WRF Research Efforts on Large Diameter Pipes

Water Research Foundation

Metropolitan Water District, Los Angeles, January 20, 2016

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Overview

- A variety of large diameter pipes covered
  - PCCP
  - CI & DI
  - Steel
  - HDPE
- General condition assessment projects

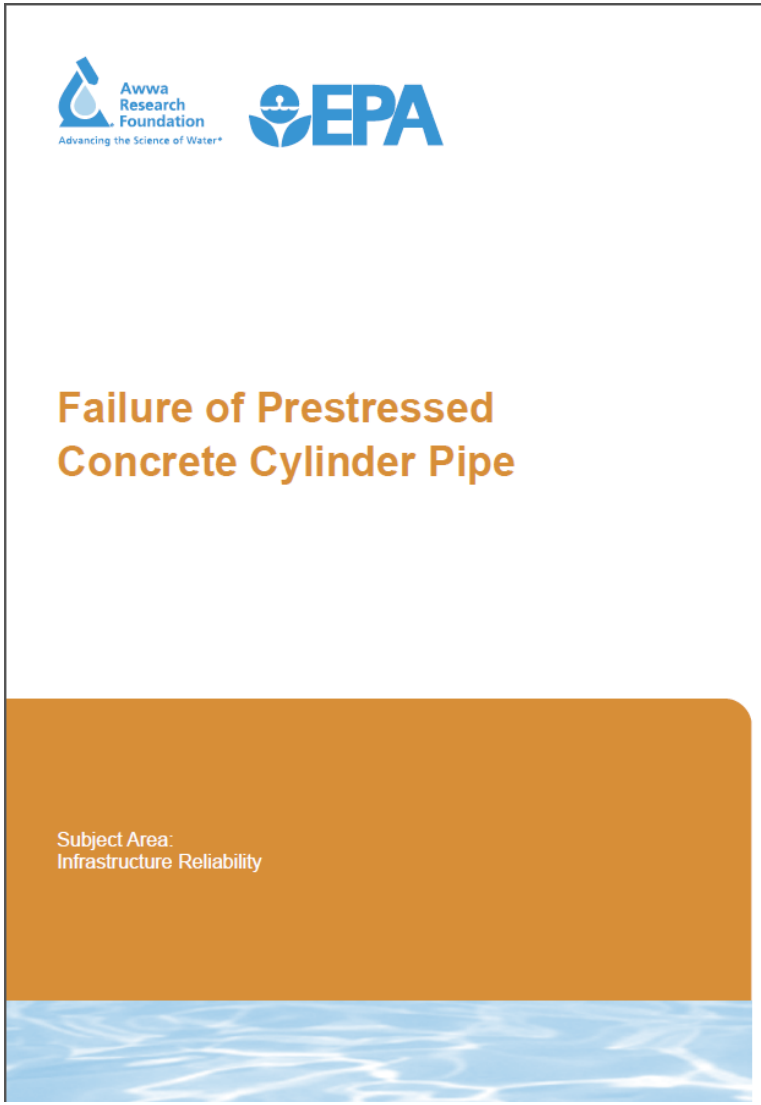
Pre-Stressed Concrete Cylindrical Pipe (PCCP)

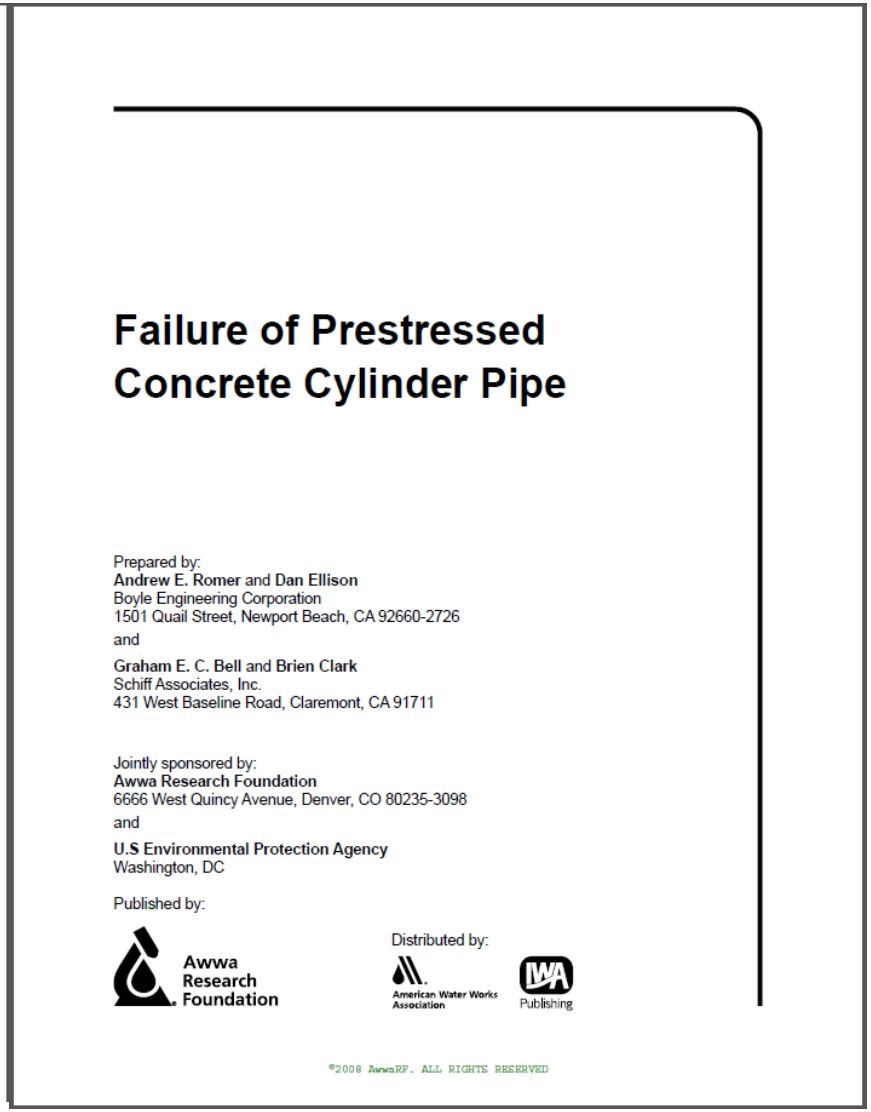
- Performance of Prestressed Concrete Pipe (#724)
- Electromagnetic Inspection of Prestressed Concrete Pressure Pipe (#2564)
- Failure of Prestressed Concrete Cylinder Pipe (PCCP) (#4034)
- Best Practices Manual for Prestressed Concrete Cylinder Pipe Condition Assessment (#4233)
- CFRP Renewal of Prestressed Cylinder Concrete Pipe (#4352, 4510 & 4592)
- Acoustic Signal Processing for Pipe Condition Assessment (#4360)

U.S. BUREAU OF RECLAMATION (BOR) PARTNERSHIP 1990 – 1994 (WRF Project #724)

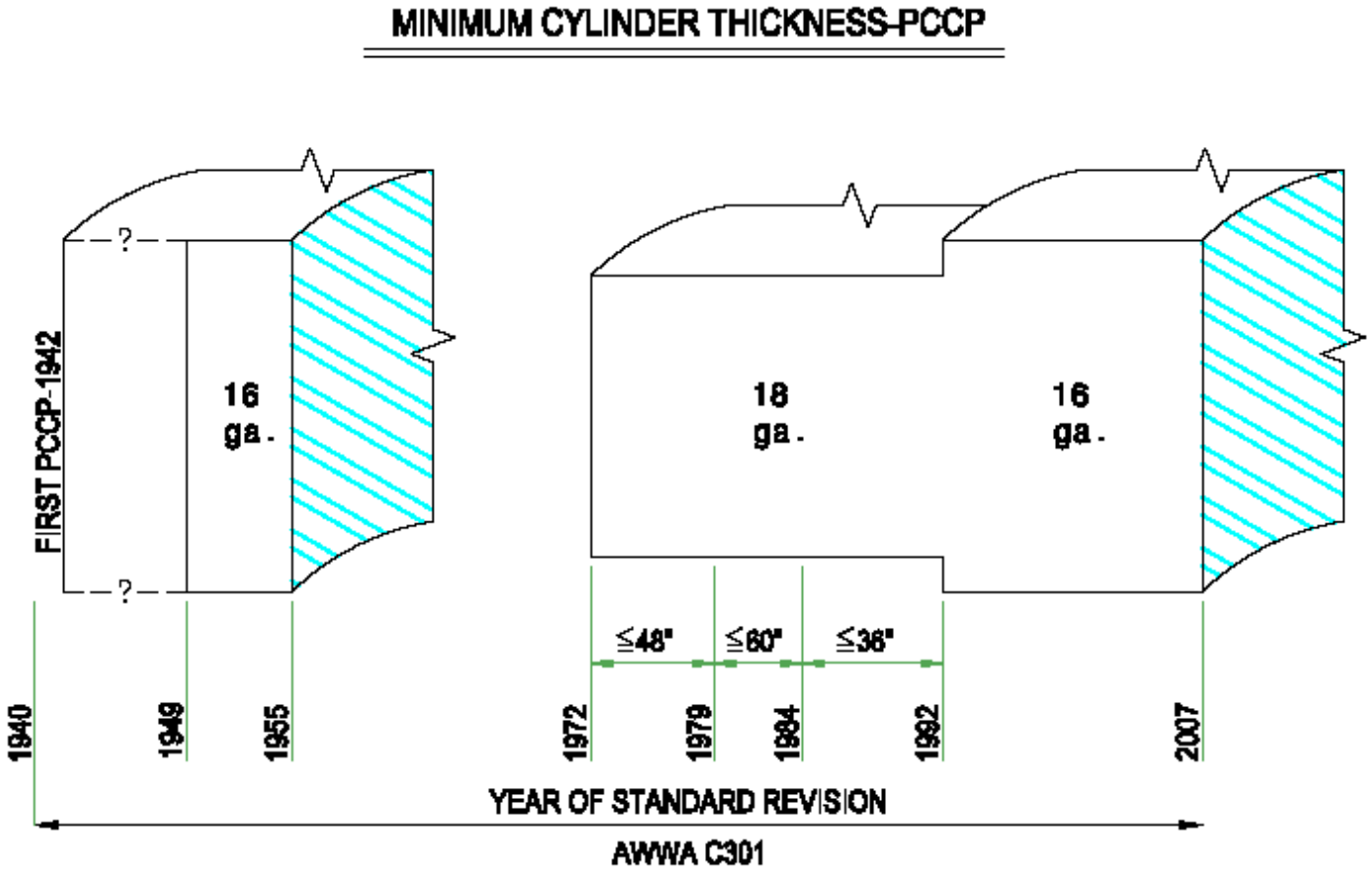
- Four Reports Published by BOR in 1994 (only available from National Technical Information Service)
  - 3 on performance of PCP Pipe
  - 1 on historical performance of all pipelines – survey project
- Considerably advanced our understanding of failure mechanisms and forensic analysis on Prestressed concrete pipe
- Developed a practical monitoring method for pipe siphons and other critical pipe sections (hydrophones)

Failure of Prestressed Concrete Cylinder Pipe (#4034)



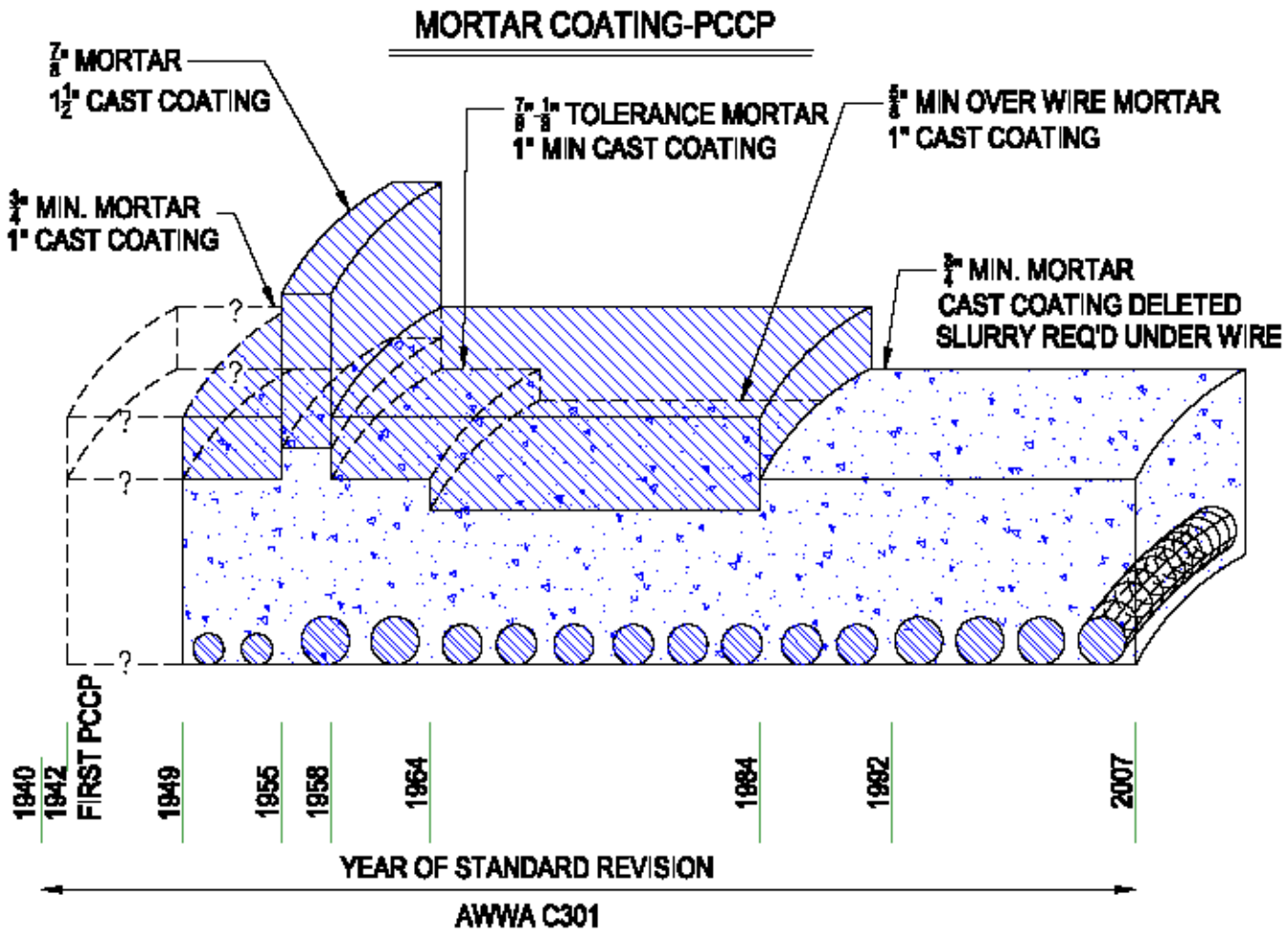


PCCP Timeline



By Andy Romer et al., WRF #4034

PCCP Timeline



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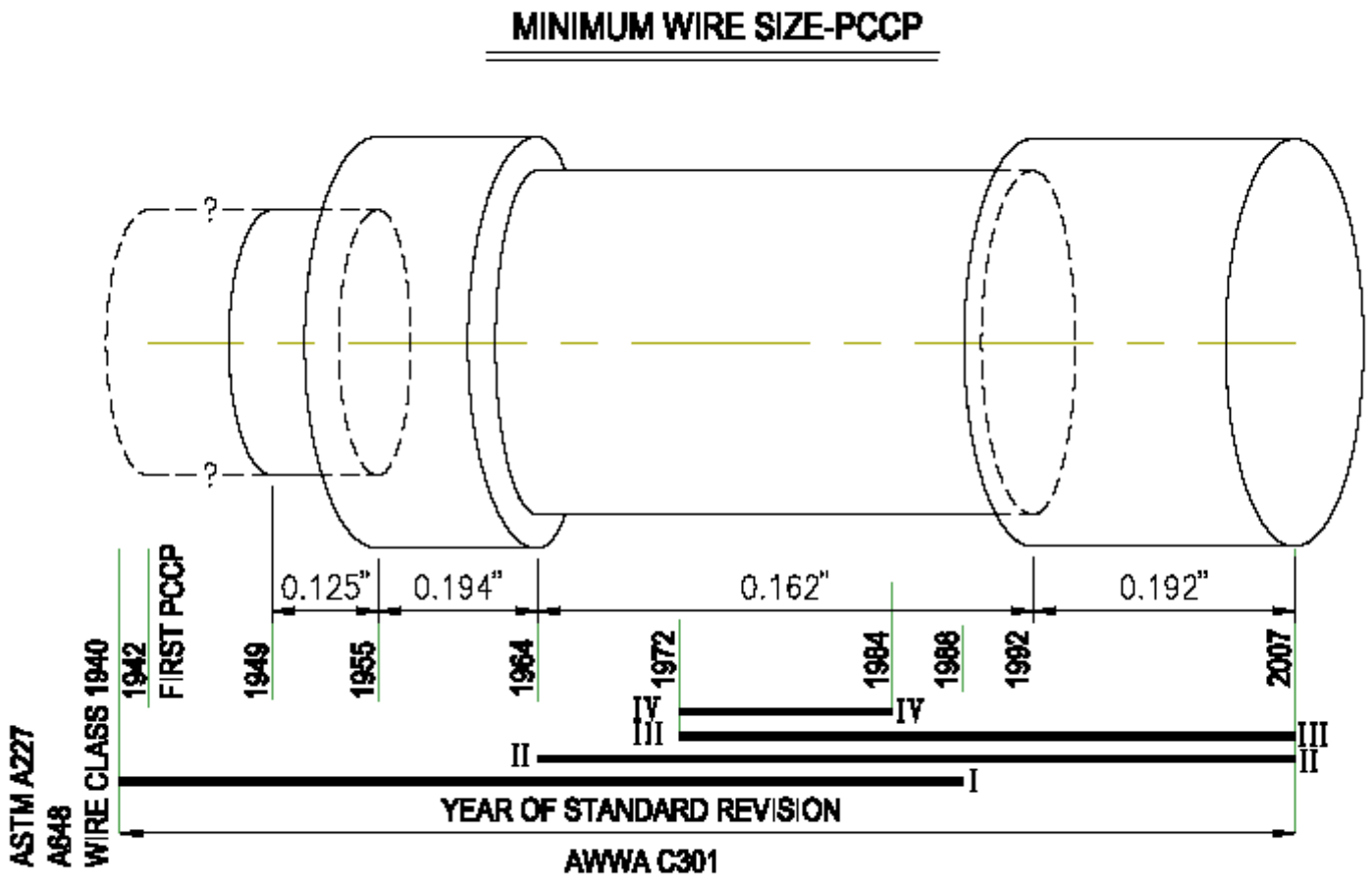

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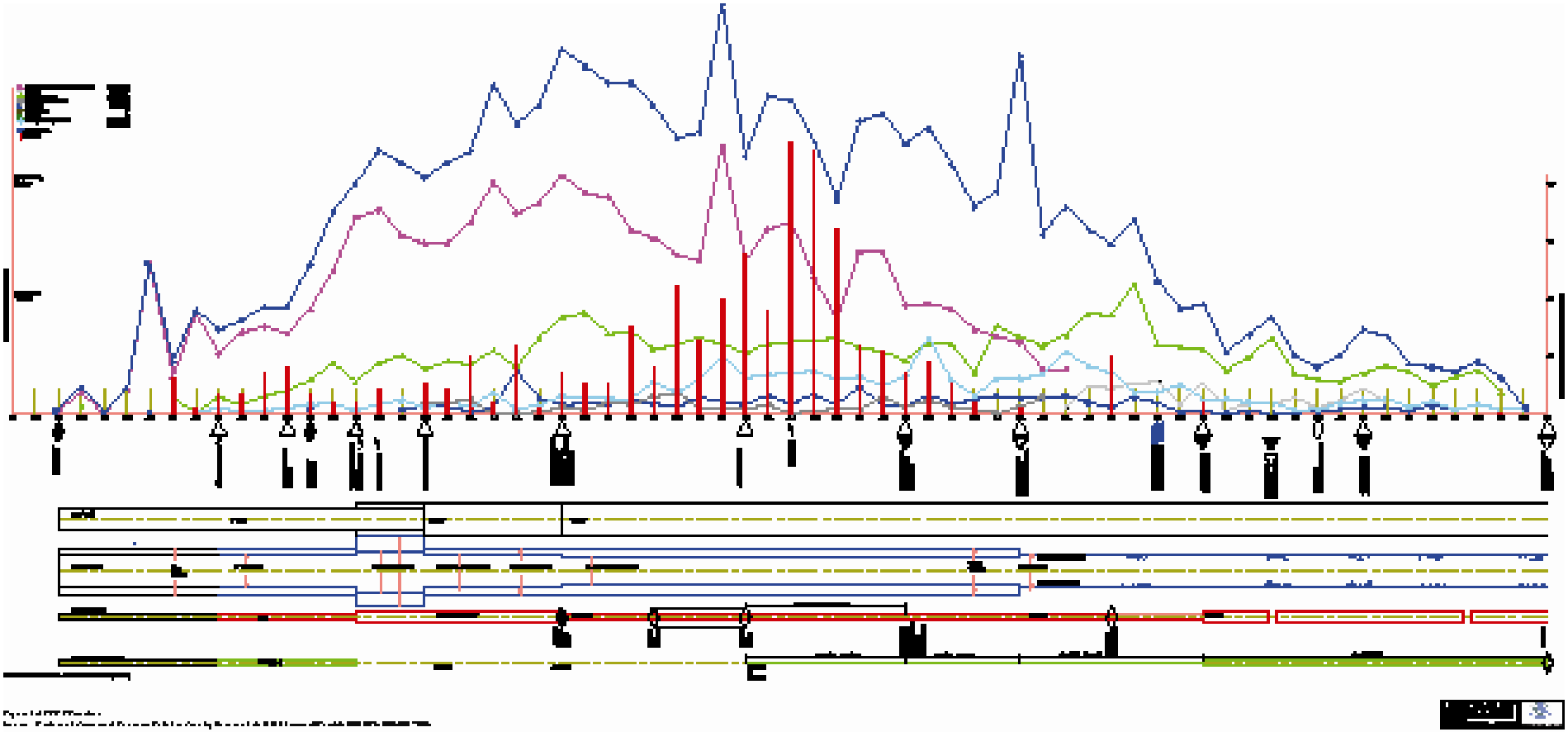

By Andy Romer et al., WRF #4034

CFRP Renewal of Prestressed Cylinder Concrete Pipe

- A suite of three projects:
  - #4352
  - #4510
  - #4592 (to be published)
- Develop theoretical and experimental bases for CFRP renewal and strengthening of distressed PCCP and the provisions for the AWWA Standard under development.
- Develop the experimental basis for CFRP renewal and strengthening of distressed PCCP and the provisions for the AWWA Standard under development.

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EPA

WERF
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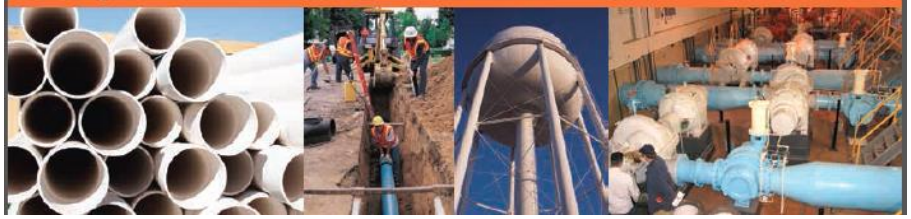
CFRP Renewal of Prestressed Concrete Cylinder Pipe

Web Report #4352

Subject Area: Infrastructure



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CFRP Renewal of Prestressed Concrete Cylinder Pipe: Part 2

Web Report #4510

Subject Area: Infrastructure

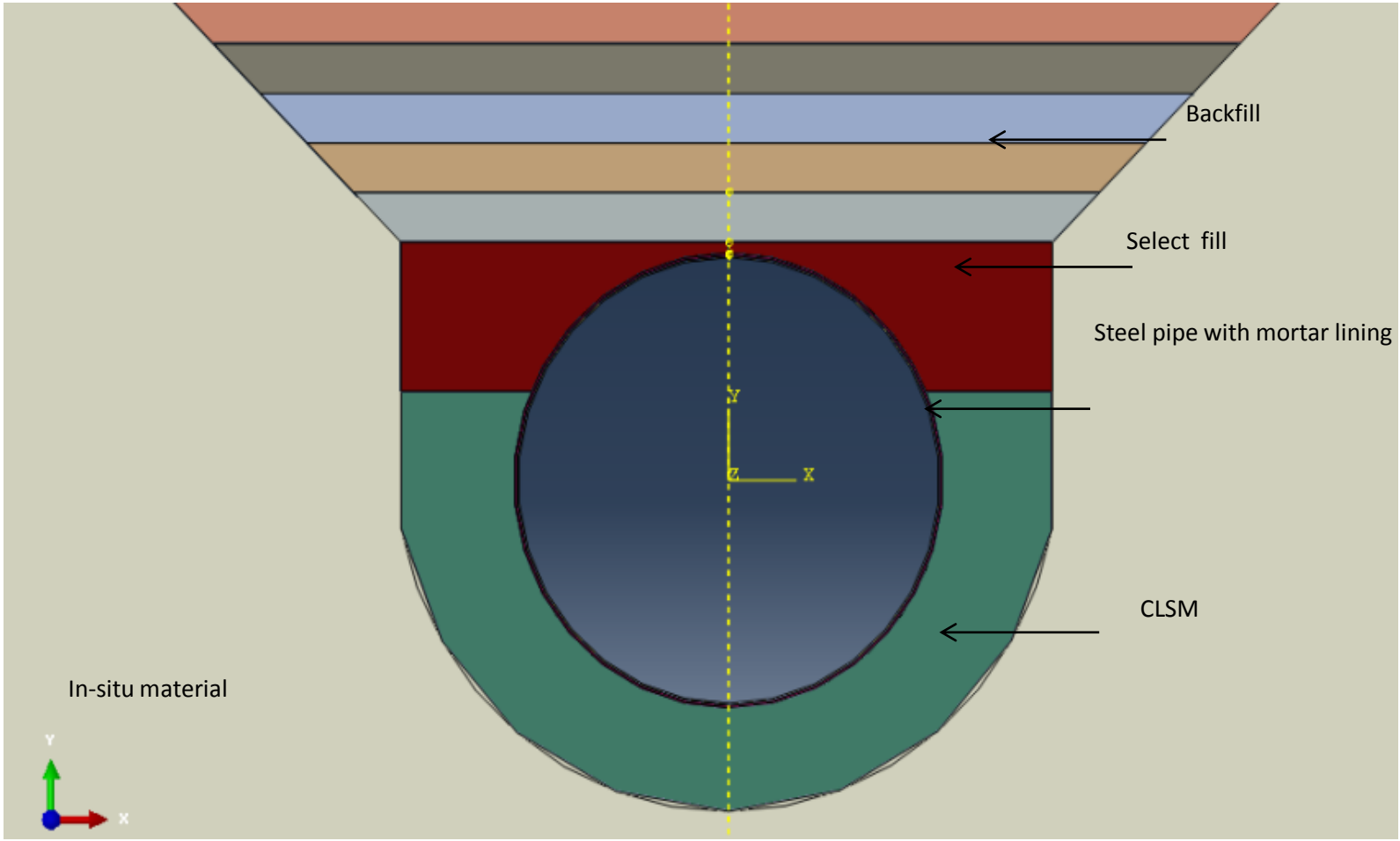
Extension and Advancement of Development of Design Equation for Large Diameter Steel Pressure Pipe (#4587)

- Research team:
  - Dr. Ali Abolmaali, University of Texas at Arlington
- Tailored collaboration partner: Tarrant Regional Water District

Extension and Advancement of Development of Design Equation for Large Diameter Steel Pressure Pipe (#4587)

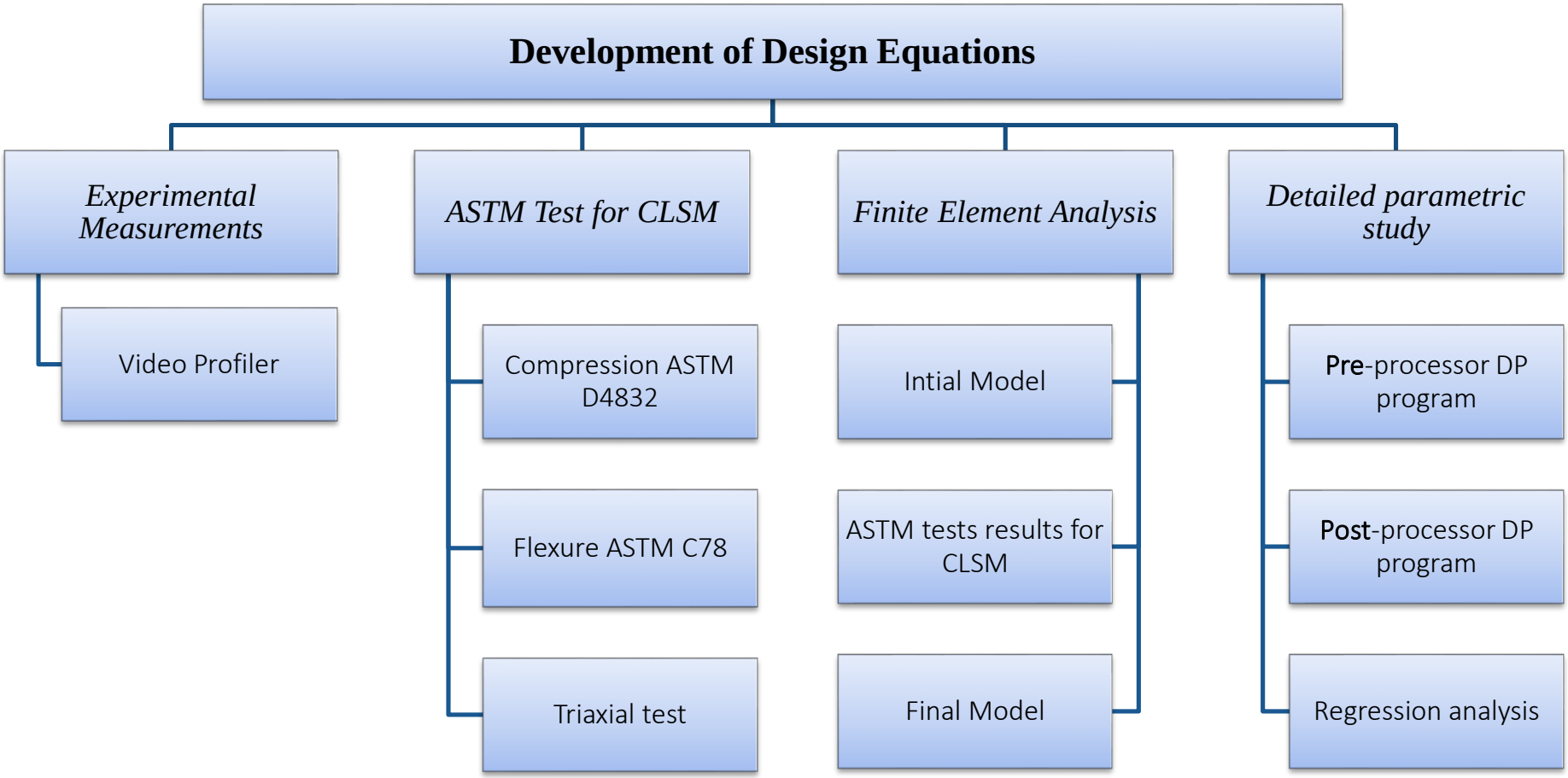
- Unique understanding of interaction of steel pipes with Controlled Low Strength Material (CLSM)
- Development of steel pipe- CLSM interaction design equations
- To accomplish:
  - Experimental testing
  - FEM simulation
  - Nonlinear regression analysis

Trench configuration analyzed



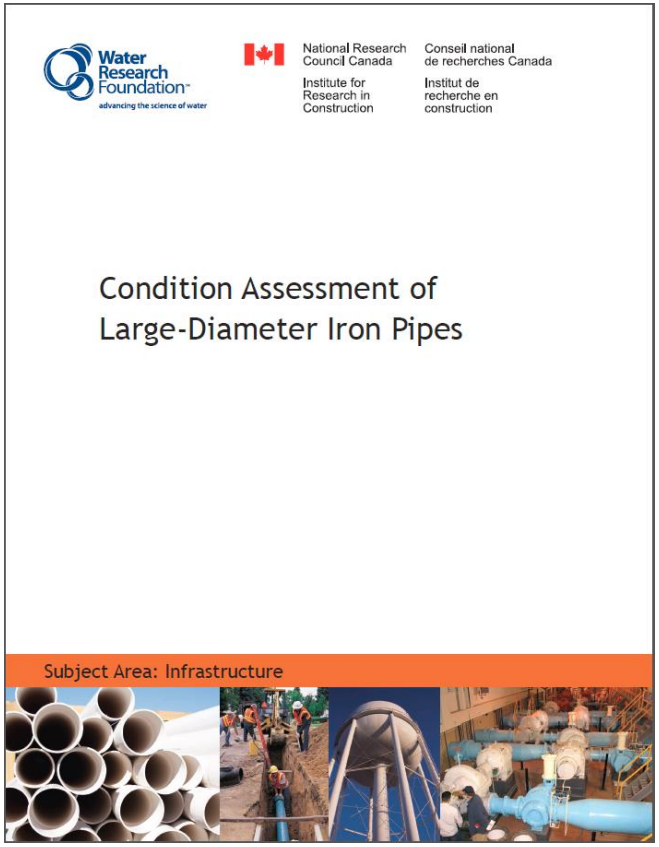
By Ali Abolmaali et al., WRF #4587

Research steps and goals



By Ali Abolmaali et al., WRF #4587

Condition Assessment of Large-Diameter Iron Pipe (#4391)



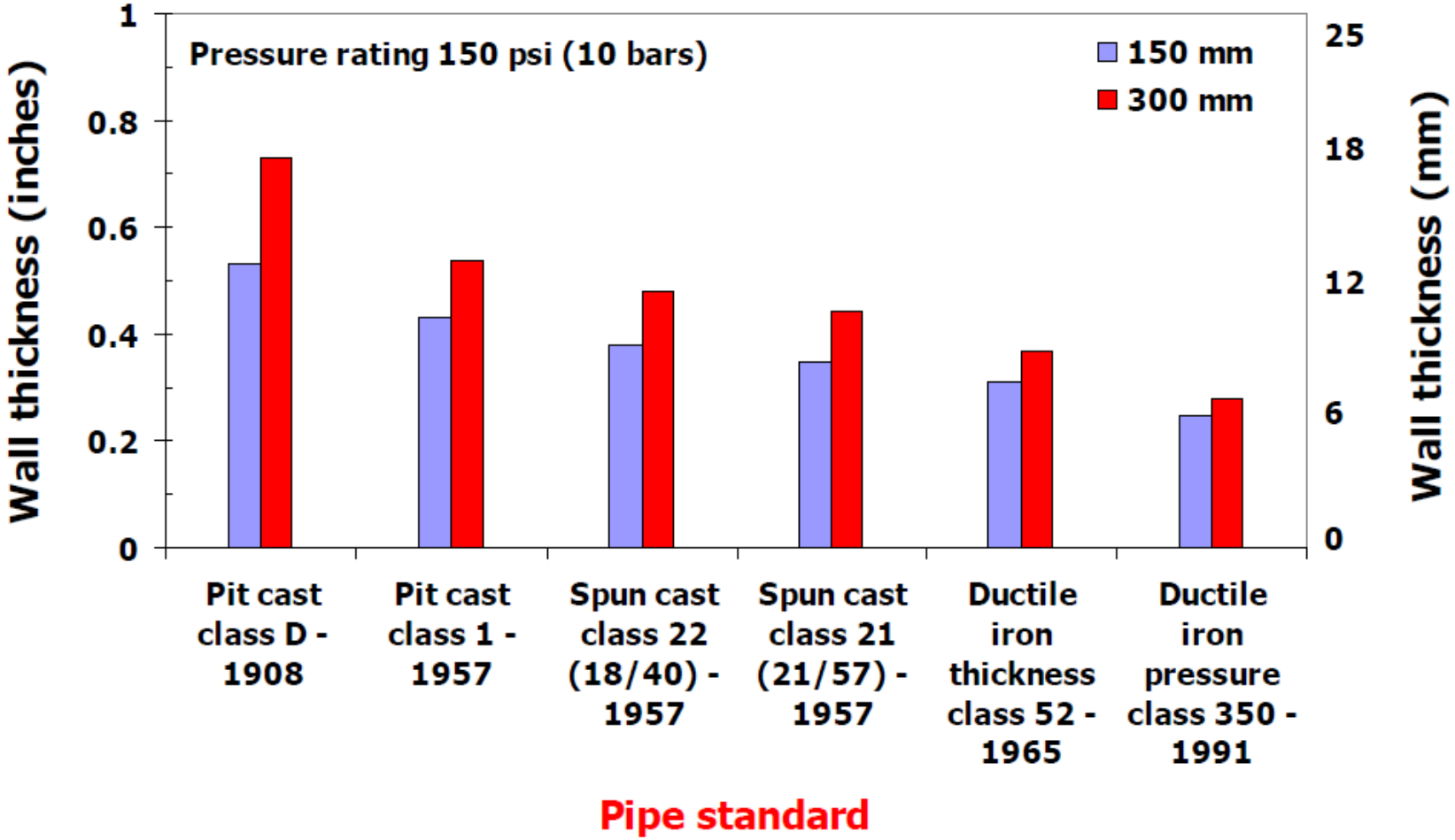
- Developed a manual of practice for condition assessment/evaluation of large diameter CI and DI pipes in order to help utilities assess their pipe inventory and identify those pipes most in need of renewal.
- Research partner: National Research Council of Canada.

Timeline

Era	Event	Characteristics
Early 1800s	Horizontal pit-cast mass-produced	Sand moulds (two halves), 4-5' length, poor Q/C. Asphalt dip.
1850s	Vertical pit-cast introduced	Concentric sand moulds, 8-12' length, better Q/C, Asphalt dip.
1870s	Vertical pit-cast mass-produced	Bells placed at bottom. Better Q/A.
Early 1920s	Centrifugal (spun) cast with metal moulds introduced	Metal moulds - water cooling & annealing. Better uniformity & Q/C – lower wall thickness.
Mid 1920s	Centrifugal (spun) cast with sand moulds introduced	No water cooling & annealing. Longer segments 16-20'.
1930s	Centrifugal (spun) cast mass-produced	Both metal & sand moulds used. Sand for diameters >24".
Early 1970s	CI pipes no longer produced	

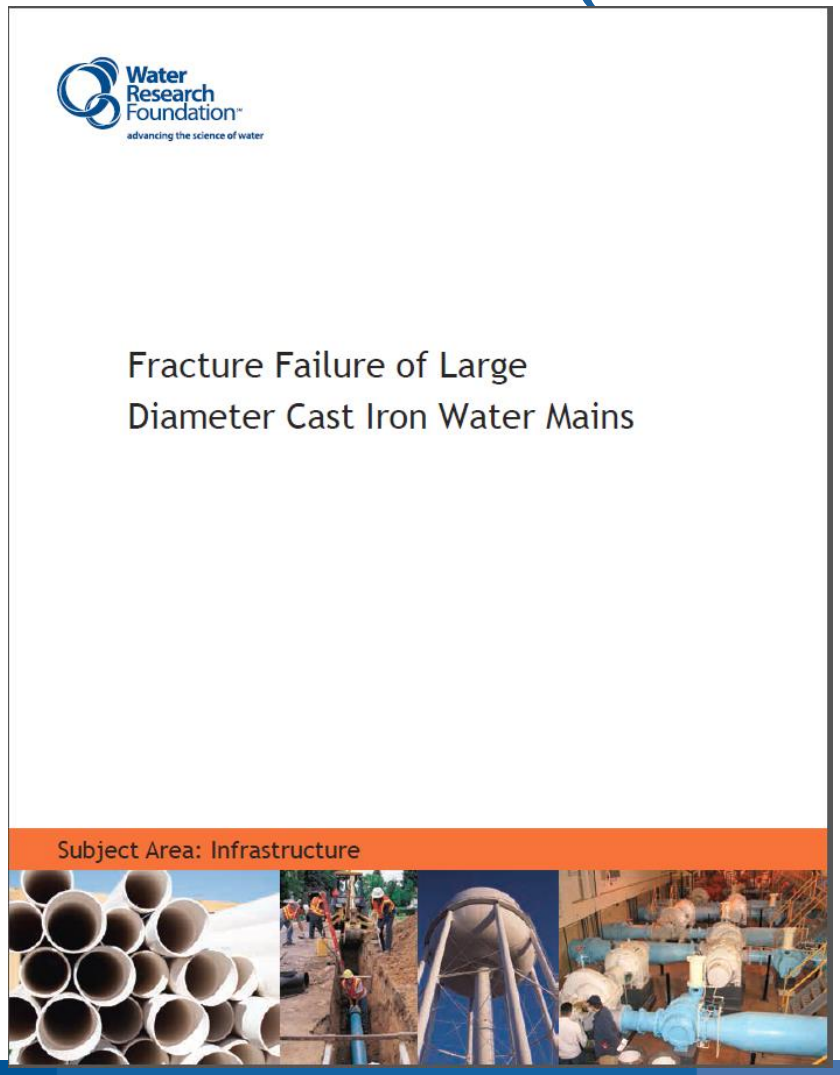
By Yehuda Kleiner et al., WRF #4391

Timeline



By Yehuda Kleiner et al., WRF #4391

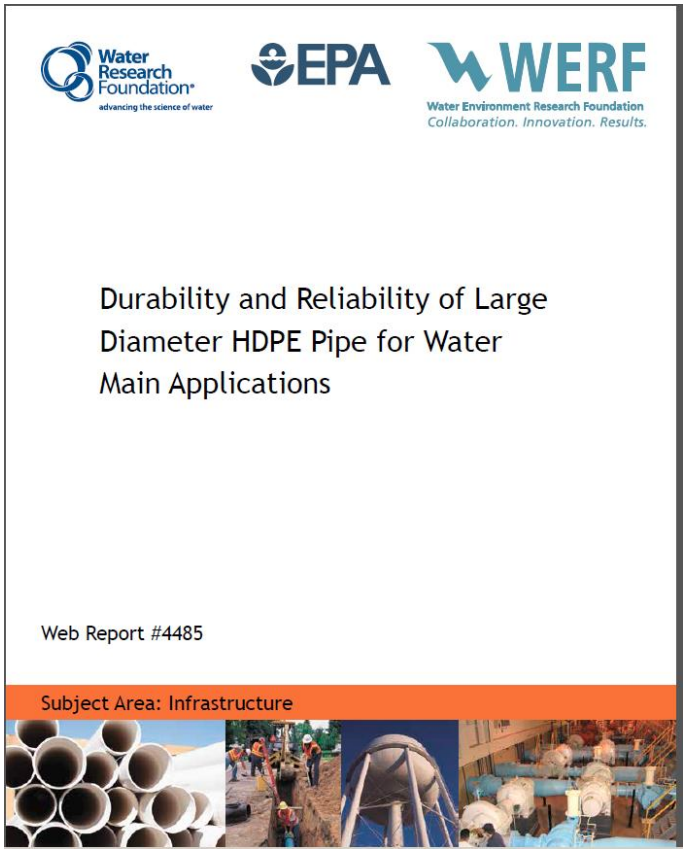
Fracture Failure of Large Diameter Cast Iron Water Mains (#4035)



Fracture Failure of Large Diameter Cast Iron Water Mains (#4035)

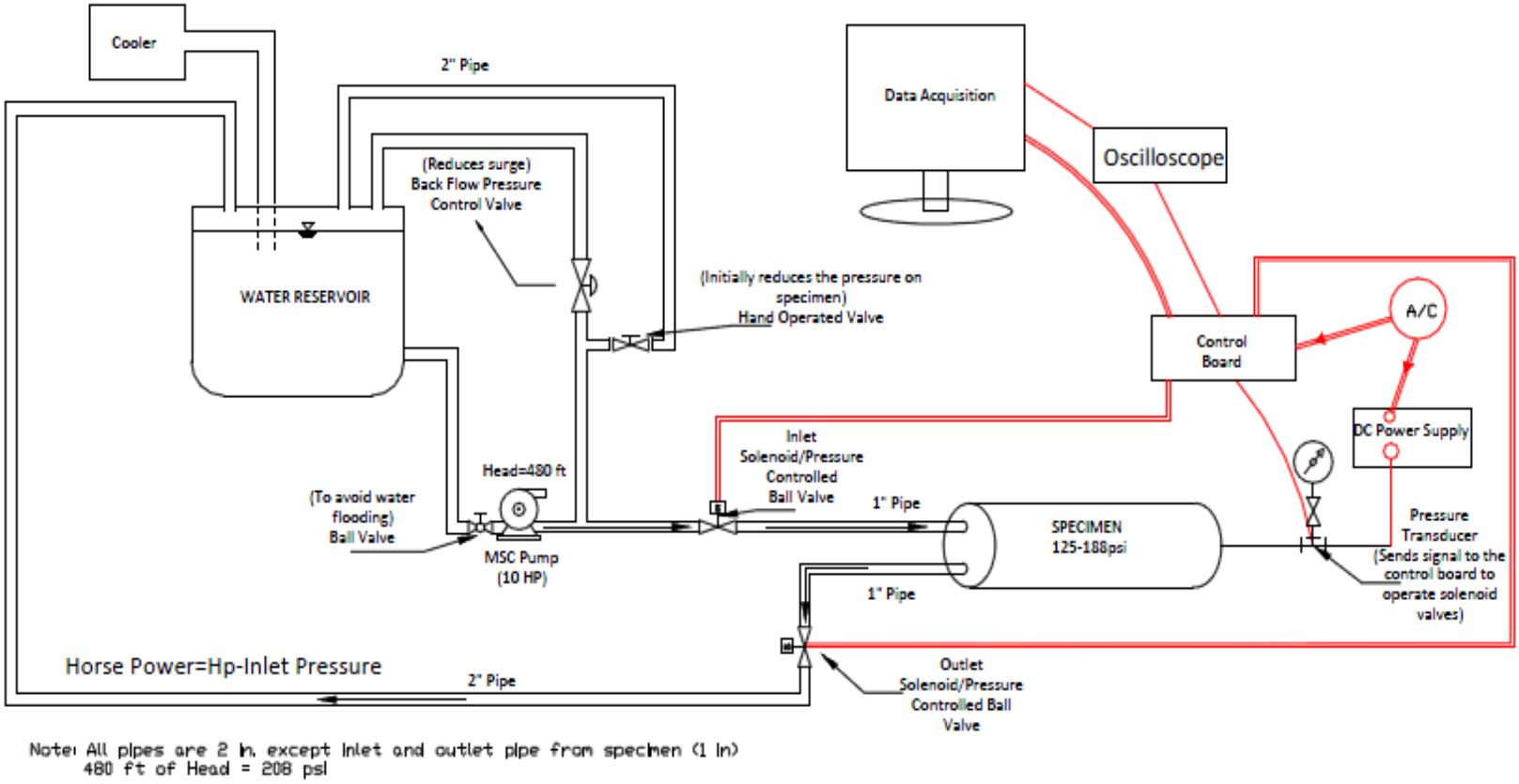
- Determined and assessed mechanisms of fracture failure of large diameter cast iron (CI) water mains.
- Adds to the water industry's understanding of large diameter CI failures through comprehensive analysis of existing data on actual failures experienced by utilities.

Diameter HDPE Pipe for Water Main Applications (#4485)



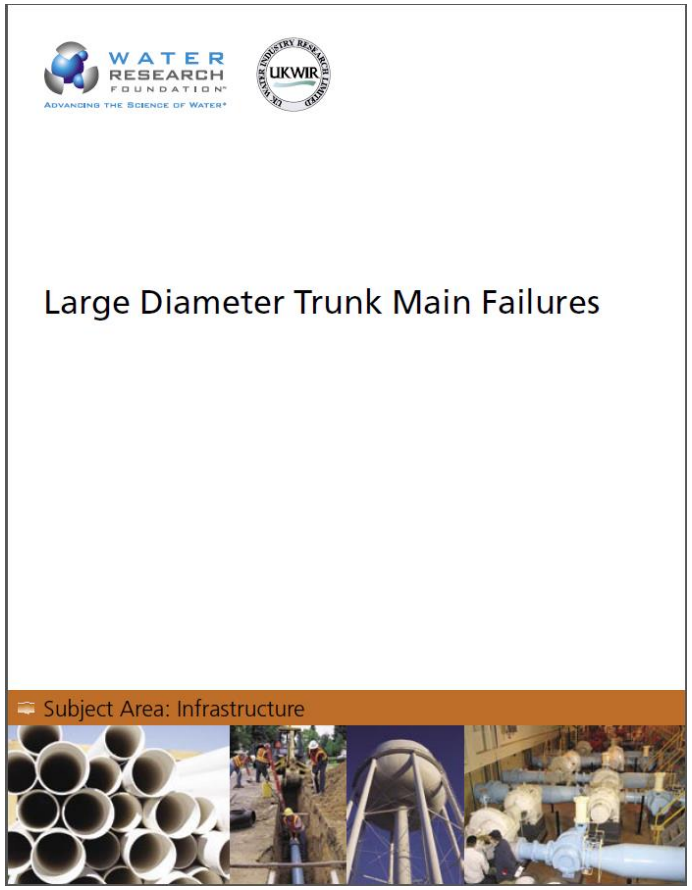
- Examined the durability and reliability of large diameter HDPE water mains (16 in. and larger)
- Durability and reliability of HDPE pipe were investigated through surveys, experimental work, and case studies.
- Research partners: WERF and EPA.

Schematic diagram of experiment setup



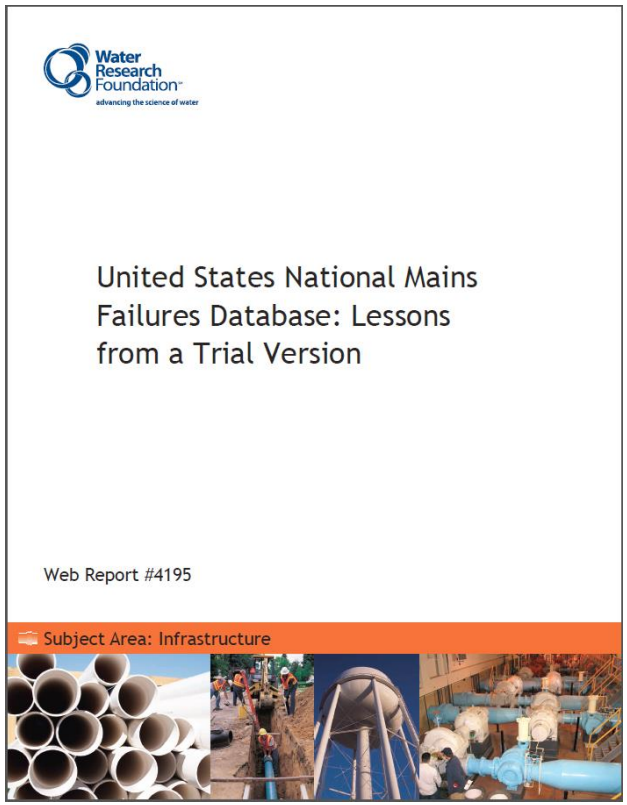
By Mohammad Najafi et al., WRF #4485

Large Diameter Trunk Main Failures (#4076)



- Partnership project with the UK Water Industry Research Limited (UKWIR). Report #91266
- Collected and analyzed historic trunk main failures information from research papers and UK water companies (13 UK water companies participated)
- 35,000 km of trunk mains ≥300 mm diameter (~12-inches) were catalogued, over periods of up to 30 years, and including 10,000 failure records
- Developed a trunk mains data protocol that, if adopted, would lead to much improved future data that would be useful in understanding the factors and variables that lead to failure

US National Main Failures Database: Lessons from a Trial Version (#4195)



PI: Neil Grigg, CSU

- Follow-up to National Water Main Failures Database (NMFD) created in 2002 for the UK by UKWIR and also as follow-up to the UKWIR Large Diameter Trunk Main Failures project
- NMFD provided useful information on overall failure rates, and allowed insights into the causes of deterioration and could help understand why some pipes fail but not others
- A beta version of a US-based NMFD was developed, and data protocols, and 12 participating US utilities had access to the database and the ability to have their data uploaded
- Use of the database was limited, the trial use period ended in 2012 after more than a year of availability
- No national pipe failure database exists in the US for large or small pipes

Thank You!
Questions?

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