THE UNDERGROUND UTILITIES EVENT
Underground Construction Technology | Jan. 29-31, 2019 | Fort Worth, TX

Gravity Sewer Rehabilitation Design

V. Firat Sever, PhD, PE, BCEE

Mo Ehsani, PhD, PE, SE

QuakeWrap, Inc.

QuakeWrap

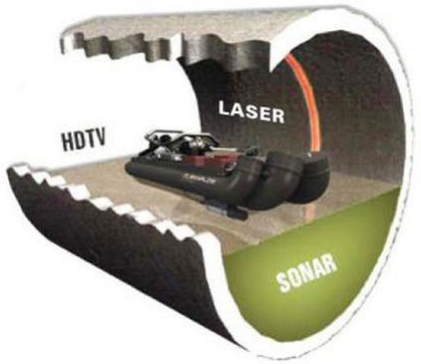
R F P Construction

4000 DAYS
No Lost Time Accidents

Outline

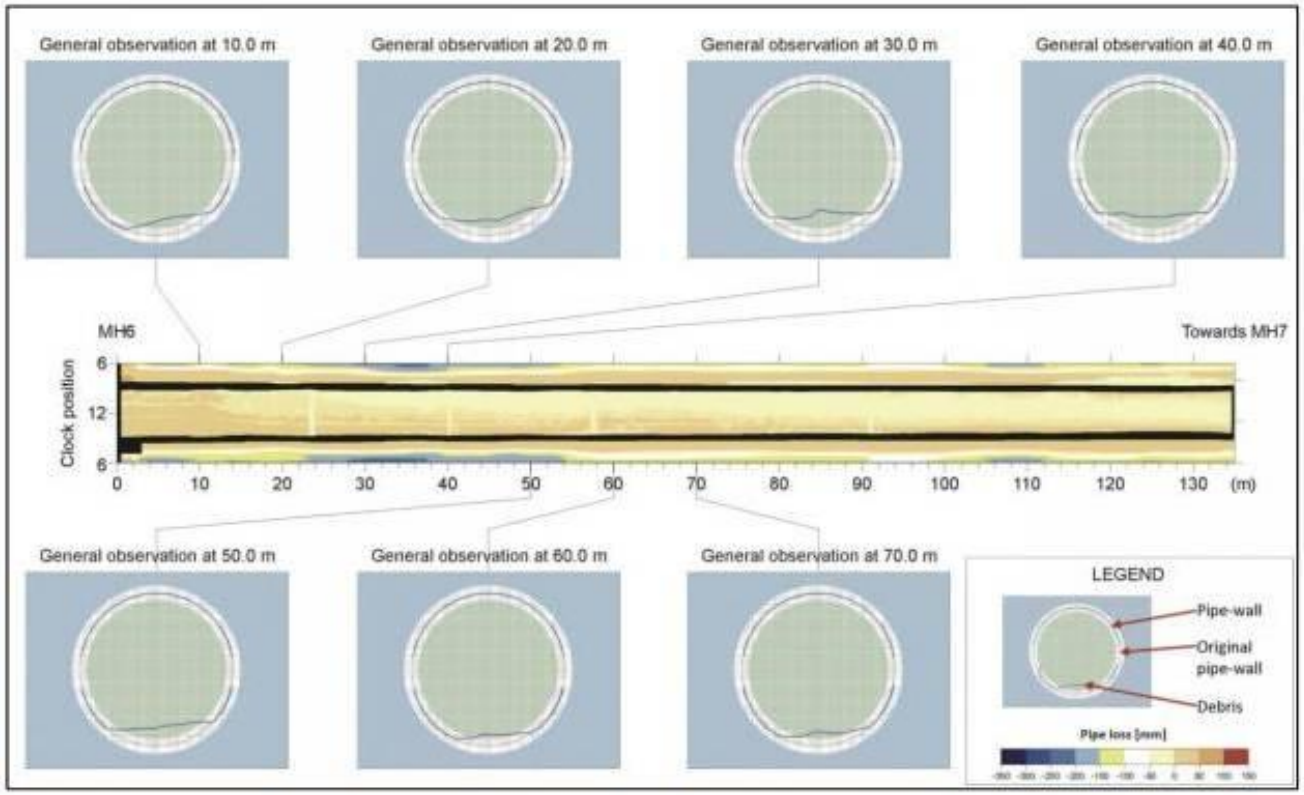
- Condition Assessment
- Design Methods
- Sewer Rehabilitation Methods
- FRP Lining System for Gravity Sewers

Inspection Methods



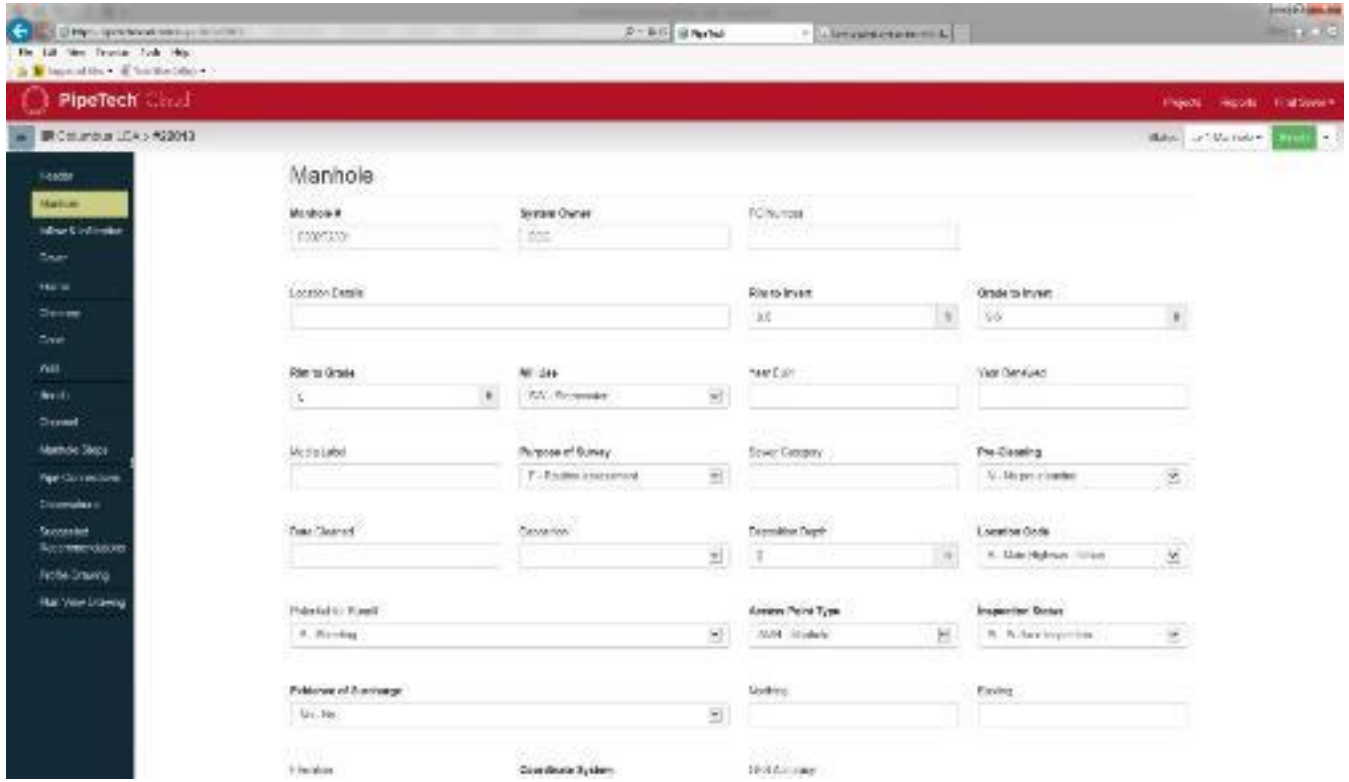
- CCTV
- Multisensor (sonar, laser)
- GPR
- Man-entry
- Other NDT (e.g., ultrasound)

Pipe Penetrating Radar (PPR)



Man-Entry

Manhole Inspection



Hole Void Visible (HVV)

Ovalization/Deformation

Bulging Crown w/ Fracture

Cracks/Fractures

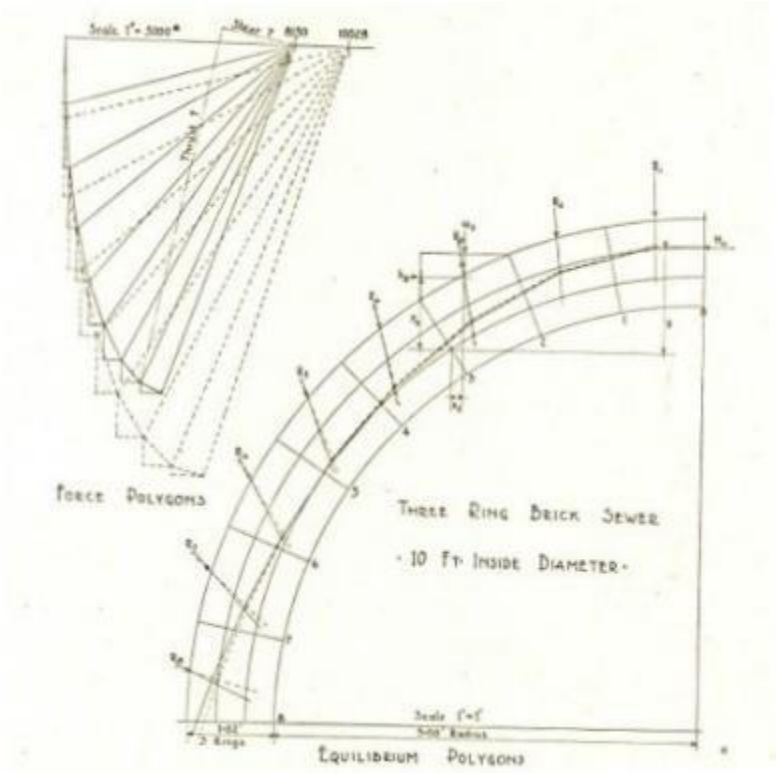
Cross-Bores

Corrosion

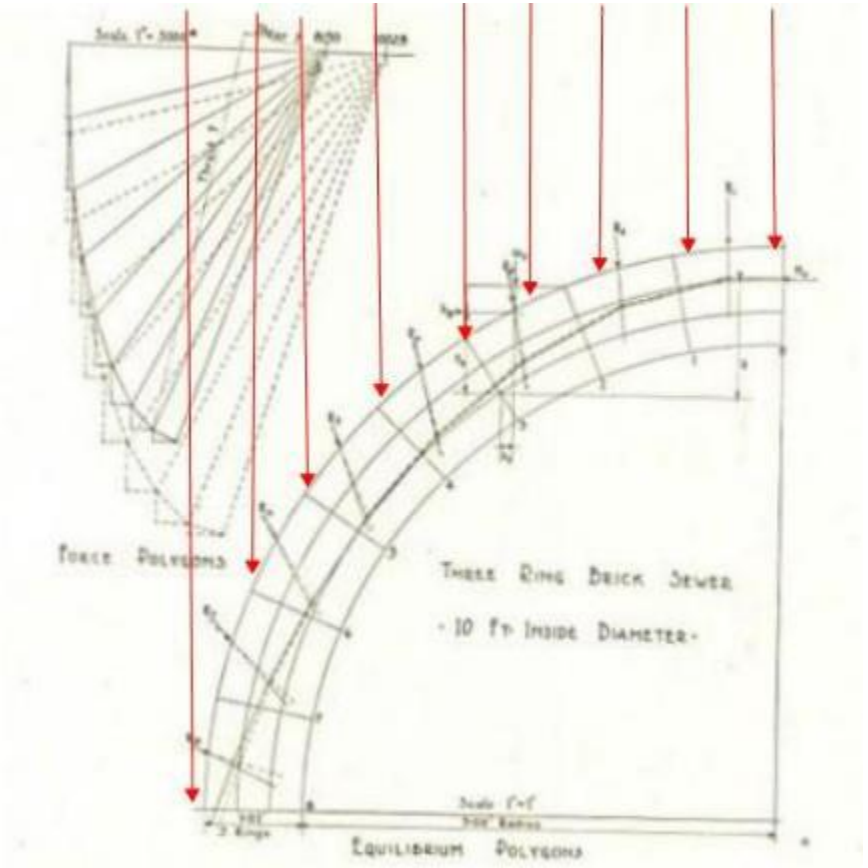
CMP Culverts

Source: M. El-Taher, 2009. The Effect Of Wall And Backfill Soil Deterioration On Corrugated Metal Culvert Stability, Queen's Univ.

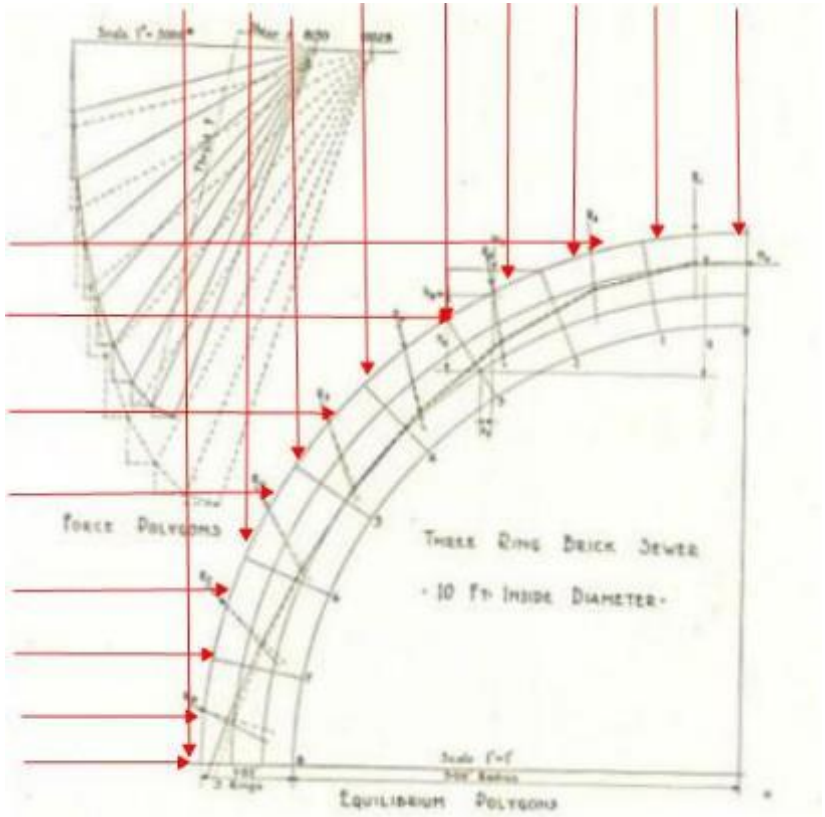
Brick Conduits – Load Distribution



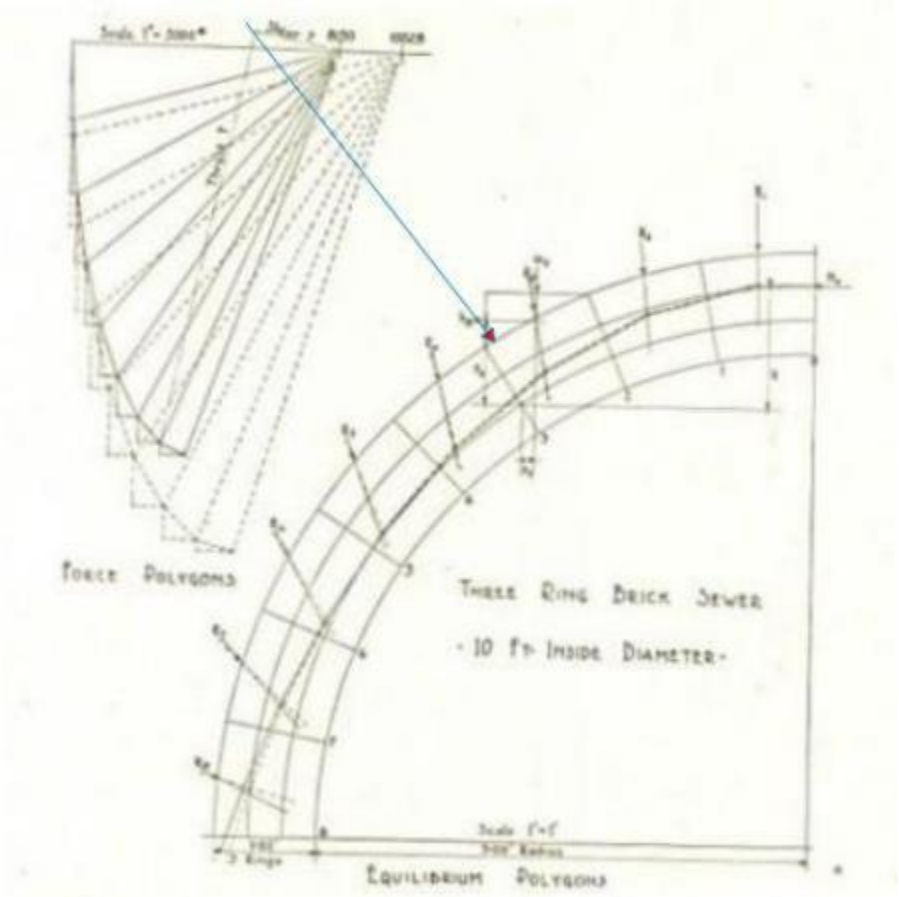
Brick Conduits – Loads contd.



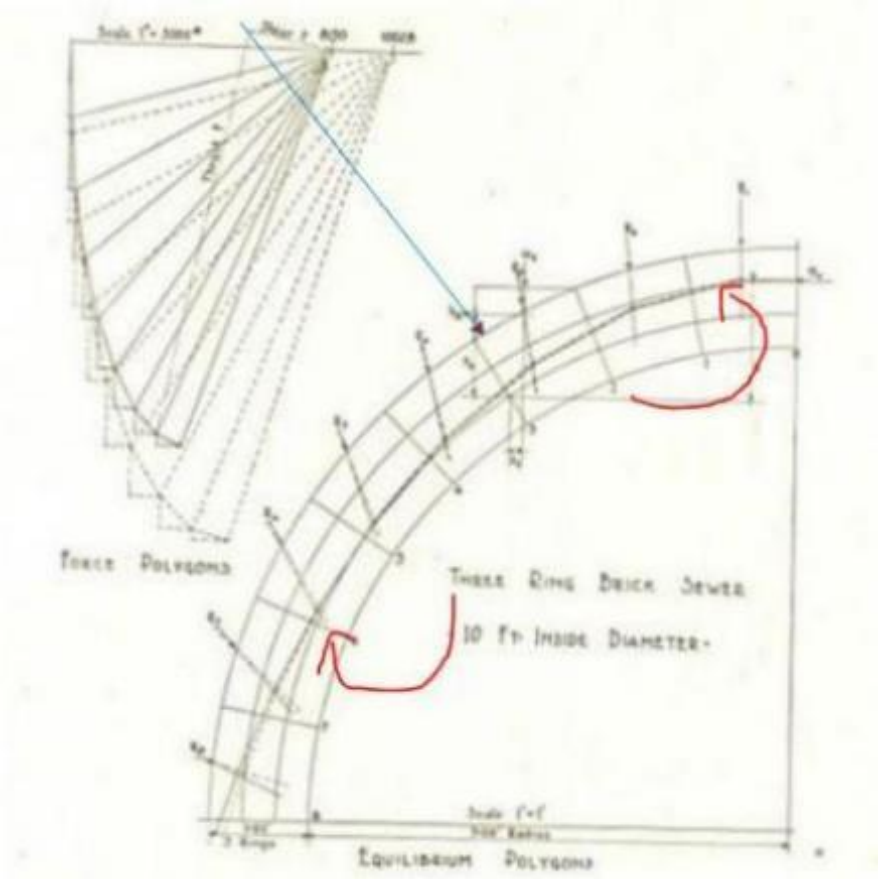
Brick Conduits – Loads (contd.)



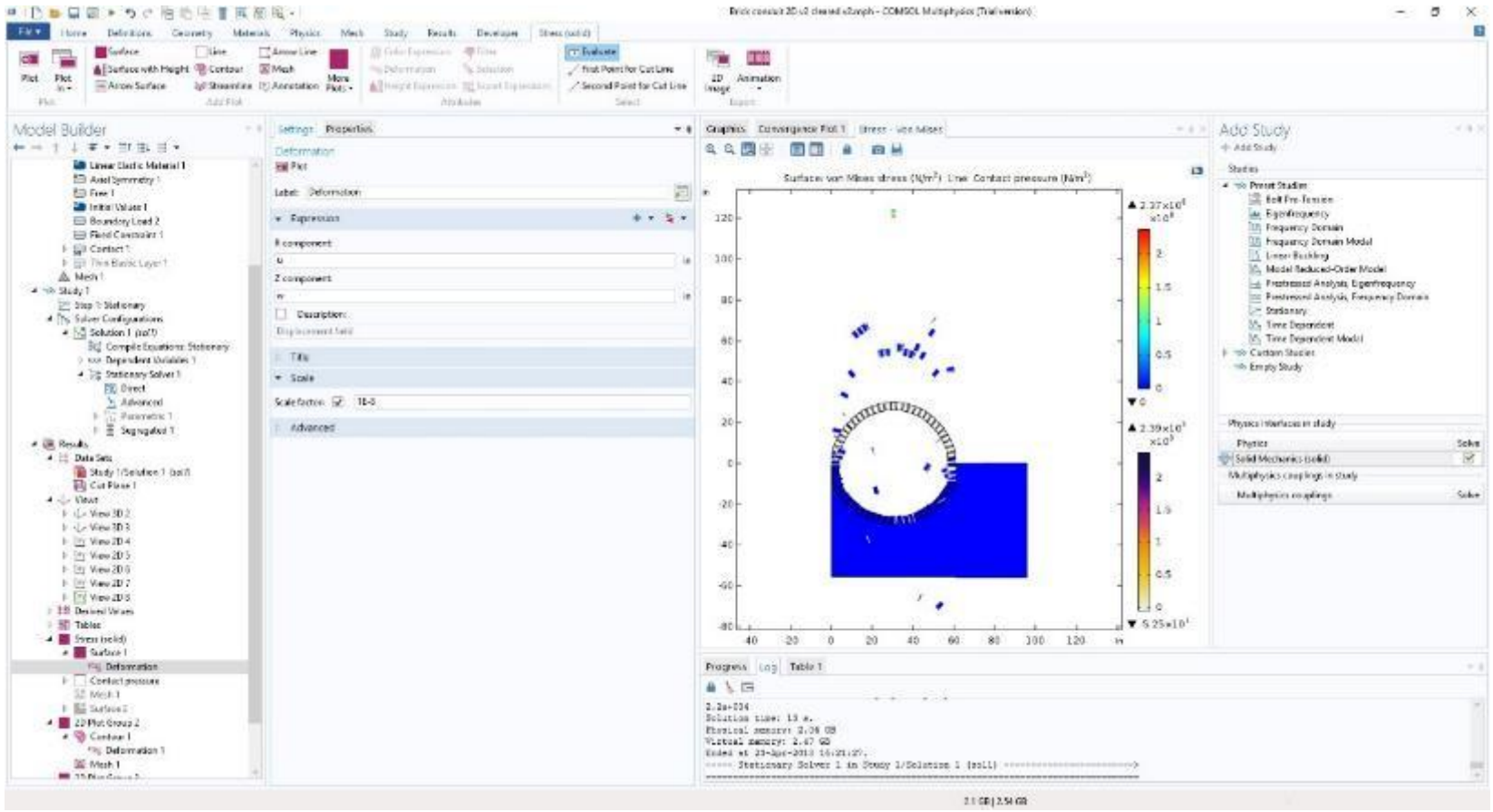
Brick Conduits – Loads (contd.)



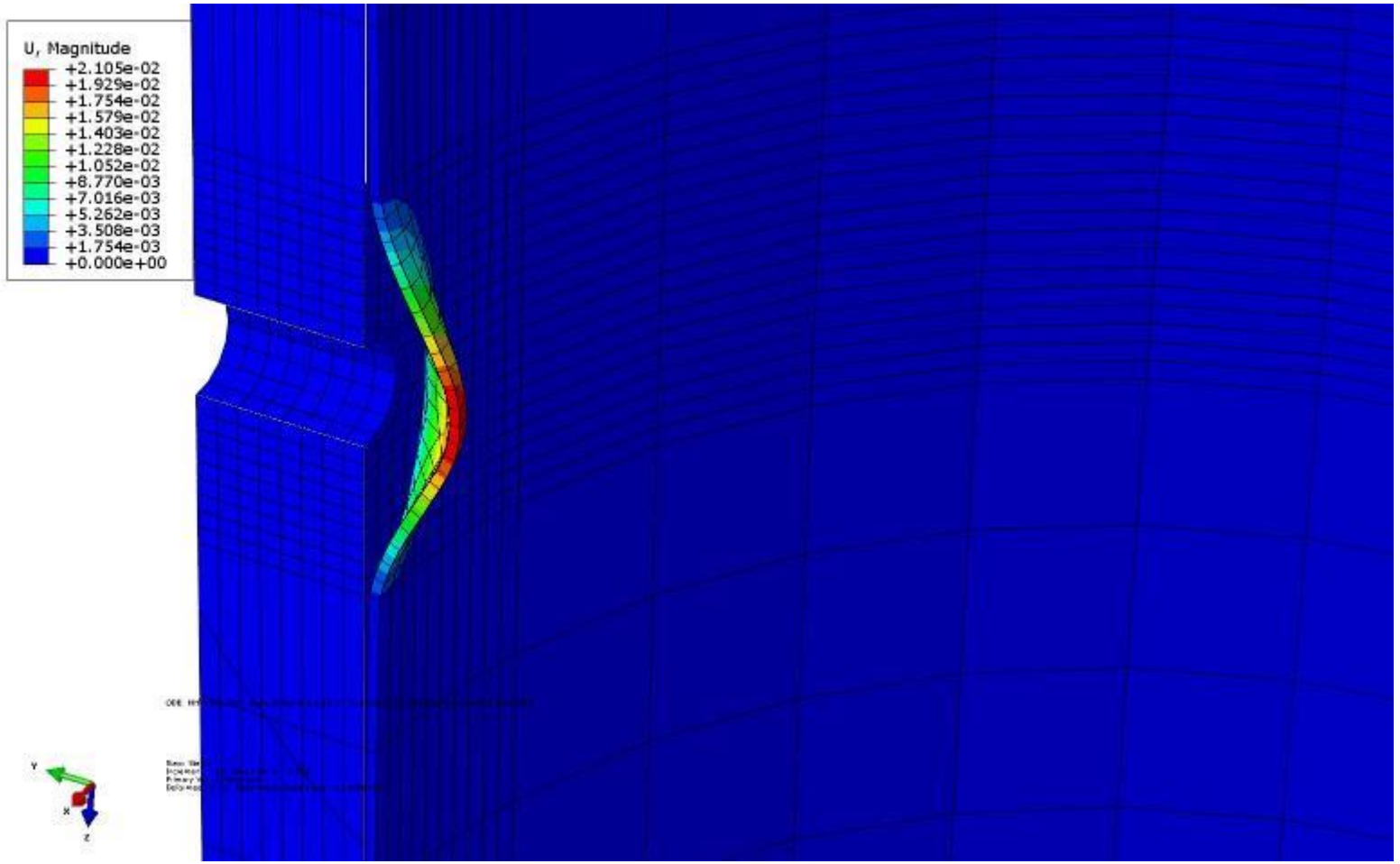
Brick Conduits – Loads (contd.)



Single Layer Brick FEA



Groundwater Pressure



Dr. Xinbao Yu, et al.

Design Factors

- Flexible (e.g., polymeric liners)
- Rigid (e.g., cementitious)
- Fully-structural (stand-alone)
- Semi-structural
- Condition
- Loads
- Soil type
- Environmental effects
- Site access conditions

Sample Design Equations

ASTM F1216 – partially deteriorated

$$P = \frac{2KE_L}{(1-\nu^2)} \cdot \frac{1}{(DR-1)^3} \cdot \frac{C}{N}$$

Soil Load – Flexible Pipe/Liner

$$\omega = C_p \gamma D^2$$

Ovality

Host Pipe Support

Stress Concentration

ASTM F1216 – fully deteriorated

$$q_t = \frac{1}{N}[32\, R_w B'\, E'_s \cdot C(E_L I/D^3)]^{1/2}$$

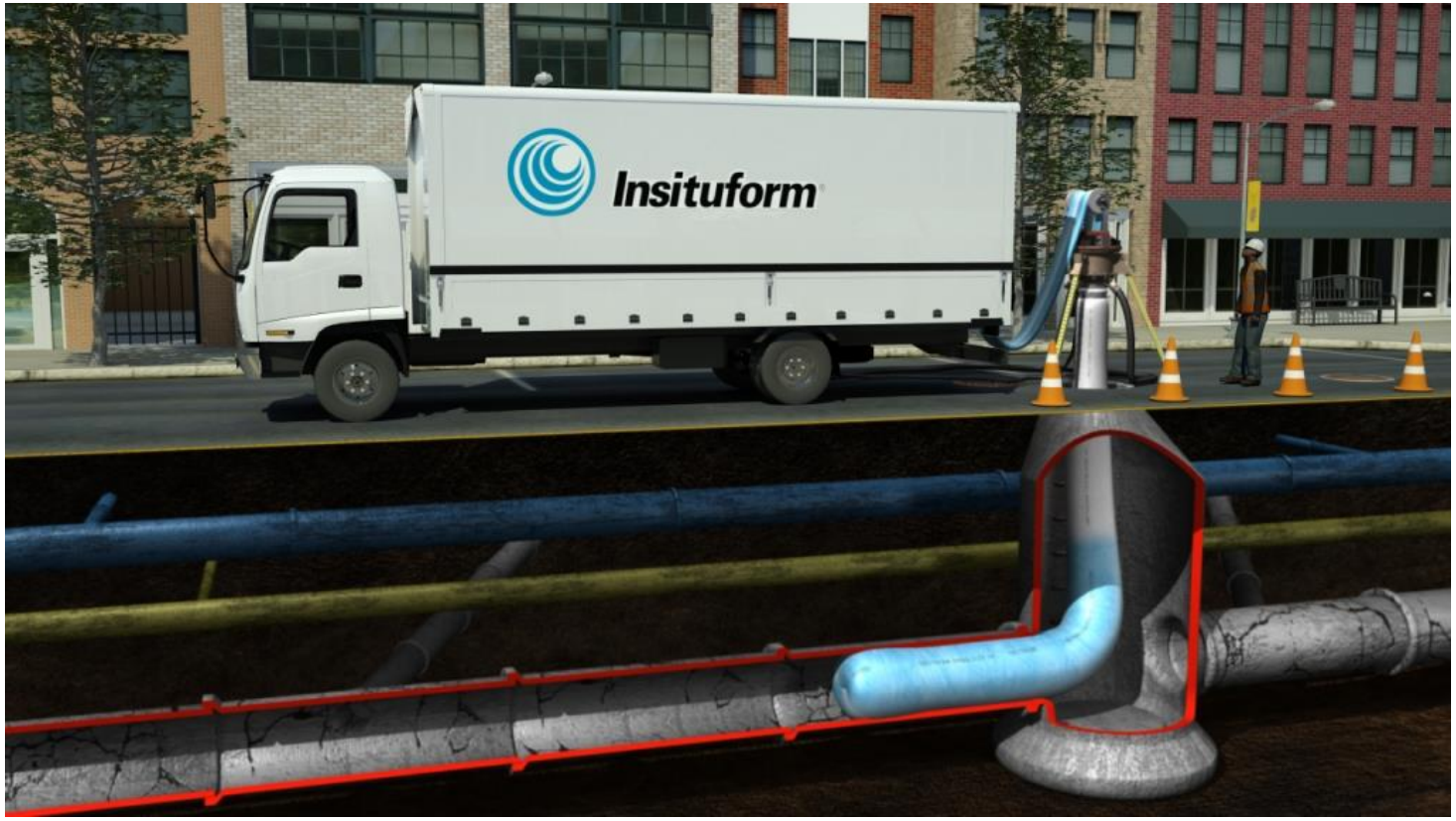
Modified Timoshenko– buckling

$$Pc = (2EC\propto\beta)/[(1-\upsilon\text{^}2\,)(DR)\text{^}3\,)SF]$$

Internal Pressure: Thin-walled vessels

$$\sigma = \frac{PD}{2t}$$

CIPP



Sliplining (Deform/Reform)

Geopolymer

Rigid Sliplining (CC-GRP)

CFRP Lining

Sliplining w/ StifPipe®

Composite Sandwich Concept

Steel I-beam

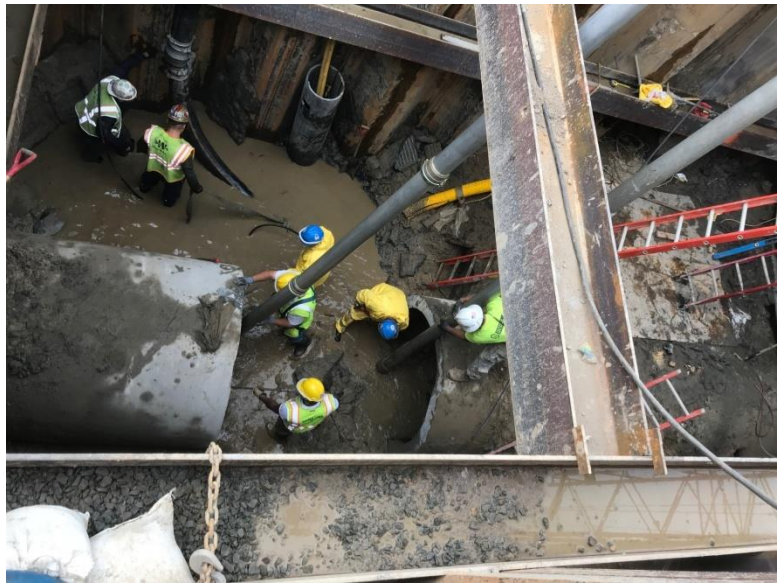
RELATIVE STIFFNESS	1
WEIGHT (Pounds/ft^2)	0.910

Avalon Pump Station Project

Avalon Pump Station Project ... Cont'd

StifPipe® Built in a Pipe

Edison, NJ Sept. 2018



Thank You!

Contact:

Firat Sever

fsever@quakewrap.com