

# Slurry Wall Standards



- **What is a Slurry Wall?**

- *Construction*
- *History*
- *Purpose*
- *Applications*

- **What Slurry Wall Voluntary Standards Exist?**

- *Deep Foundations Institute Publication 74*
  - *Who developed?*
  - *History of this standard*
  - *Structure*
  - *References to other standards*
  - *Deep Foundations Institute Publication 74*

- **What is the Value of DFI Pub 74?**

- *What specifications does it provide?*
- *Has it been adopted?*

- **Deep Foundations Institute Organization**

- *Relationship to other standard setting organizations*
- *DFI by-laws*

- **Regulation**

- **Environmental Protection Agency interest/regulation**
- **State of Colorado Regulation Efforts**





## Definition and Construction



- *“A ‘Slurry Wall’ is a structural foundation element constructed below ground using a controlled slurry fluid, consisting of a colloidal suspension of either bentonite, pulverized clays or polymer thoroughly mixed with water to support the sides of an excavation, that is later backfilled with tremie concrete.” (Deep Foundations Institute Publication 74)*



TUNNELING UNDER

**Boston**





# Slurry Wall Applications

- *Subways/Tunnels*
- *Buildings*
- *Dams*
- *Underground garages*
- *Load Bearing Vertical Elements*
- *Power Plant facilities*
- *Marine Structures*
- *Ground Stabilizations*
- *Ground Water Containment*
- *Isolate Hazardous Wastes*



# Functionality



# Slurry Wall Projects

- *World War II Memorial (DC)*
- *Mt Vernon/Navy Yard metro stations*
- *WTC site (The bathtub)*

**National Coalition to Save Our Mall**





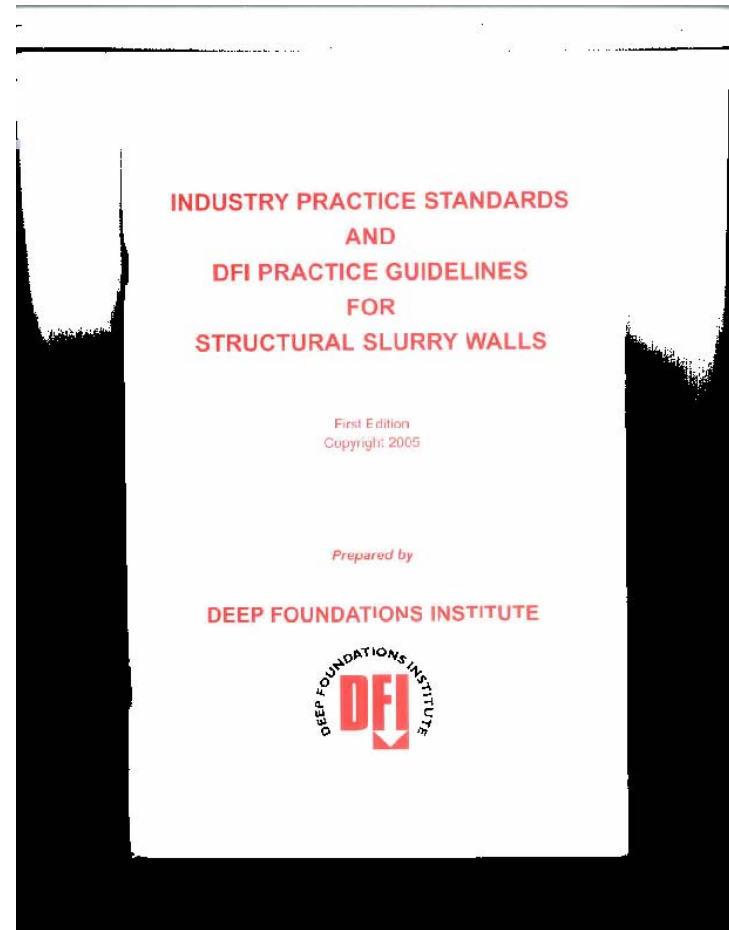
# Slurry Wall History

- **Traced back to the Third Century B.C.**
  - *Used to dig deep wells*
    - *Efficiency of tools improved by using a slurry since soil softened*
    - *Helped prevent cave-ins*
- **Technique improved in the Nineteenth Century**
  - *France developed fluid flushing and rotary drilling system*
  - *U.S. oil industry used improved technique (bentonite) in early 1900s*
- **1900-1960 techniques continue to improve**
  - *Drilling fluid properties improved*
  - *Concrete and plastic barriers applications developed*
  - *Well depths exceed 1 mile*
  - *Italy and France develop interlock slurry wall techniques*
  - *Slurry trenching method developed in U.S.*
    - *Used extensively in the 1940's to contain the Mississippi to prevent floods*
- **1960-1990: slurry wall excavating equipment maturity**
  - *Hydraulic clamshells, percussion chisels, churn drills, slurry mixing trucks*
- **1990-2004: super-sized applications**
  - *Dam rehabilitation (depths exceed 400 ft)*
  - *Boston's Big Dig largest application in North America*
- **May 2005: Deep Foundations Institute publishes DFI Pub 74 (Industry Practice Standards for Slurry Walls)**



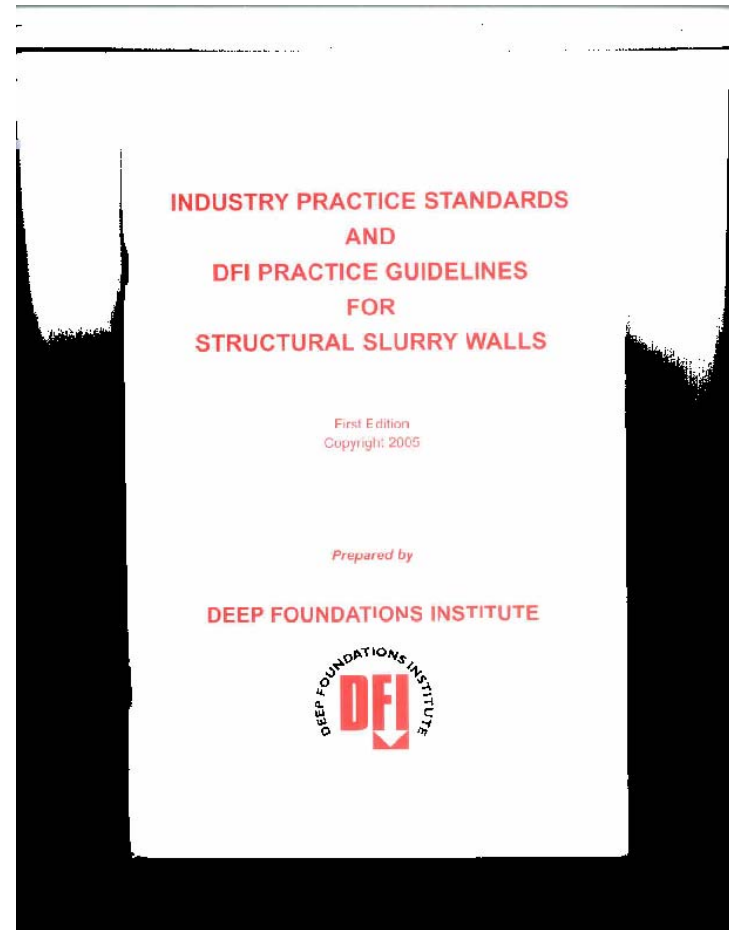
# Slurry Wall Standards

- Neither ANSI or the ISO have published Slurry Wall Standards.
- Deep Foundations Institute
  - Publication 74 (*Industry Practice Standards and DFI Practice Guidelines for Structural Slurry Walls*)
    - Published in May, 2005 (First Edition)
    - Agreed to by the DFI Slurry Wall/Trench Committee (14 members from U.S. and international corporations)
  - Educational Activity
    - Non-profit educational activity
    - Incorporated in 1976 (NJ)
    - Technical Association
    - Worldwide membership
  - Broad spectrum of membership
    - [Drilling Contractors](#)
    - [Engineering Services](#)
    - [Equipment](#)
    - [Manufacturers/Suppliers](#)
    - [General foundations contractors](#)
    - [Inspection Services](#)
    - [Materials for Foundations](#)
    - [Piledriving Contractors](#)
    - [Services for Foundations](#)
    - [Specialty Foundations Contractors](#)
    - [Testing Services](#)



# DFI Publication 74 Structure

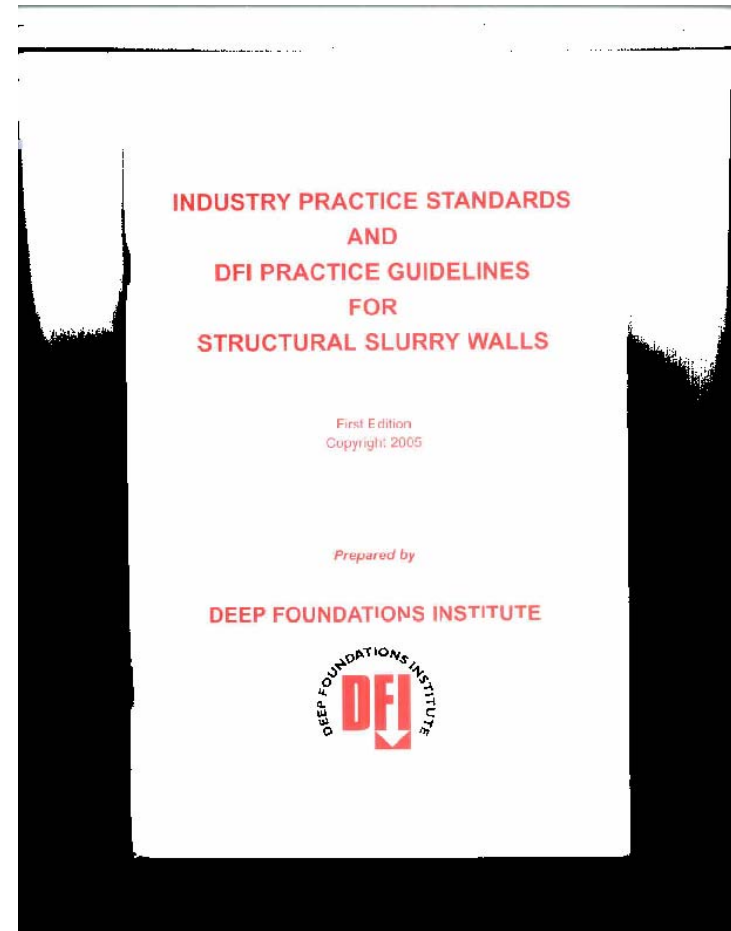
- Preface
- Part I Industry Practice Standards
- Part II DFI Practice Guidelines
- Part III Definitions
- Part IV Figures
- Part V Additional Information
- Part VI Project List



# DFI Publication 74 Structure

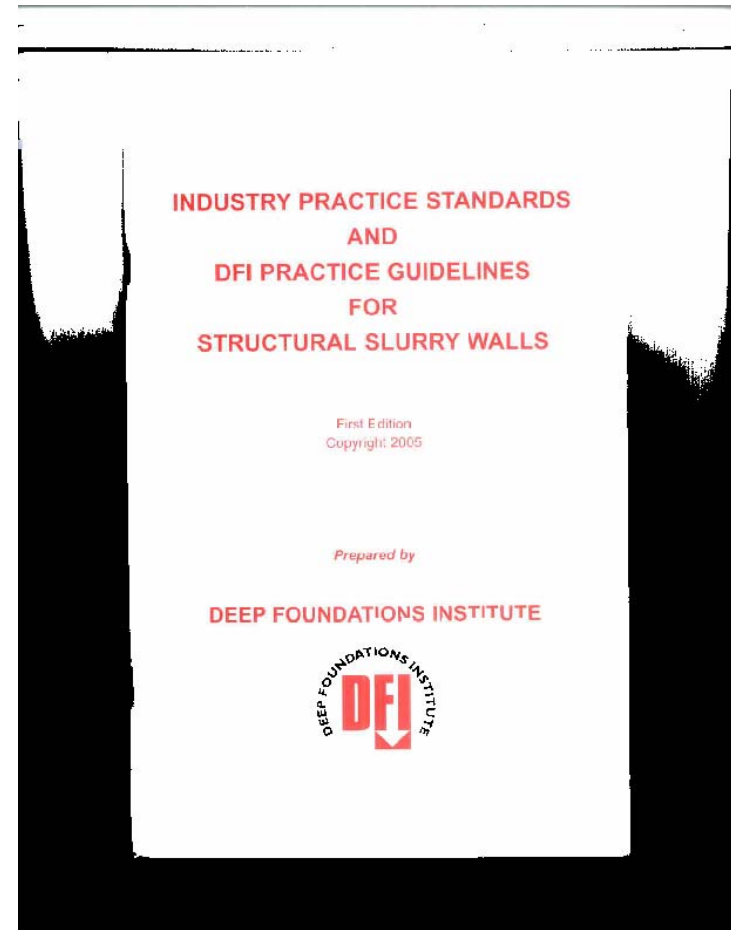
- **Preface**

- “Industry practice standards and DFI practice guidelines are intended to highlight **major considerations** in selecting structural slurry wall elements for temporary and permanent use as foundations elements. **Since the application of slurry wall elements in tunnels, bridges, buildings, dams, marine construction, etc. is so diverse, a single publication cannot cover all the conditions and codes governing its specifications and usage.**”  
(DFI Publication 74)



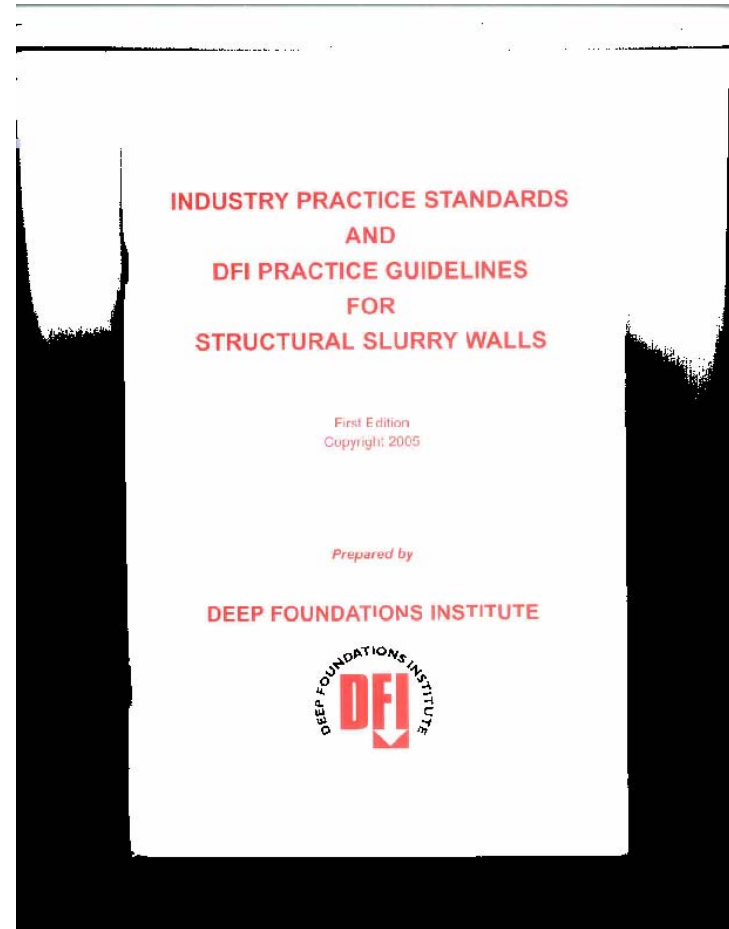
# DFI Publication 74 Structure

- **Part I Industry Practice Standards**
  - Classification of Slurry Wall Panels
  - Typical Sizes of Slurry Wall Panels
  - Panel Depths
  - Equipment
  - Slurry Fluids
    - Refers to the American Petroleum Institute Specification 13A for the viscosity and gel strength.
  - Phases of Panel Construction
  - Inspection, records and Final Condition Observations
    - “The inspector should have ACI training in concrete testing and reinforcing placement. See ACI Manual of Concrete Inspection, SP-2 for inspector’s duties, records, and reports.” (DFI Publication 74)



# DFI Publication 74 Structure

- **Part II DFI Practice Guidelines**
  - Contractor Qualifications
  - Subsurface Investigation
  - Design and Site Considerations
  - Materials
    - E.G., “Concrete should meet the specified minimum compressive strength at 28 days, usually between 3000 psi and 5000 psi, at a slump ranging between 7 and 9 inches.”
    - E.G., “Steel reinforcement should consist of new deformed billet steel bars conforming to the requirements of ASTM A615, [ASTM A36, or ASTM A-572, A-588 or A-992] or equivalent metric standards.” (DFI Pub 74)
  - Schedule Submittal Requirements
  - Preparation for Excavation
  - Excavation
  - Reinforcement Placement
  - Concrete Placement
  - Tolerances
  - Water Tightness Criteria



# DFI Publication 74 Structure

- **Part III Definitions**

- **Examples:**

- **Bentonite Slurry**: A mixture of bentonite (impure clay) and water.
    - **Cage**: network of interconnected reinforcing steel bars
    - **Closed Specification**: A specification, which describes the end product and how it is to be achieved. Usually used for permanent walls.
    - **Go Devil**: Device placed in tremie pipe prior to placement of concrete into pipe. Device is intended to prevent concrete from mixing with bentonite slurry during initial placement of concrete.
    - **Kelly-Bar**: vertical shaft used to transfer torque from a power unit to a rotary type drill, or to raise and lower a clamshell bucket.

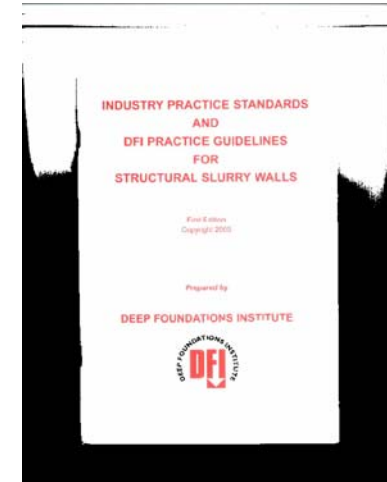


Photo by: D. A. Kolotouros  
Available by the Geoengeiner Website  
<http://www.geoengeiner.org>

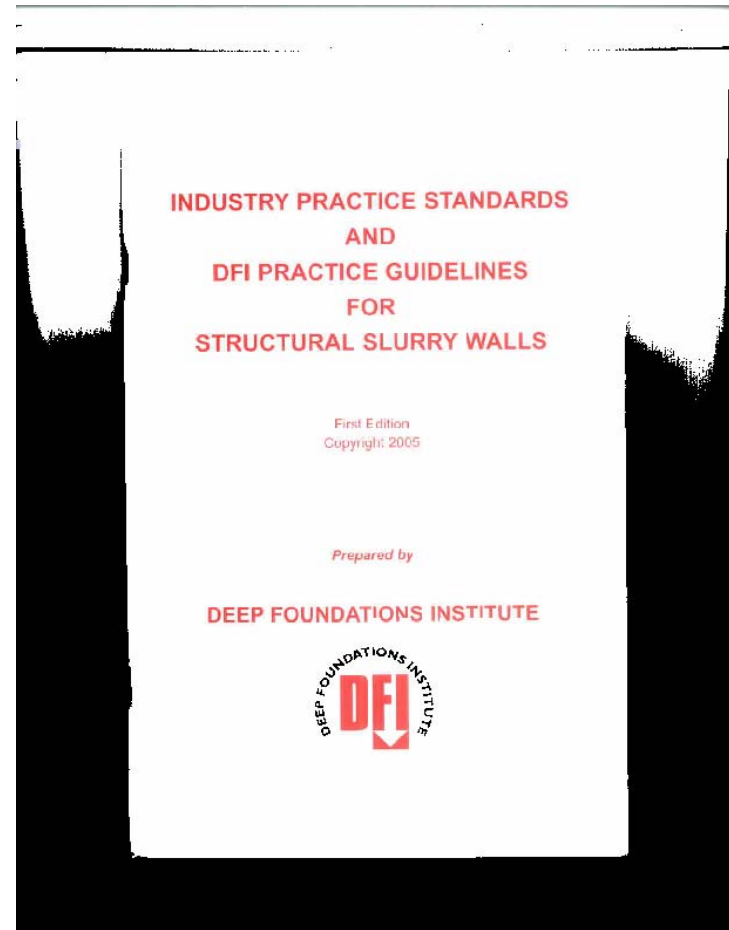


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# DFI Publication 74 Structure

- **Part IV Figures**
  - **Classification of Panels**
  - **Slurry Wall Panel Configurations**
  - **Types of Clamshell Buckets**
    - Although not referred to, ISO 22242 (Road Construction and Road Maintenance-Basic Types-Identification and Equipment) provides similar standards.
  - **Slurry Fluid Test report Forms**
  - **Tremie Concrete Inspection report Form**
  - **Slurry Wall Tolerances**

and others....

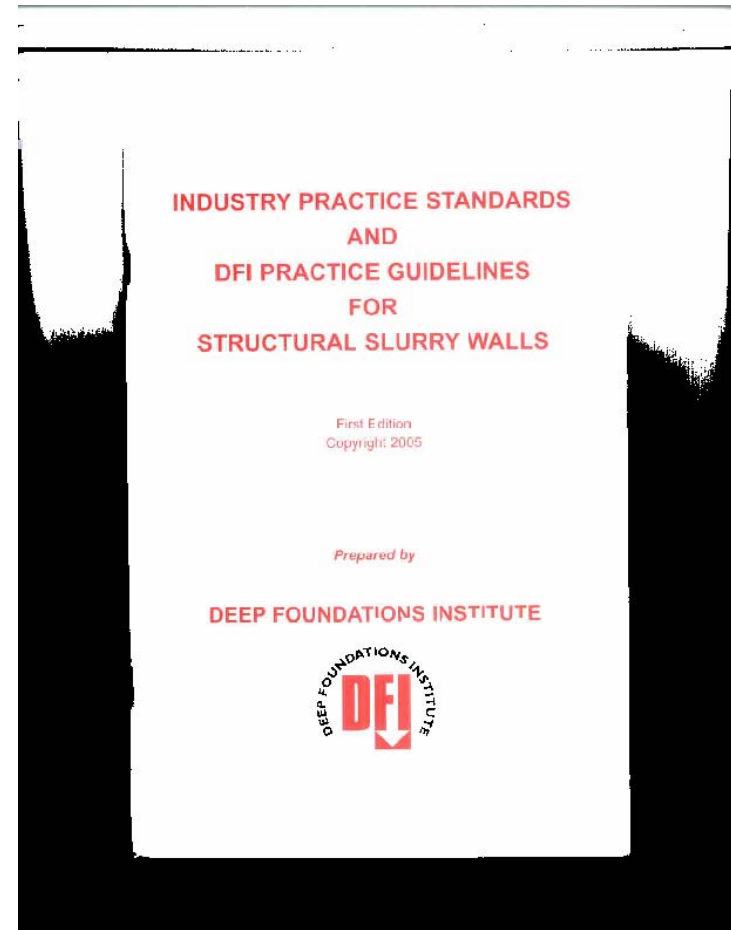


# DFI Publication 74 Structure

- **Part V Additional Information**

- **References**

- E.G., American Petroleum Institute, “Specification from Drilling-Fluid Materials”, APL Specification 13, Washington DC (1990)
    - British Standards institute, “Execution of Special Geotechnical Work-Diaphragm Walls”, Document 94/106168, London (1994).
    - Huder, J., “Stability of Bentonite Slurry Trenches with Some experience in Swiss Practice”, proceedings of the Fifth European Conference on Soil Mechanics and Foundation Engineering, Vol 1, Madrid (1972)
    - Kapp, M.S., Slurry Trench Construction for Basement Wall of World Trade Center”, Civil Engineering, ASCE (1969).
    - Xanthakos, P., “Slurry Walls”, 1<sup>st</sup> Ed., McGraw-Hill, New York (1979)



Metric Conversion Table



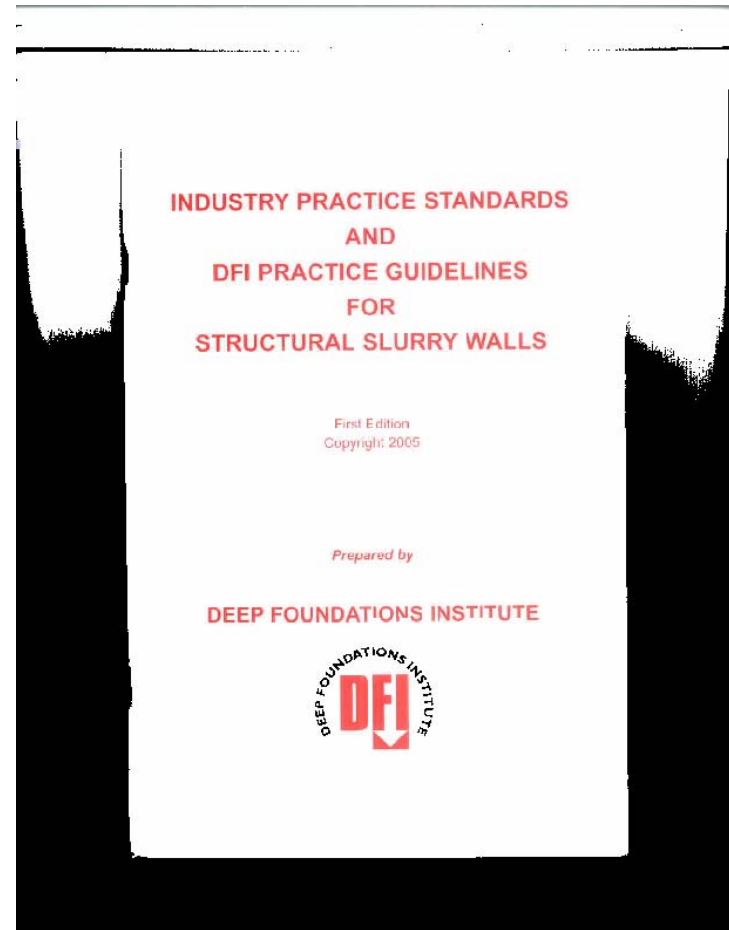
# DFI Publication 74 Structure

- **Part VI Project List**
  - Bank of California Building
  - China Basin Plumbing Plant
  - City of Denver , 15<sup>th</sup> Street Modification
  - Federal Triangle Development, Ronald Reagan Building
  - Mexico City Subway Line 8, Garibaldi Station
  - Calgary Light Rail Underpass

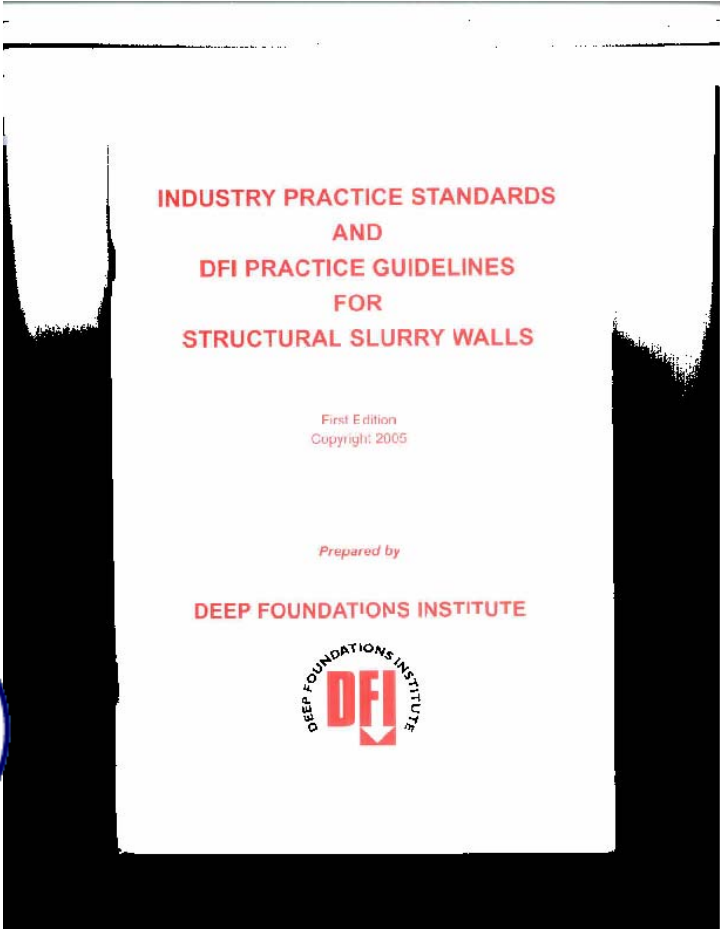
And several hundred more...

Info provided:

Type of Construction used,  
Construction Area (width, depth,  
area), Project Description.



# What's the Value of DFI Pub 74?



# Deep Foundation Institute By-Laws: Insight into an Organization

- **ARTICLE II - PURPOSE**
- *The Institute is organized to serve as a primary means through which members of the Institute may participate in the improvement of the planning, design and construction aspects of deep foundations and deep excavations.*
- **ARTICLE IV – MEMBERSHIP**
- **Section 7. Voting Rights.** *Each individual member and corporate delegate shall be entitled to **one vote**.*
- **Section 8. Removal.** *Report of conduct of members prejudicial to interests of the Institute shall be investigated by the Board of Trustees. The members shall be notified and shall have a **right to be heard** during these investigations. For what they consider sufficient cause the Board may, by **two-thirds vote** of those present, request a member to resign, or if necessary, expel the member. The Board may, by two-thirds vote of those present, request the recall of a designated representative of a corporate*



# A Selection of Deep Foundation Institute By-Laws (cont)

- **ARTICLE V - INSTITUTE MEETINGS**

- **Section 4. Quorum.** *A quorum for any meeting shall consist of 20 percent of the total membership of the Institute, either present or represented by proxy duly submitted before the start of the meeting.*
- **Section 5. Notice of Meetings.** *Notice of all meetings shall be in writing and shall be mailed not less than 30 calendar days in advance of the date of the meeting to the address of record of each member*



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# A Selection of Deep Foundation Institute By-Laws (cont)

- **ARTICLE VIII - PRESIDENT AND VICE-PRESIDENT**
- *Section 1. The President, or in his absence the Vice-President, shall preside at meetings of the Institute, the Board of Trustees, and the Executive Committee. If neither the President nor the Vice-President is present, the Secretary, or in his absence the Treasurer, shall preside at all meetings. In the absence of all officers, those present at any meeting may elect a presiding officer.*



# A Selection of Deep Foundation Institute By-Laws (cont)

- **ARTICLE XIV - COMMITTEES**  
*Section 3. Membership on Special Committees.* Members of special committees shall be selected to serve for the duration of the particular project or subject. Membership on special committees shall not necessarily be limited to membership in the Institute, **Corporate members may suggest persons with special expertise in a committee's sphere of activity, as an addition to their regular representation in the Institute.** All such persons shall have full voting rights within their committee.





# There is some Slurry Wall Regulation out there...

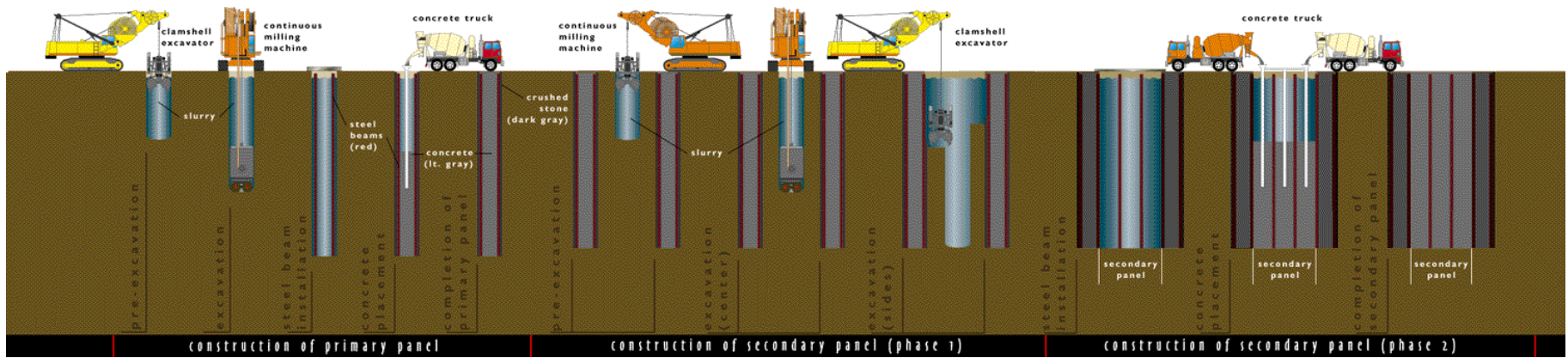


- **Guide to Specification Preparations for Slurry Walls and Clay Liners as a Component of a Colorado Mined Land Reclamation Permit**
  - September 2000
  - Published by the Colorado Department of Natural Resources
  - Provides specifications very, very similar to DF Pub 74
  - **“The final approval and success for the performance of the slurry wall...lies with the State Engineer. The Division of Mineral’s and Geology is required to hold financial warranties sufficient to assure that the State Engineer’s standards will be met in the event the state becomes responsible for the site.”**
- **EPA Study: Evaluation of Subsurface Engineered Barriers at Waste Sites**
  - EPA interested in Slurry Walls performance containing contaminated ground water/chemicals
  - Retrospective analysis conducted July 1998
  - Evaluated 36 of 130 identified sites
  - 19 of 36 sites meet the intent of construction
  - Bottom line: EPA interested in Slurry Wall performance!
  - Foreseeable that DF 74 or other standards could be used in future litigation

# Federal Regulations

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- Three major pieces of federal legislation deal with hazardous wastes and toxic substances.
  - The Resource Conservation and Recovery Act of 1976 (or RCRA, pronounced 'rekra')
    - RCRA is intended to control hazardous waste from creation to ultimate disposal and at all steps.
  - The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA or Superfund)
    - The intent of Superfund is to clean-up abandoned hazardous waste sites.
  - The Toxic Substances Control Act of 1976 (TOSCA)
    - This deals primarily with the manufacture of new chemicals and their effects on human health and the environment.



# Questions?

