EARTHQUAKE ENGINEERING

# Ductility Provisions for Outlet Works

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# Problem Statement

- The Corps lacks sufficient guidance on designing for ductility in new structures and evaluating the ductility of existing structures.

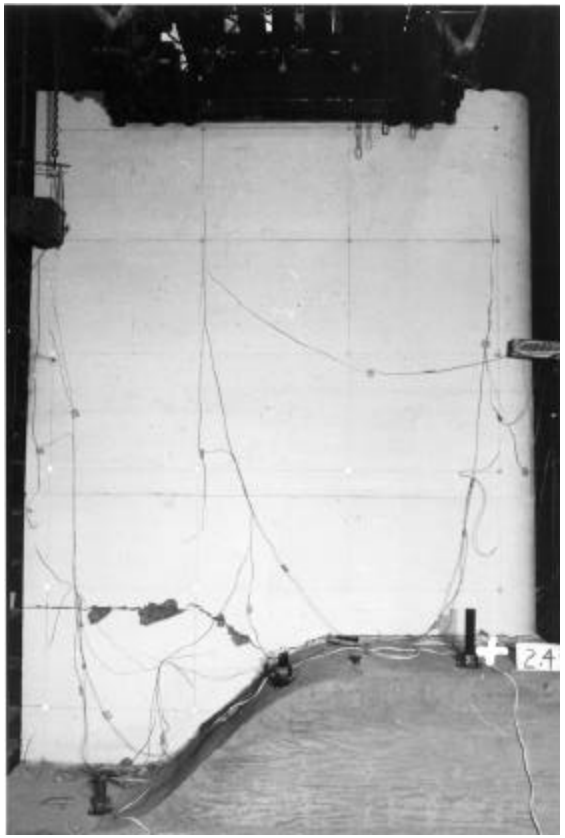
# Potential Structure Types

- Gate Piers
- Retaining Wall Resemblance
  - Stilling basin
  - Approach channel
  - Outlet channel
  - Training wall
- Conduits
- Service Bridge Piers and Abutments

# Pier Wall Experiment

- 1/10 - scale model of Smithland tainter gate pier
- Displacement controlled
- 3 cycles per displacement interval to insure capacity
- Vertical gravity force (scaling effects) included
- Applied horizontal force at model top

# Pier Wall



# Pier Wall

- Response was dominated by localized rotation similar to intake tower experiments
- Assumption of single crack is conservative
- Deflection based analysis technique is appropriate

# FY 00 FRG Results

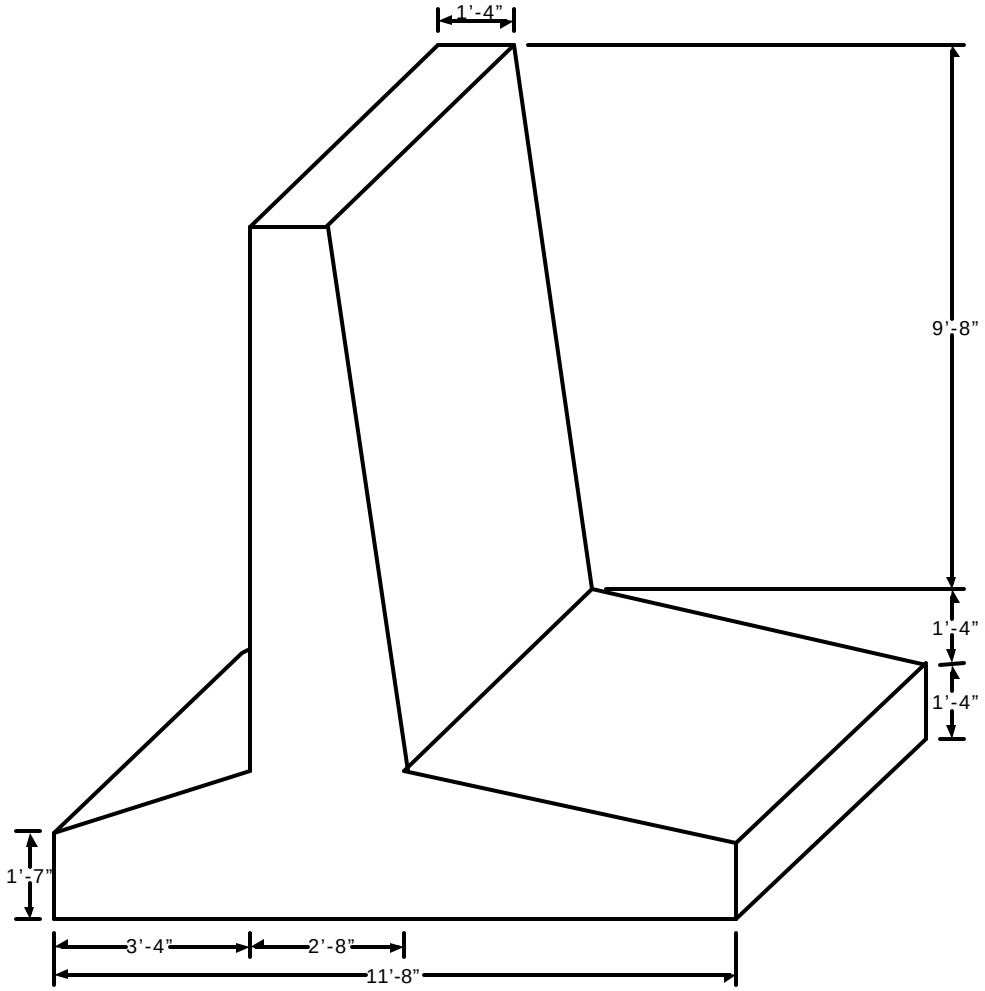
- "…focus on evaluation and testing of outlet works structures, with work coordinated with the seismic analysis/design of cantilever retaining walls work unit"

- Conduct one-way excursion retaining wall experiment

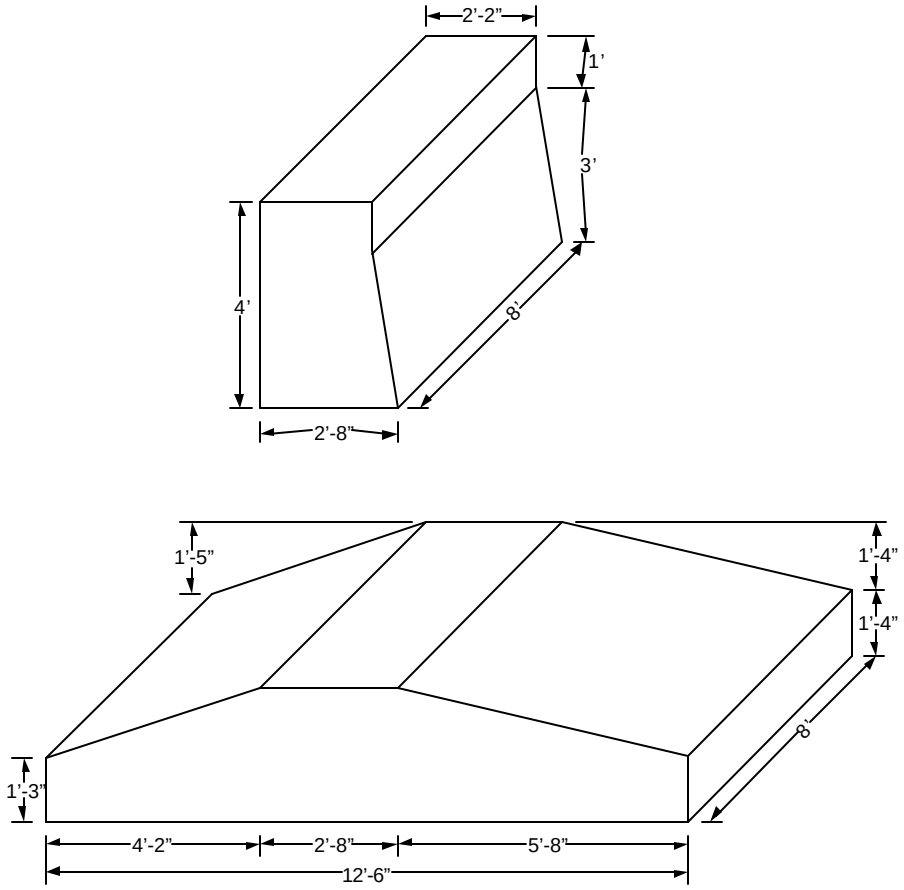
# Experimental Design

- Experimental design was of a 1/2 scale model of a typical retaining wall under increasing, one-way, cyclic horizontal displacements.
- Vertical loading simulated scaled gravity forces.
- Horizontal loading location determined using displacement controlled analysis approach being incorporated into CSLIP program.

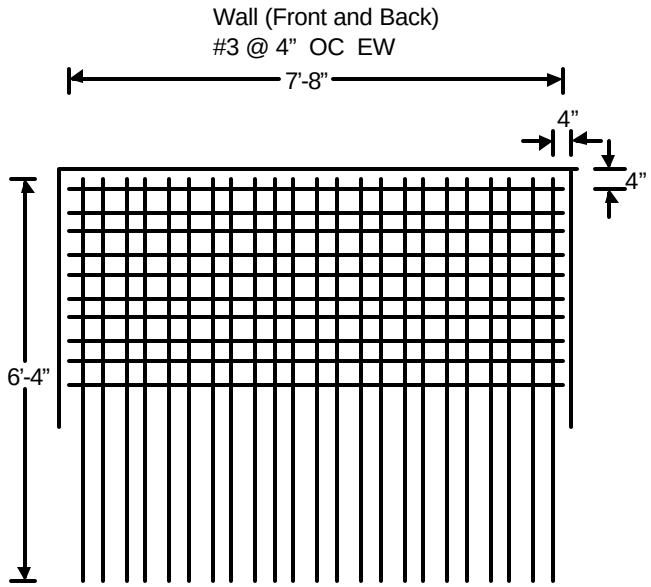
# Cantilever Retaining Wall



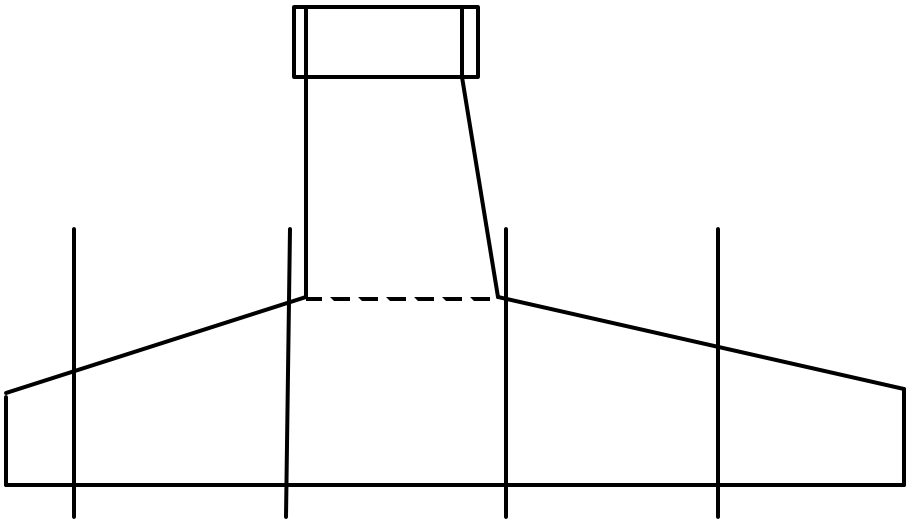
# Load at Midheight



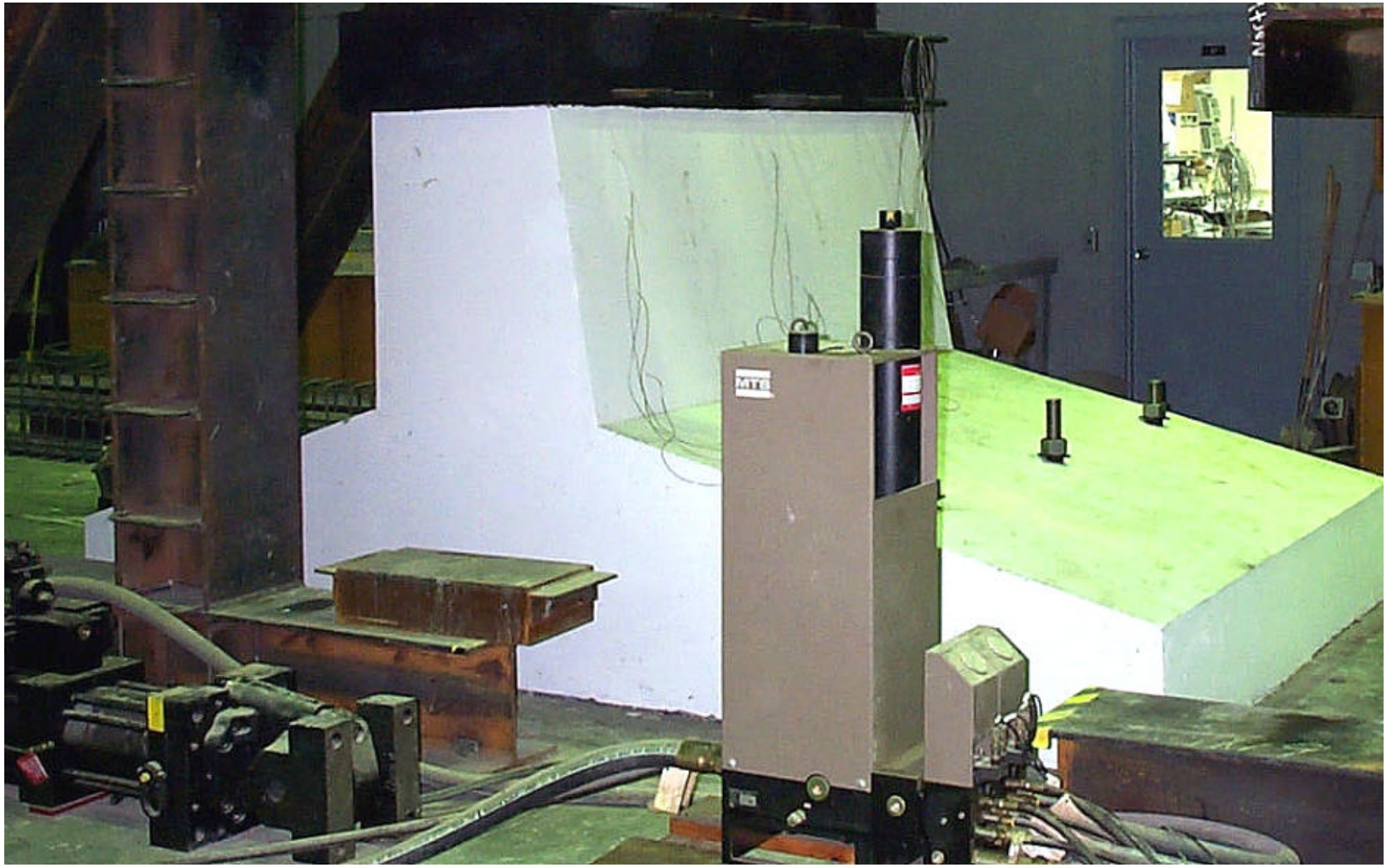
# Reinforcement



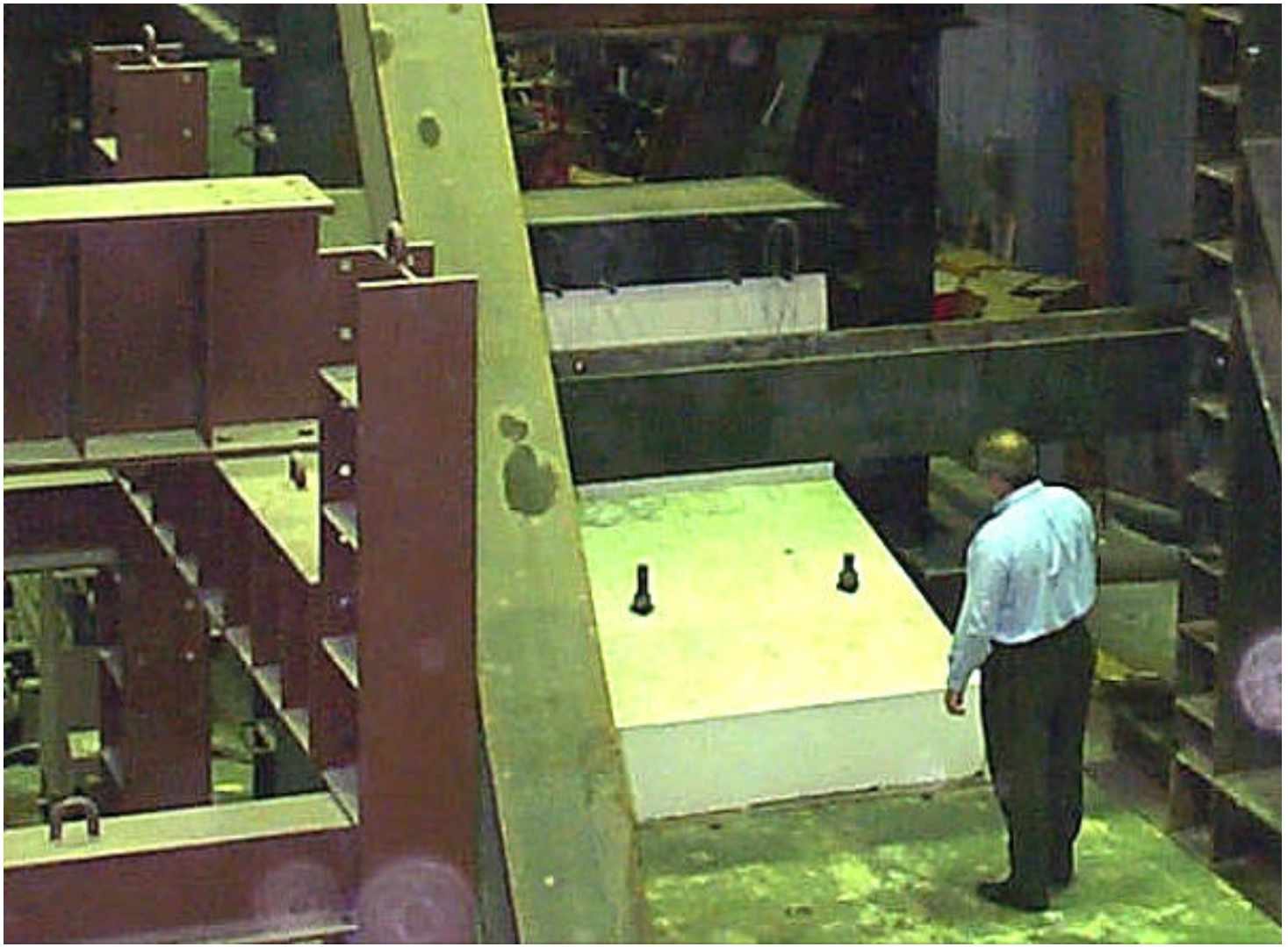
# Anchor Base



# Model



# Model



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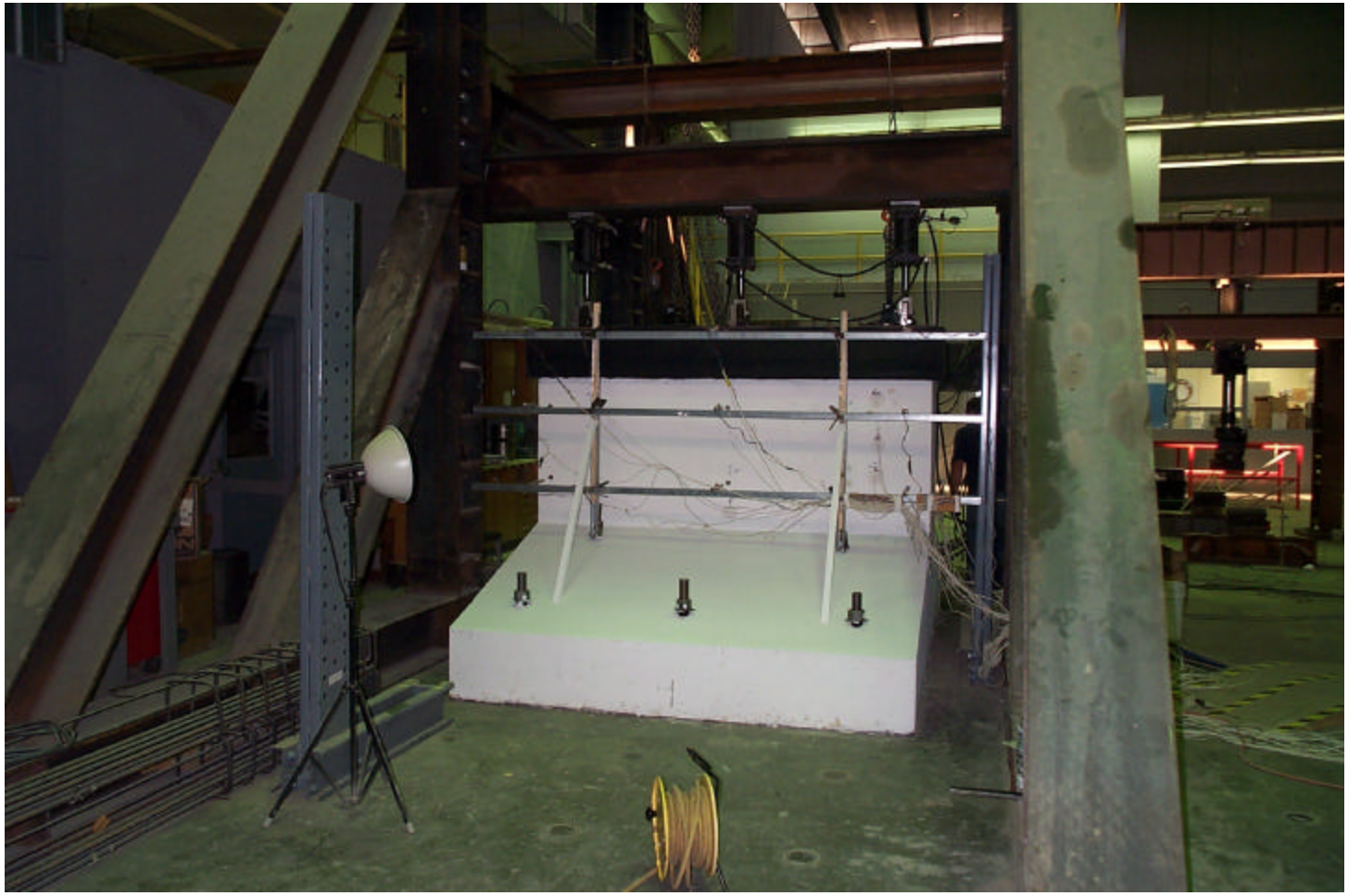
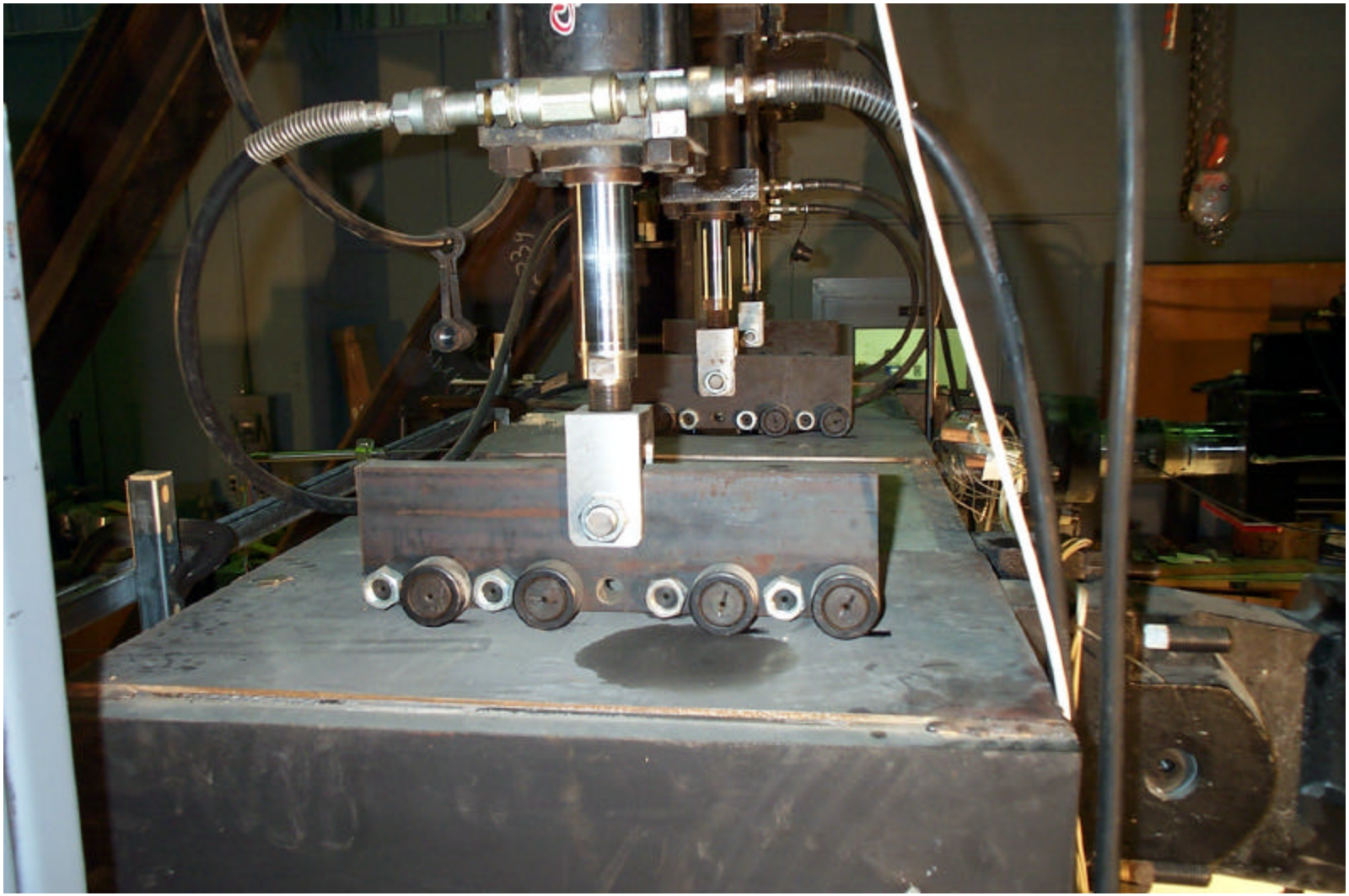
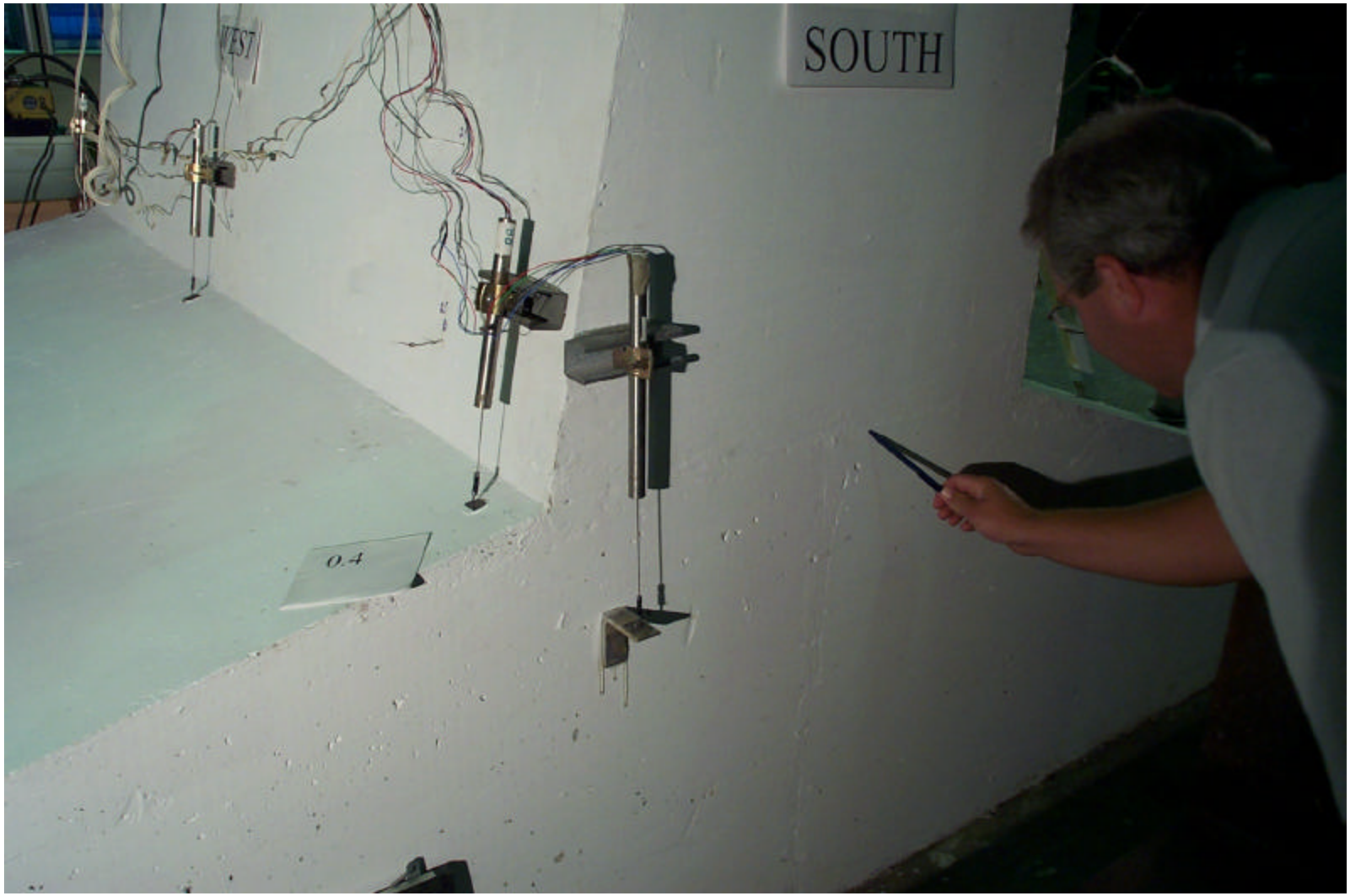


# Vertical Load Device

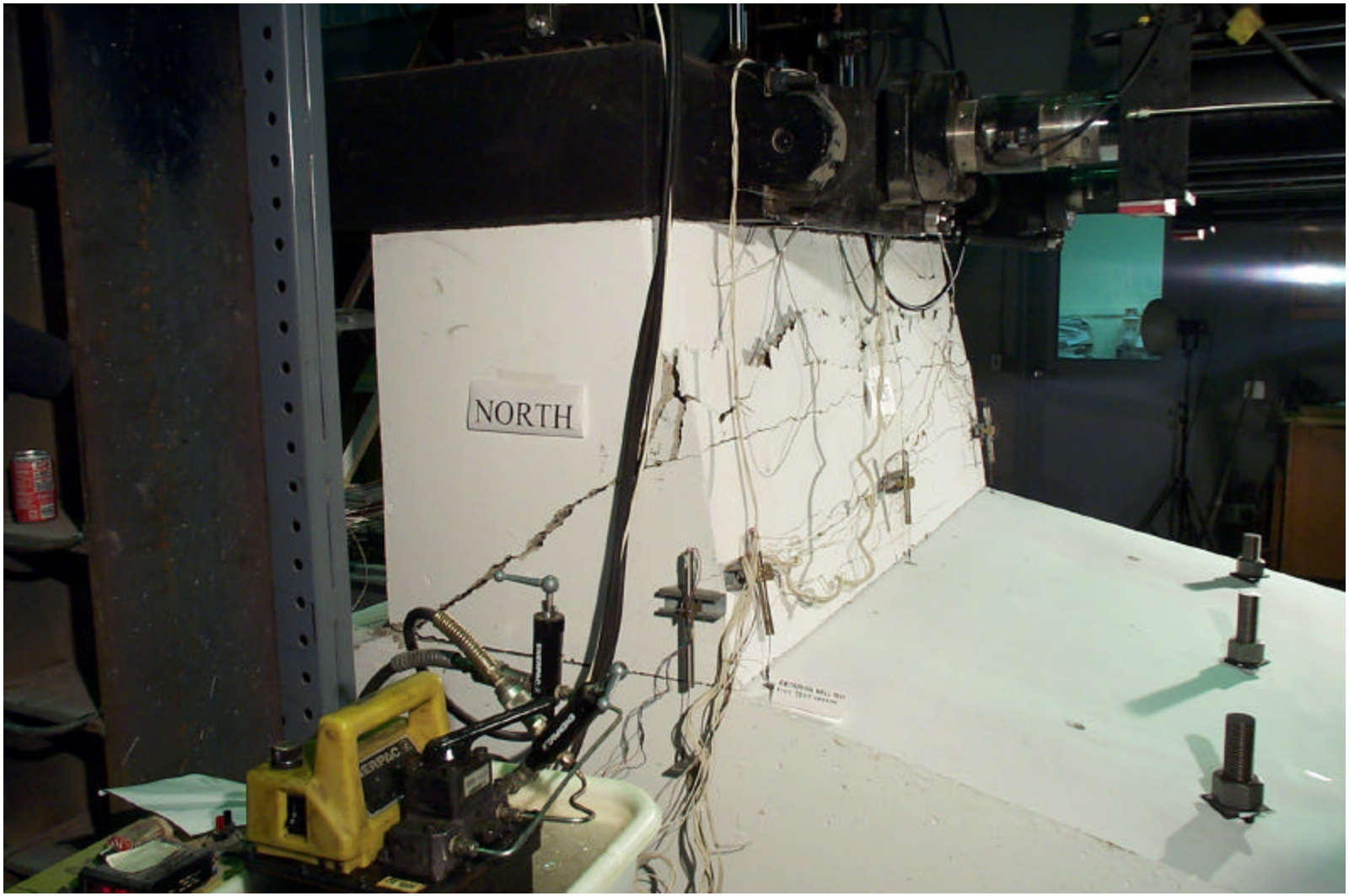


# First Crack Location



# Formation of Secondary Cracks

# Ultimate Failure Plane



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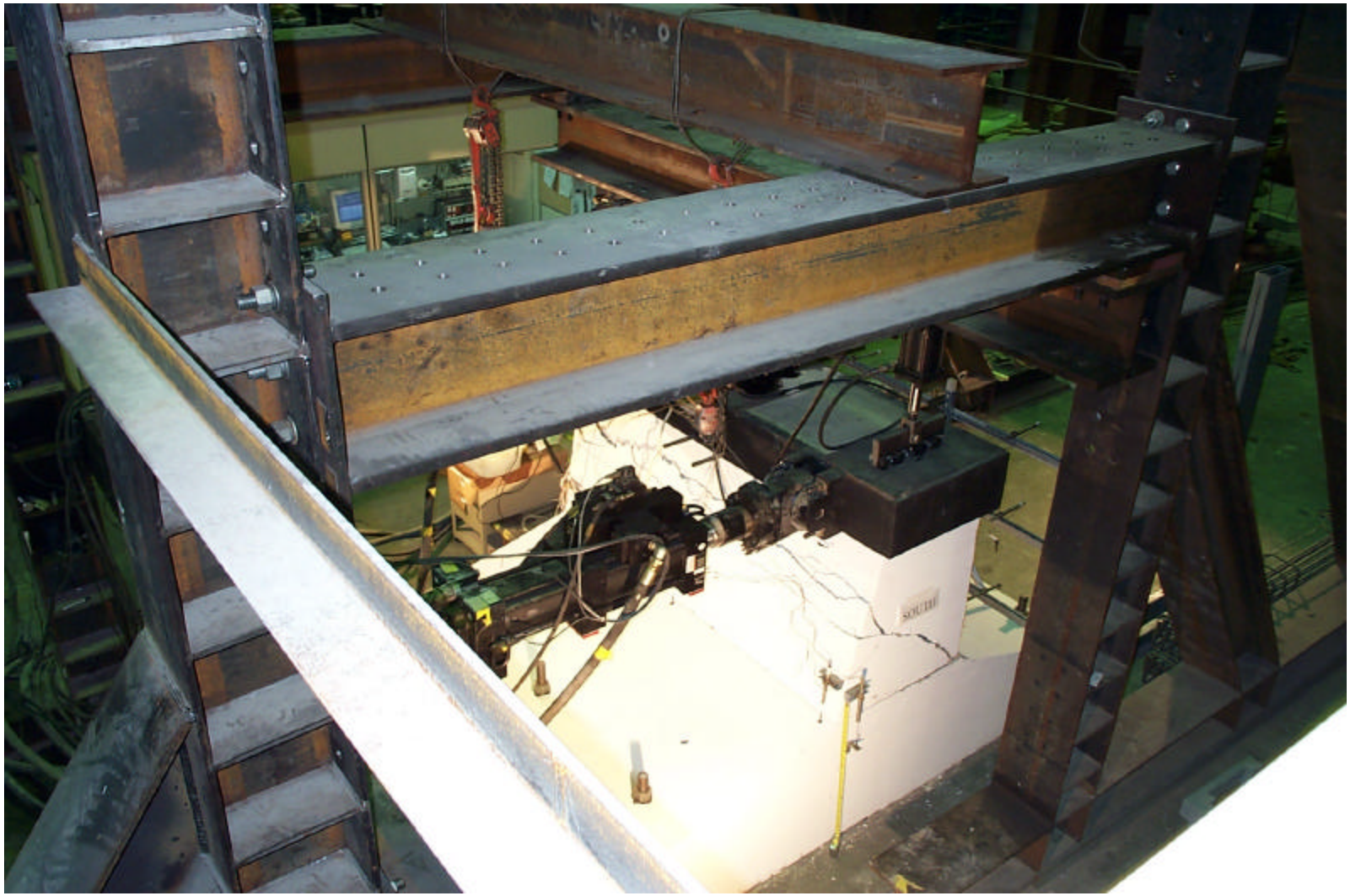

# Ultimate Failure Plane

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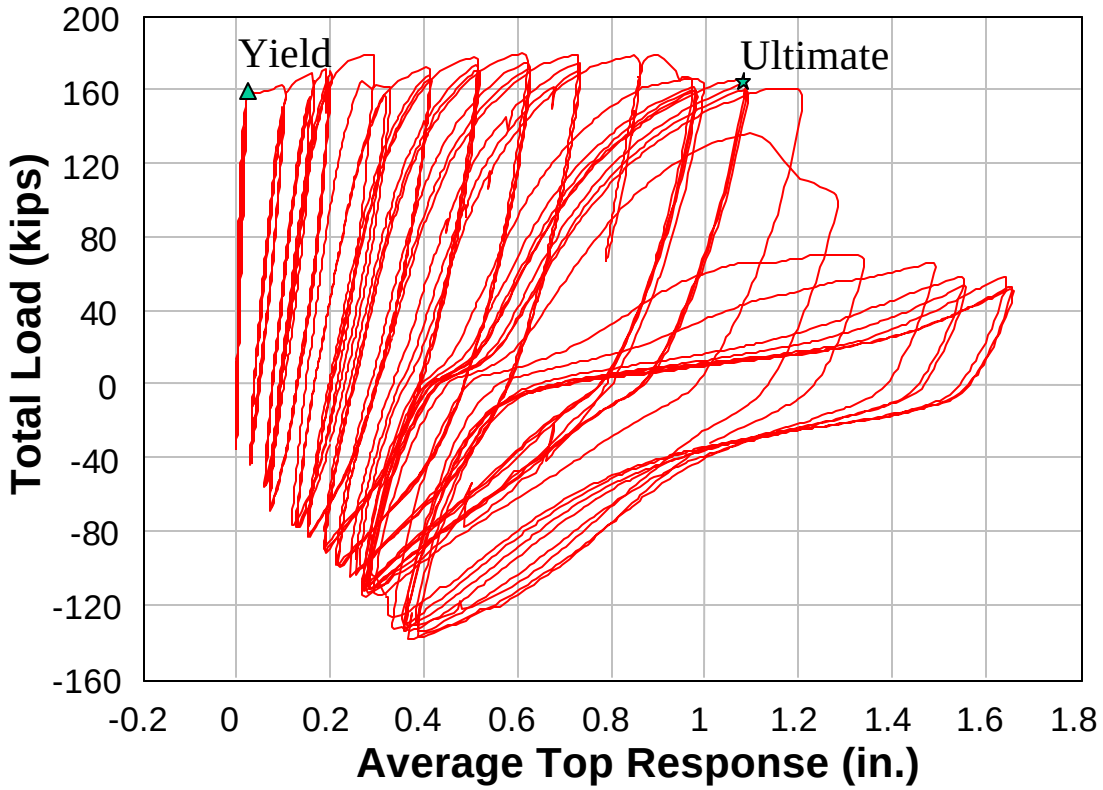
# Load Deflection Response



# Results

- Response was dominated by shear failure of section, not the localized rotation seen in pier wall and intake tower experiments.
- Deflection based analysis technique does not seem to be appropriate for this relatively thick, short retaining wall.
- Deflection based analysis technique would likely be appropriate for more slender sections.

# Conclusions

- It has been shown that the deflection-based analysis procedure can be used for structures other than intake towers.
- The specific load and structural parameters determines the applicability of the procedure.
- If the deflection-based analysis technique is applicable it may need to be modified to reflect the specific specific load and structural parameters.

# Modifications Needed

- **Current deflection-based analysis capacity based on crack width equation derived from experimentation on #3 to #6 bars**
- **Bar diameters found in structures of interest often reach #11 bars.**
- **Additional large bar diameter experiments should substantially improve prediction of deflection capacity and expand the applicability of deflection-based analysis.**
- **Future work should address the specific load and structural parameters that determine the applicability of the procedure.**

# FY01 Effort

- Original plans called for strain penetration experiments for larger bars needed to expand applicability of deflection-based analysis.
- Strain penetration experiments were designed and construction begun.
- Funding was only provided for completion of analysis of prior experimentation.
- Analysis of prior experimentation will be completed by the end of FY01.

# Summary

- **Development of ductility guidance for design and evaluation of Corps structures is dependent upon the failure mode, loading and structural parameters of the system.**
- **The deflection-based analysis procedure can be used for ductility assessment of some Corps structures.**
- **While this provides a substantial capability, this work unit has barely scratched the surface of the problem given the variety of structures of interest.**
- **Much further work will be required to completely address the issue of ductility guidance for design and evaluation of Corps structures.**