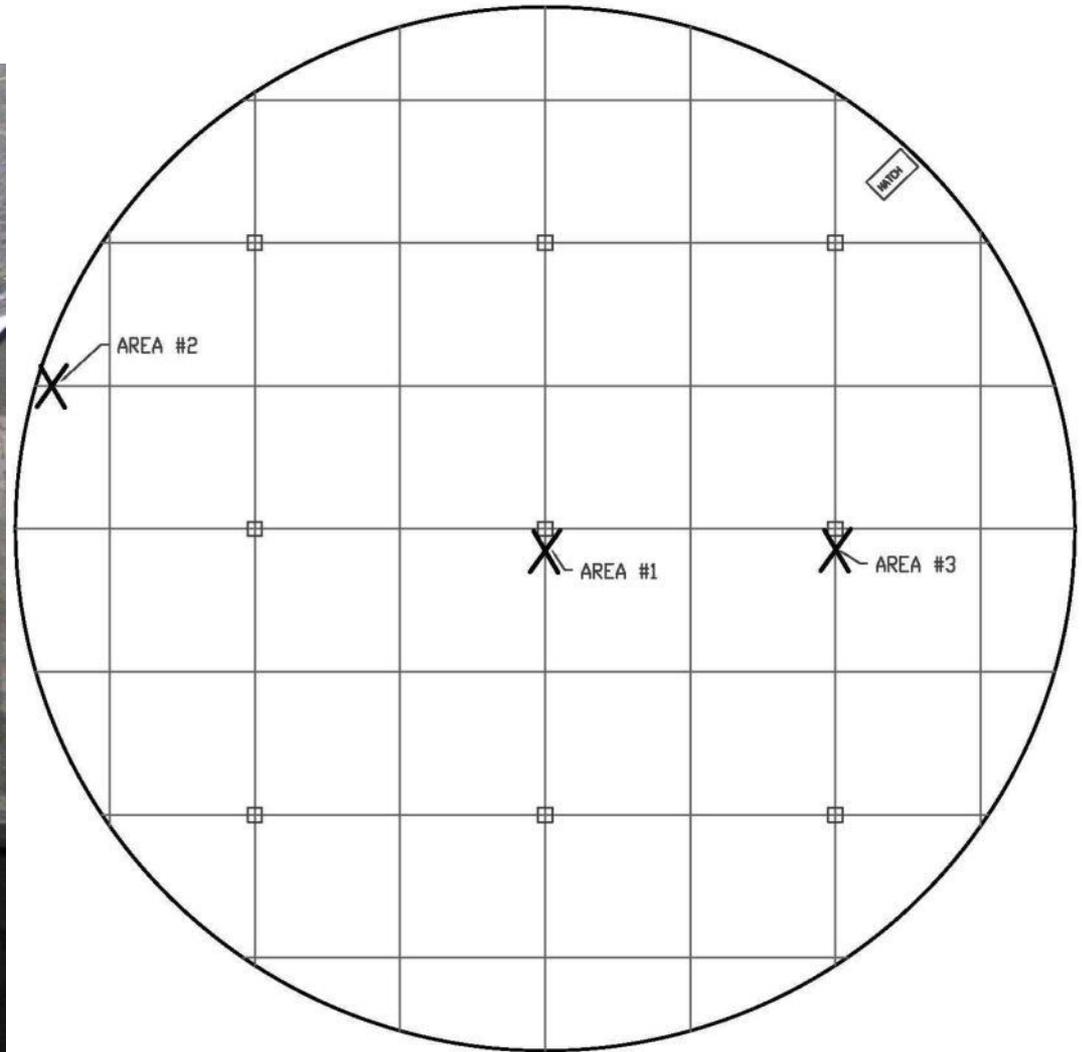


# Boat inspections



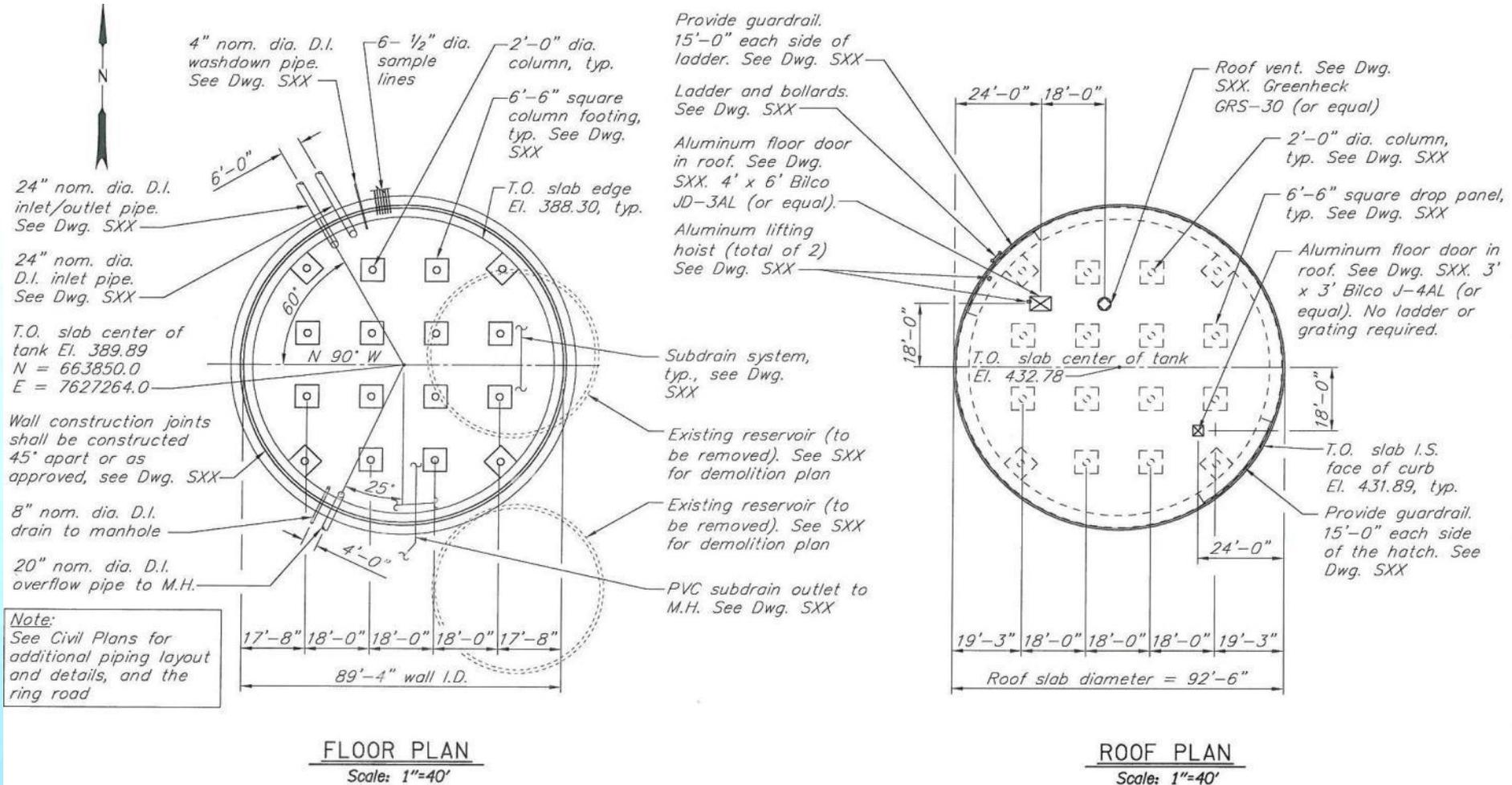


## Network of beams and columns





## Columns and drop panels





## Columns and drop panels





# Concrete roof inspections

Looking for cracked, spalled, or crushed concrete



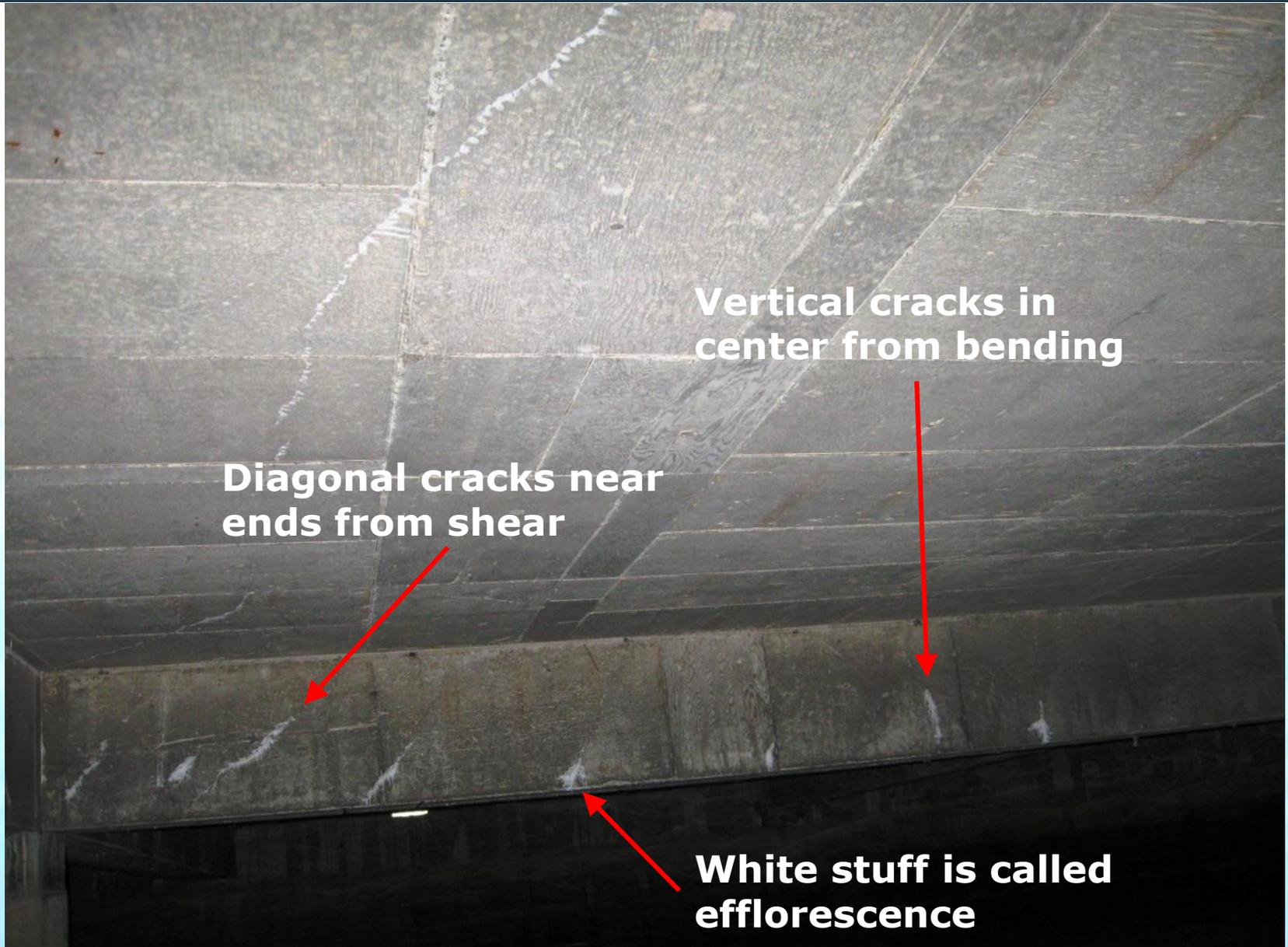


**Beam breaking free of roof slab**

**Spalling from beam/beam pocket friction**



# Beam and slab cracking



**Diagonal cracks near ends from shear**

**Vertical cracks in center from bending**

**White stuff is called efflorescence**



# Beam failure

**Beam breaking free of roof slab**

**This began as a shear crack**

**When crack hit longitudinal bars,  
they peeled free**

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# Beam failure





# Developing beam failures





# Marking cracks in beams





# Roof to wall connection



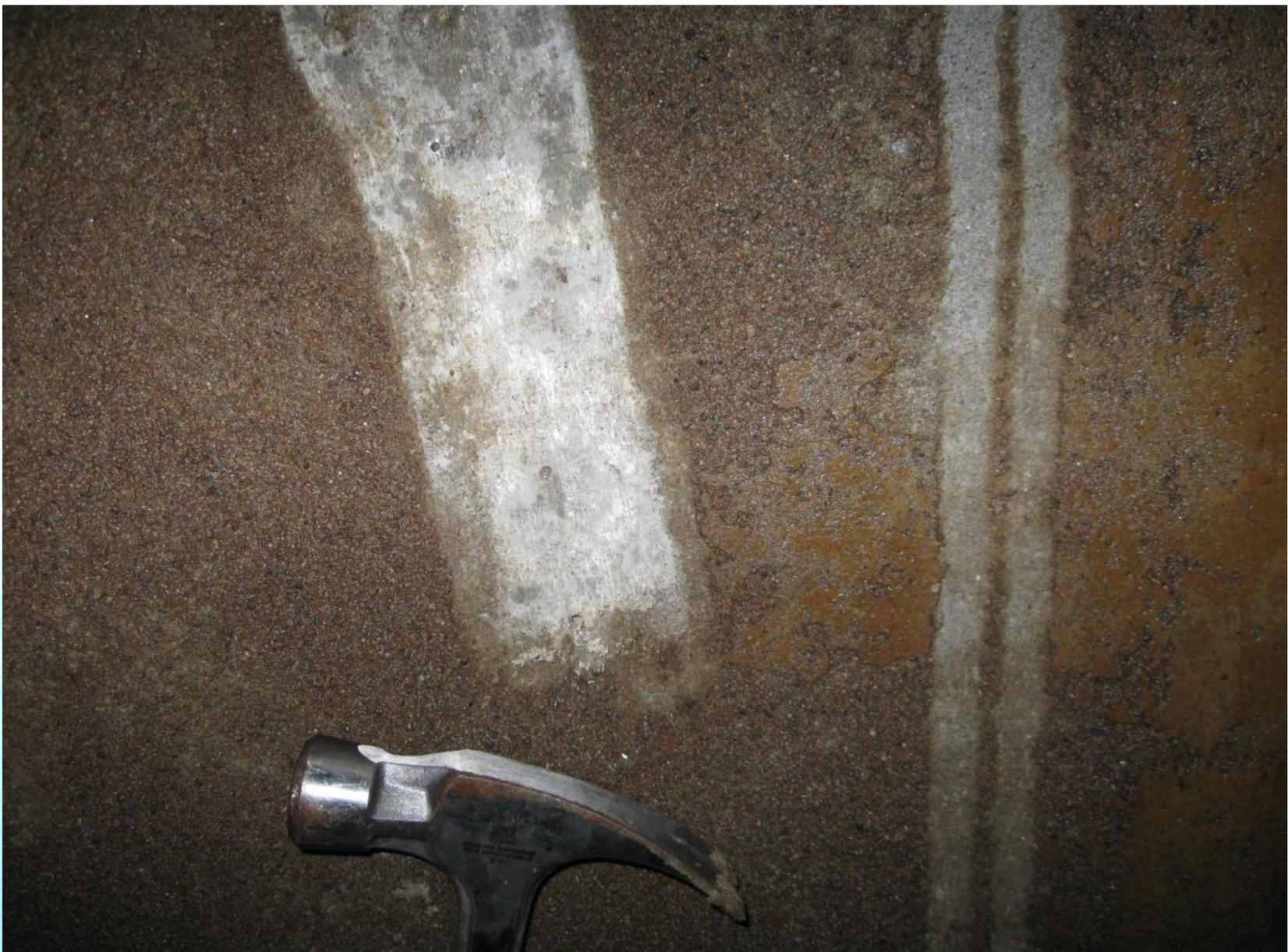


# Rock pockets in columns





# Deteriorating concrete wall coating





# Hatches

- Hinges
- Latches
- Locks





## Ladders

- Corrosion
- Attachment





## Piping

- Corrosion
- Attachment







# Exterior inspections





# Deteriorating paint





- Safety planning
- Gather information
  - As-builts
  - Previous inspections
- Documentation
  - Photos
  - Inspection reports
- Evaluation and analysis by structural engineers
- Plan for repairs



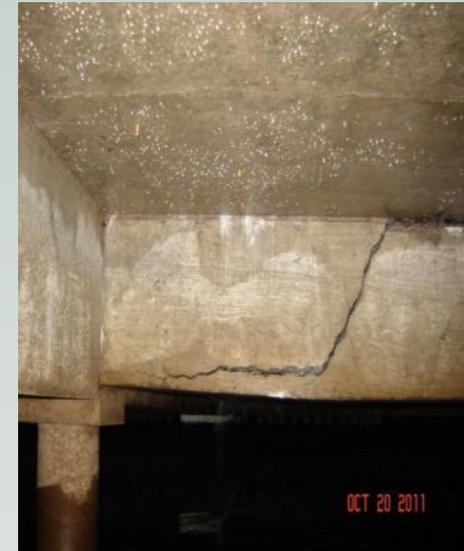
# Reservoirs— Structural Analysis and Retrofits



# Appropriate Inspection Program

In addition to those applicable and mentioned previously by TVWD (Pete Boone)

- Nondestructive testing (NDT)
- Inspect the Roof
- Inspect the Wall
- Observation Below Grade
- Sample and test Shotcrete



# Appropriate Structural Analysis and Retrofit Strategies

## Analysis

- Analysis of the existing structure
- Review available documents
- Determine the era of tank construction
- Determination of load rating capacity

# Appropriate Structural Analysis and Retrofit Strategies

## Evaluation

- Identification and prioritization of deficiencies and repairs
- “Short-term” versus “long-term” repairs and risks
- Alternatives for "short-term" repairs
- Preliminary cost estimates
- Previous loadings

# Appropriate Structural Analysis and Retrofit Strategies (cont'd)

- **Seismic structural analysis is based on:**
  - Field inspections
  - Available design, construction, and past inspection report documentation.
  - Knowledge of construction techniques at the time of construction
  - Current code
  - All failure mechanisms

# Understand the Causes



- Deterioration
  - (don't just cover it up!)
- Spalled shotcrete cover
- Rusty, deteriorated & broken wrap wire
- Concrete carbonation
- Leakage & freeze/thaw damage at wall top

# What a Water District needs to know about Seismic Loads on your Reservoir

- Tank, anchorage and foundation under distress.
- Possible failures: anchorage breakage, buckling, pipe connections and soil liquidfaction.
- Older reservoirs are undercapacity for the current Code levels.
- Taller, narrower tanks have more issues.
- All nonstructural features need bracing.
- Install shut-off valves.
- Locate all ponds and basins down slope from tank.
- Earthquake levels: 2% probability of being exceeded in 50 years.
- Seismic Slosh and Required Freeboard.

# Also Consider...



- Decisions must include non-seismic considerations and life-cycle costs
- Piping connections, soil capacity, anchorages, design codes, size .
- Economical ways to reduce load and deterioration

# Geotechnical Considerations

Site specific information is necessary to accurately identify the true vulnerability including

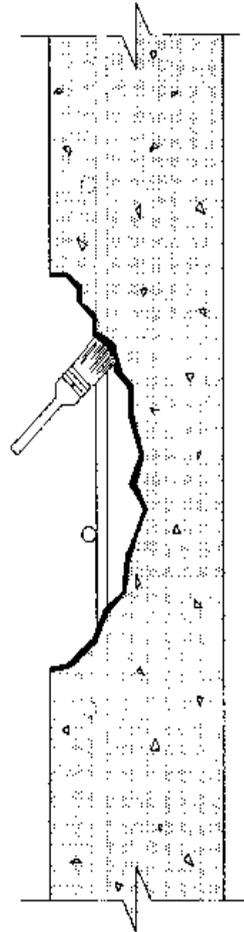
- landslide potential, liquefaction of the soils
- ground rupture (based on proximity of the closest mapped fault)
- stability of the site.



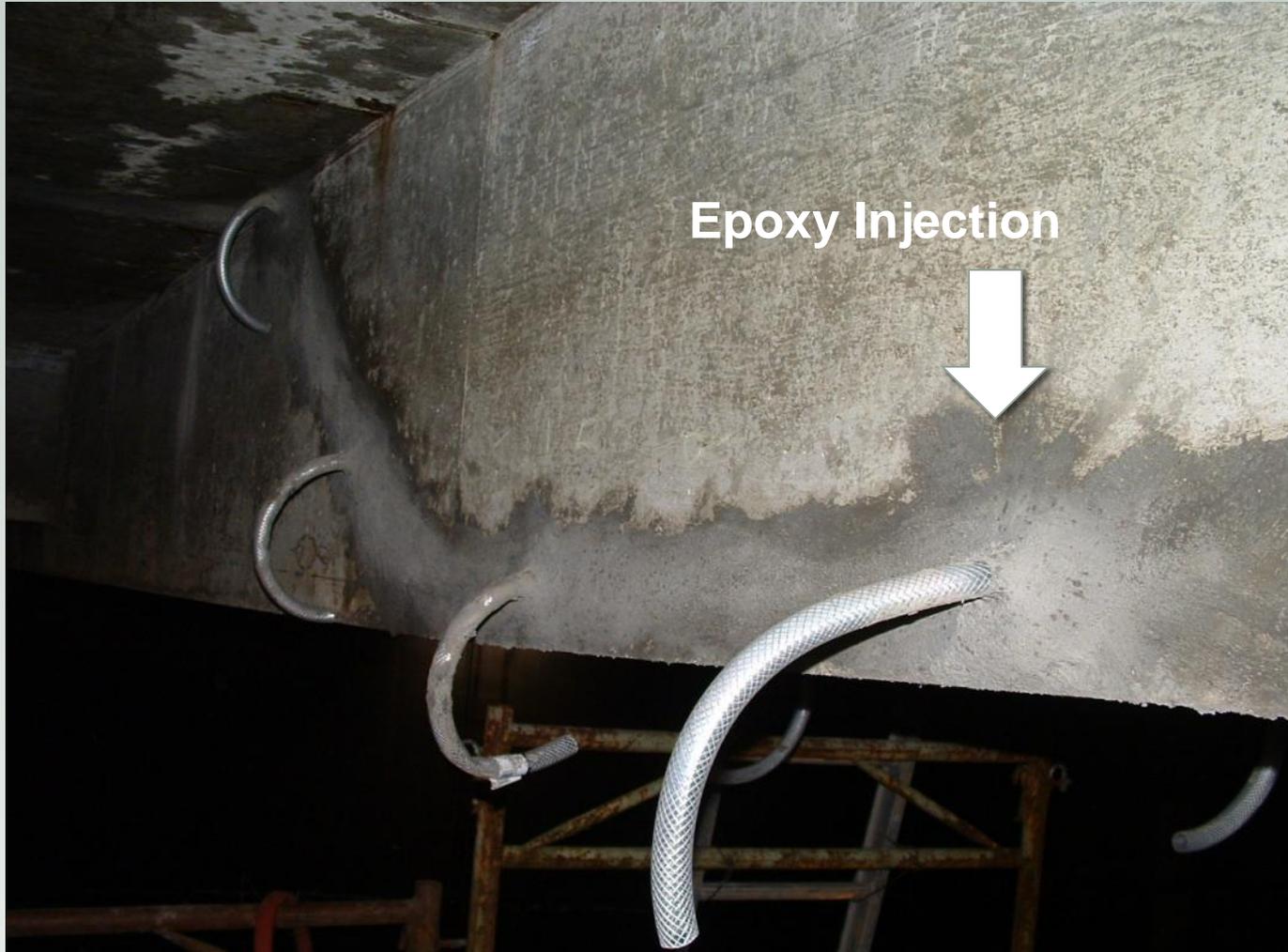
# Repair Examples

## SC-200 Sika® Armatec 110 Bonding Bridge

1. Pre-wet surface to saturated surface dry (SSD).
2. Apply by stiff bristle brush or spray apply with "Goldblatt pattern pistol" or equal equipment.
3. Place repair material while Sika Armatec 110 is still wet or dry up to 24 hours.



# Corrective Measures

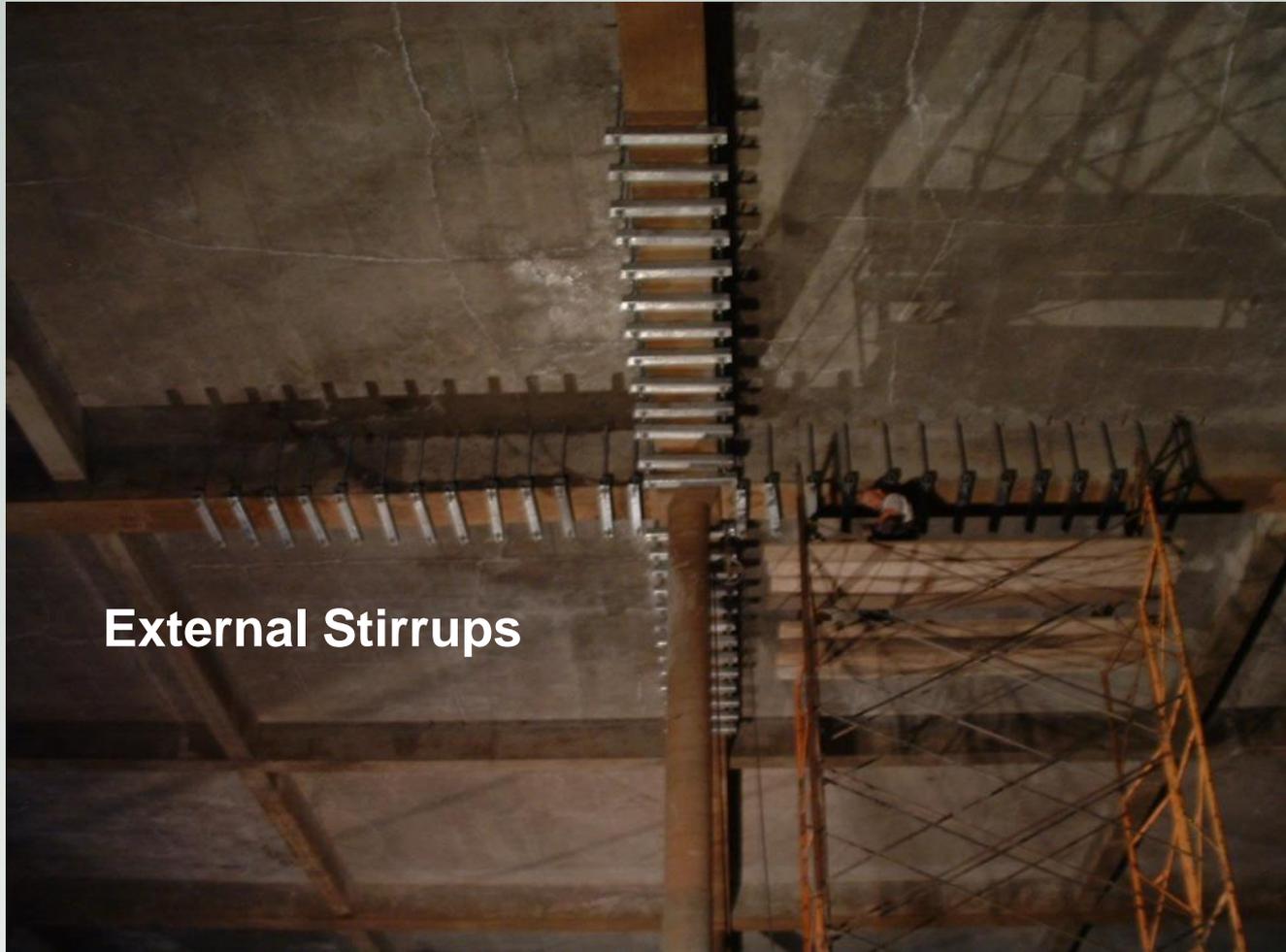


# Corrective Measures



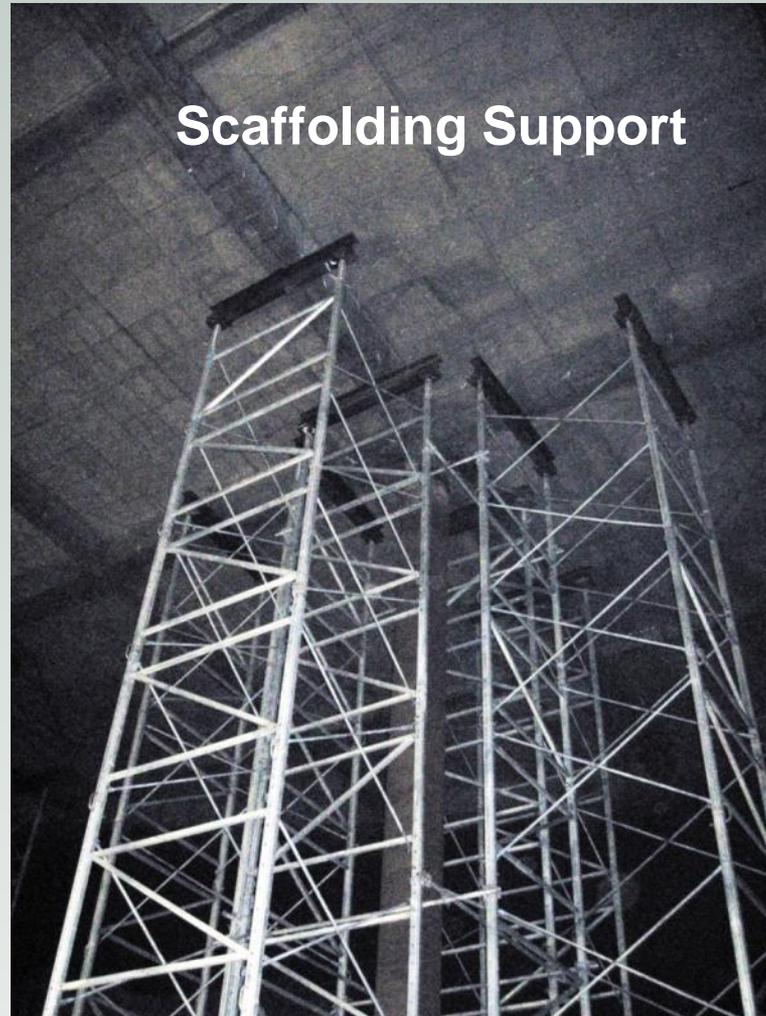
**External Stirrups**

# Corrective Measures



**External Stirrups**

# Corrective Measures



# Questions?





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