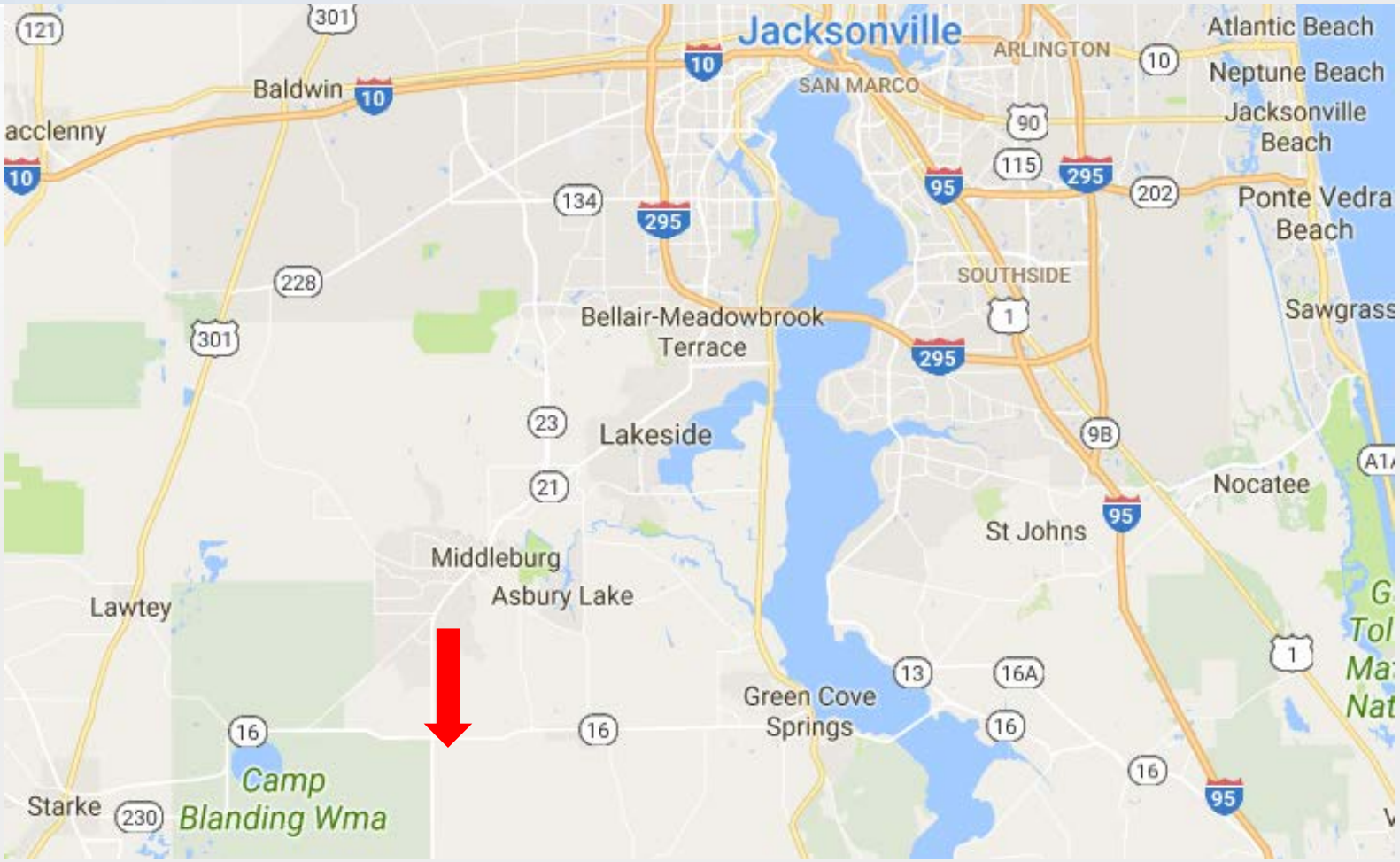
Florida State Route 16:

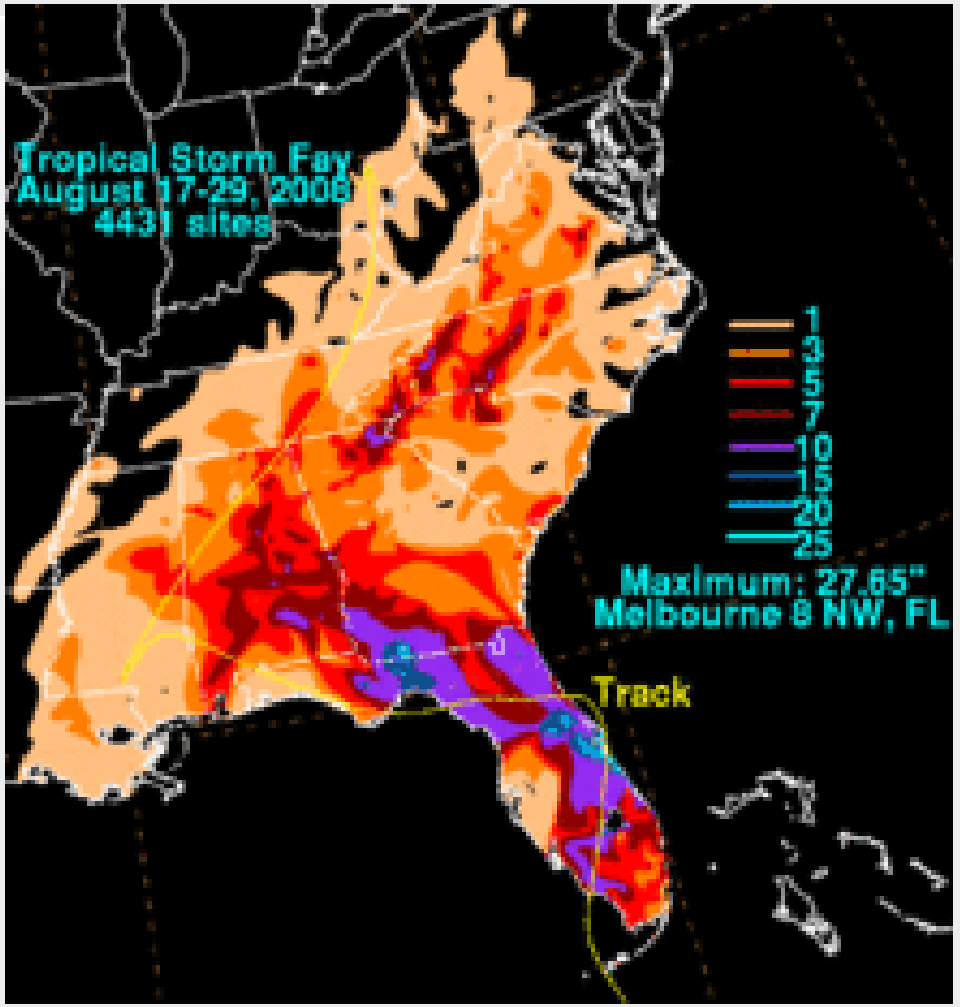
Rehabilitation and Subsequent Live Load, Strain Gauge Testing

CENTRI-PIPE

Location: SR-16



2008 Tropical Storm Fay



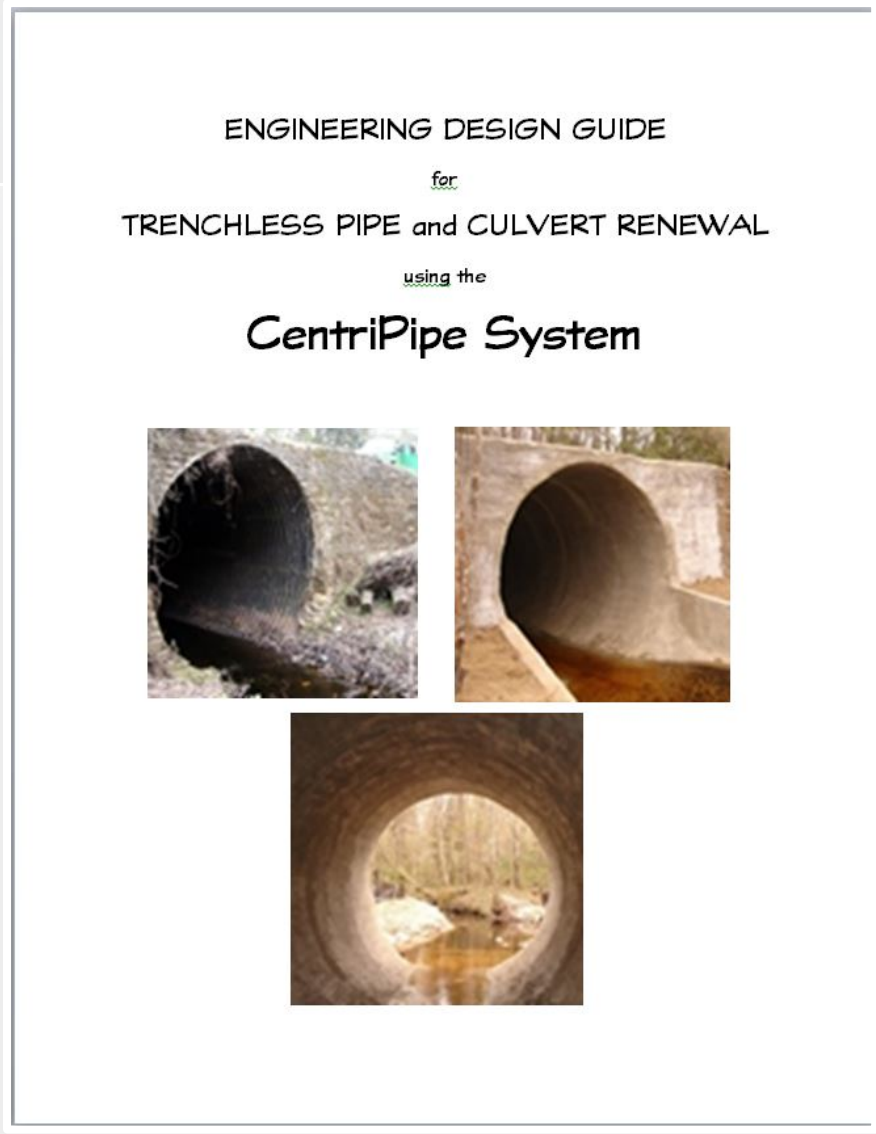
SR-16 – Large voids discovered

FL SR16: FACC Solution

- Evaluated available rehab options.
- FDOT selected the application of high-strength fine aggregate composite concrete.
- FACC provided long term structural pipe without stopping traffic.

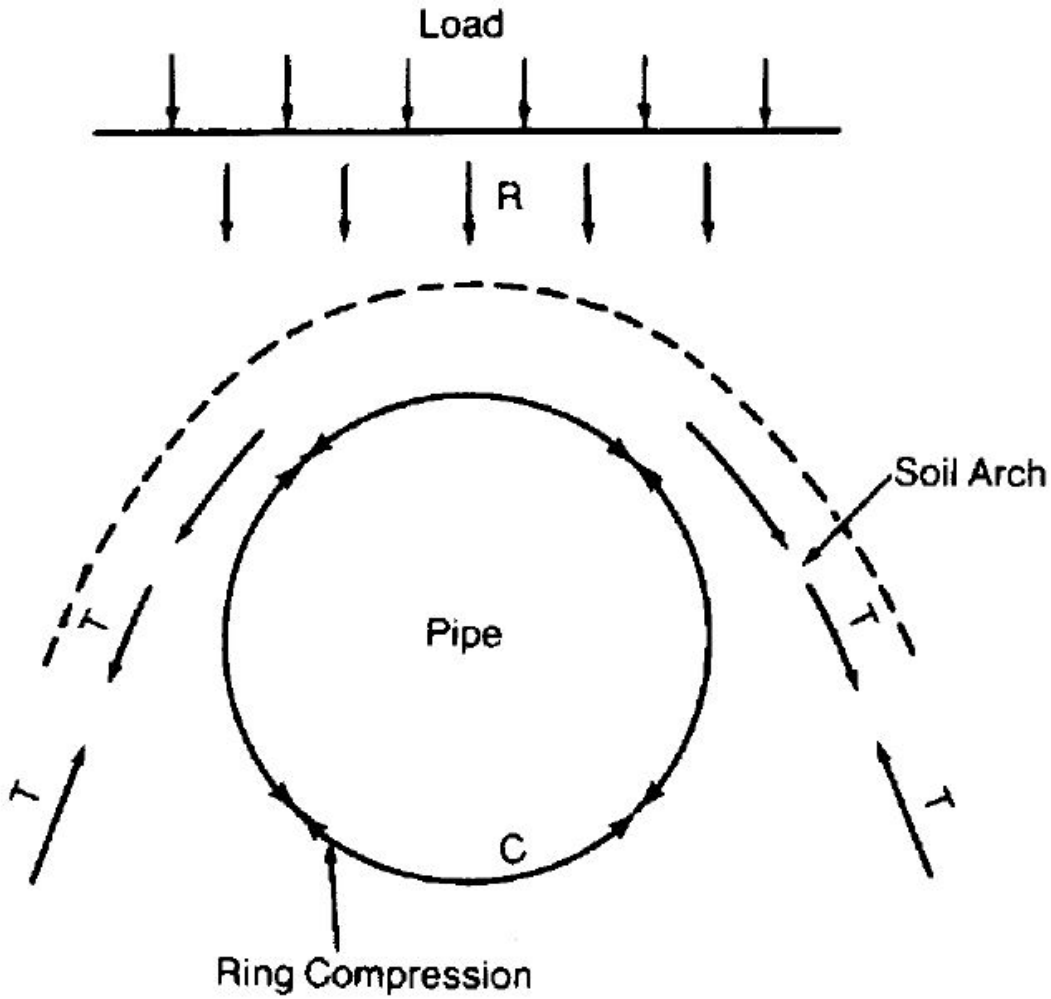
Engineering

- Engineering Design Guide provides in-depth overview of multiple situational and environmental considerations.
- Input on proper engineering design calculations to address concerns presented by the individual pipe.



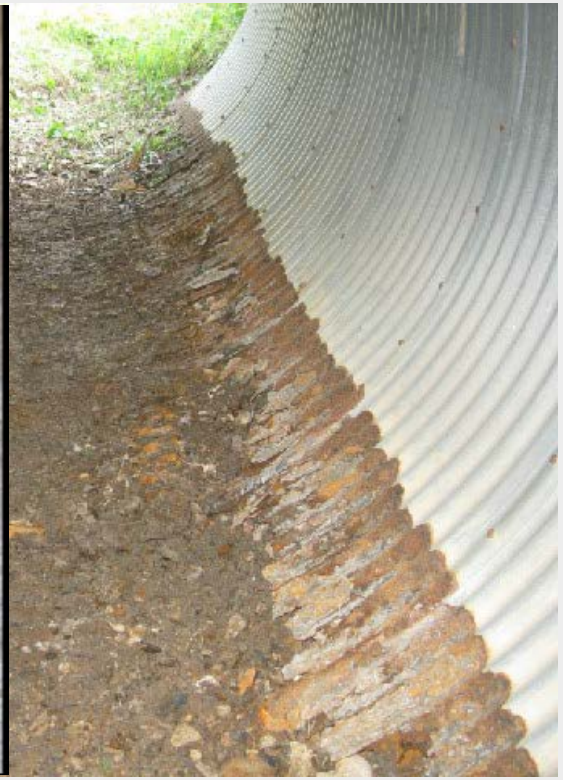
On Site Design Considerations

- Pipe size and construction
- Pipe condition
- Depth to crown (Cover)
- Pavement type (Rigid / flexible)
- Soil type
- Depth of water table
- Corrugation pattern
- Hydraulic Capacity
- Load requirements – H 20?
- Any future loads?



Determining the required minimum wall thickness…

- **Is there any long-term structural value in the host pipe structure?**
- How does the lining system perform with the host structure?
- What loads, if any, are likely to come onto the lining after its installation?
- What is the likely load-response mode of the liner to be?



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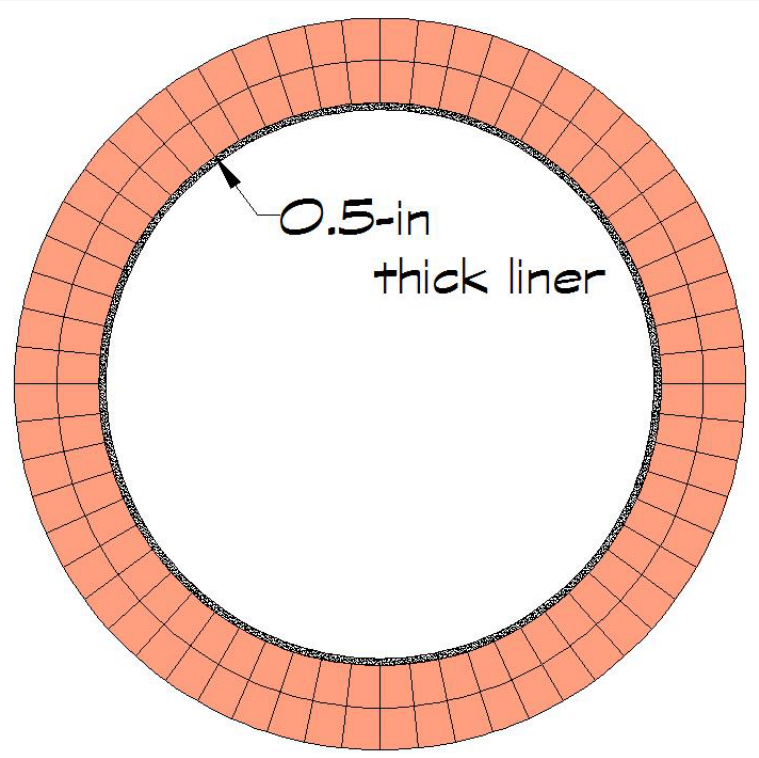
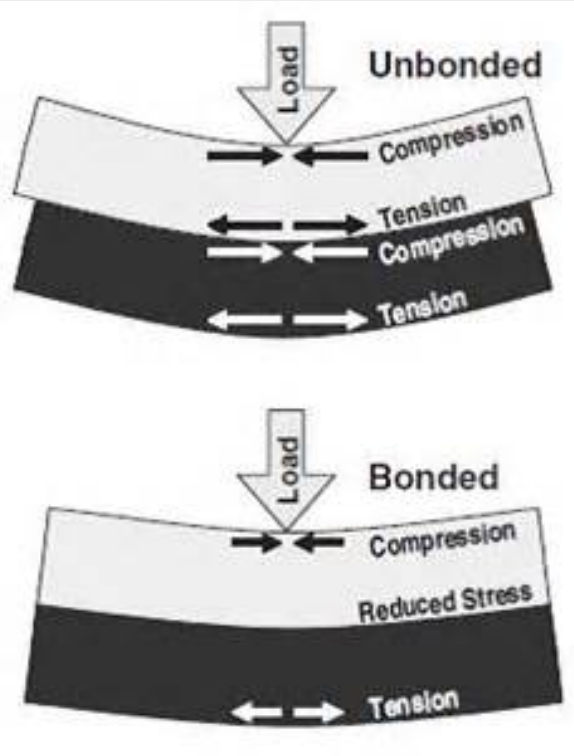


Compound Beam

Composite Beam



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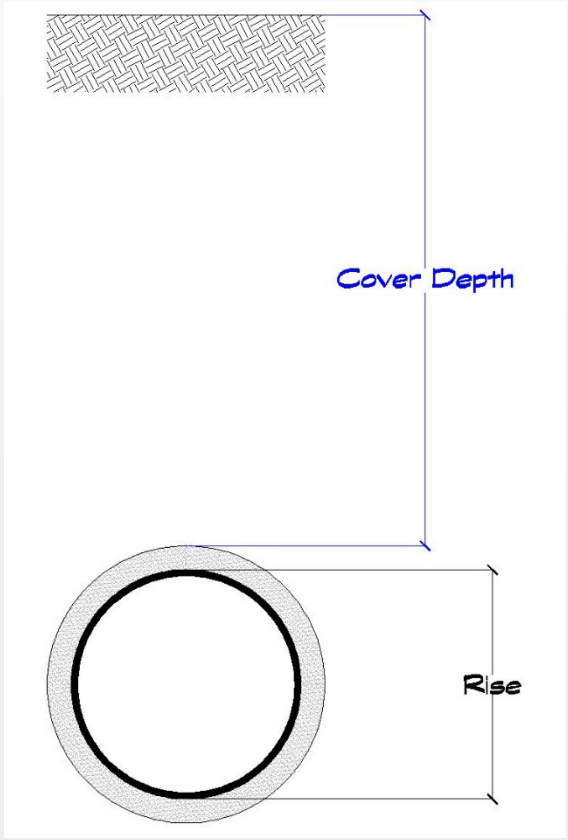

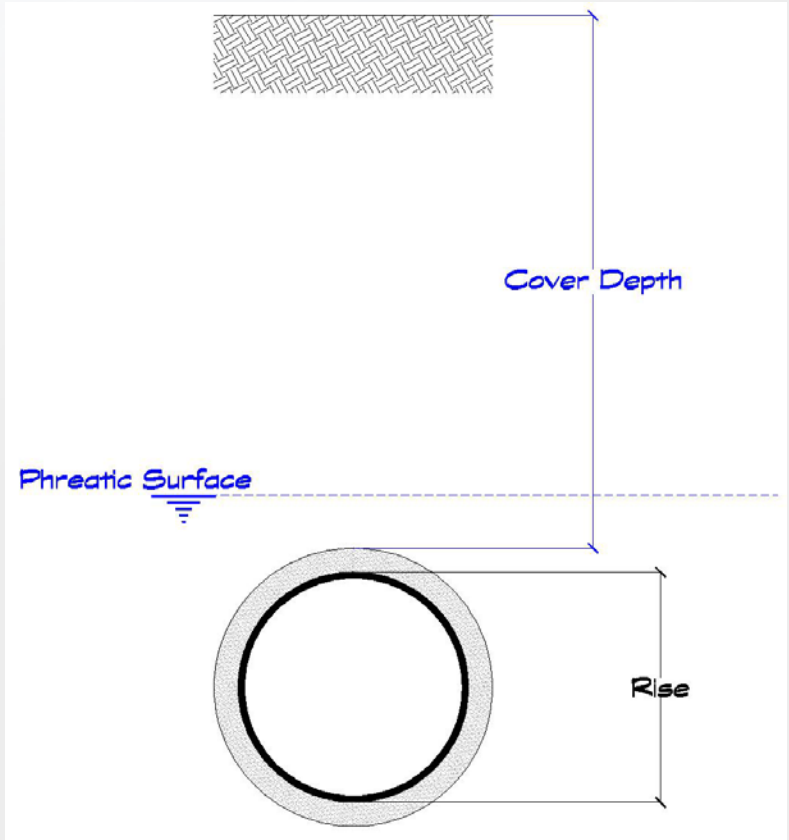

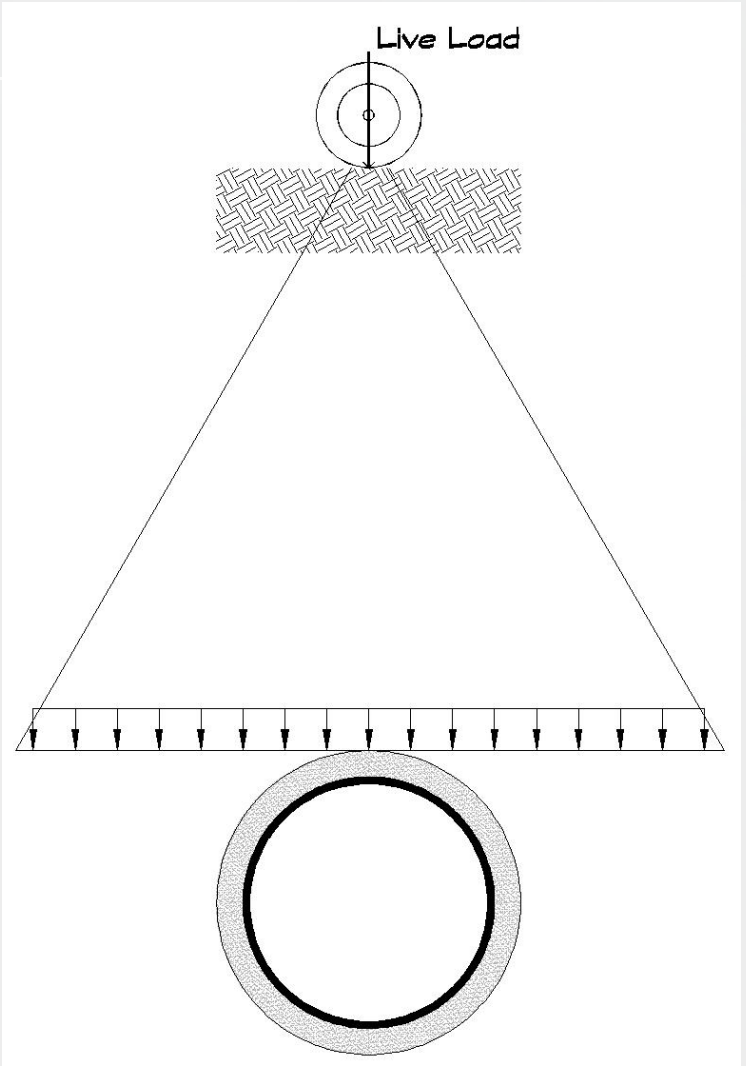

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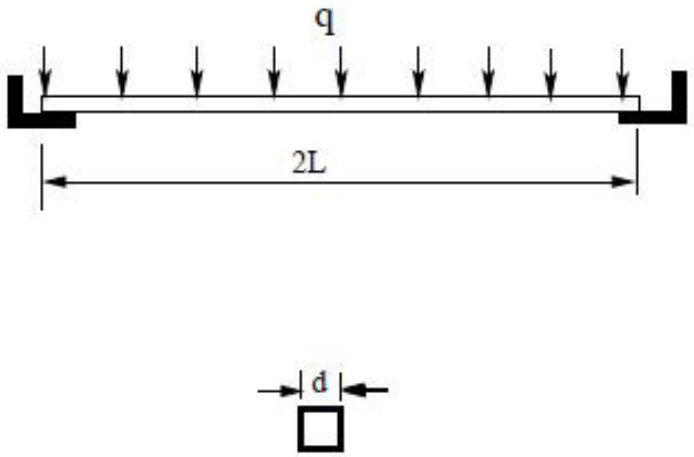
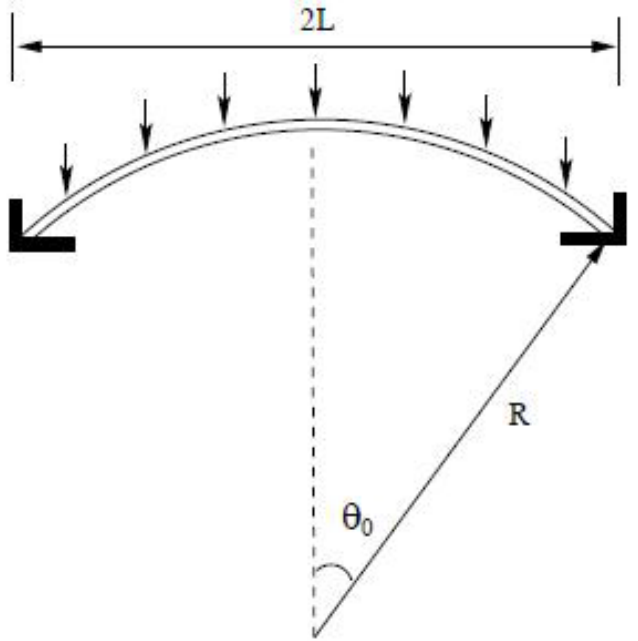
- **What is the likely load-response mode of the liner to be?**

A simple beam in bending, or…



an arched structure in Thrust



Fine Aggregate Composite Concrete (FACC)

Pipe within a Pipe…

There are four variables to consider in FACC Linings…

1. The FACC mix design's engineering properties

2. The application methodology

3. The existing Soil-Structure Interaction System

4. Determining the loads that will be applied after lining takes place.

On Soil-Structure Interaction —

The real behavior of structures in contact with ground involves an interactive process beginning with a state of balance after a period of adjustment of stresses and strains within the structure and within the ground influenced by the structure. *Steve Thorbum*

The Art of Fine Aggregate Concrete Composite Mix Design

Modulus of Elasticity

Flexural Strength (Modulus of Rupture)

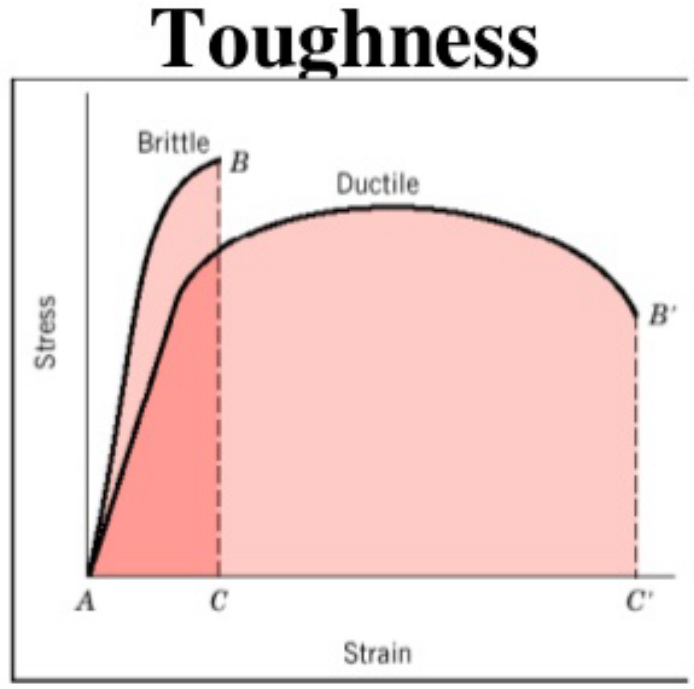
Thin-Shell Toughness of Finished Liner

Permeability

Freeze-Thaw Performance

Thixotropy

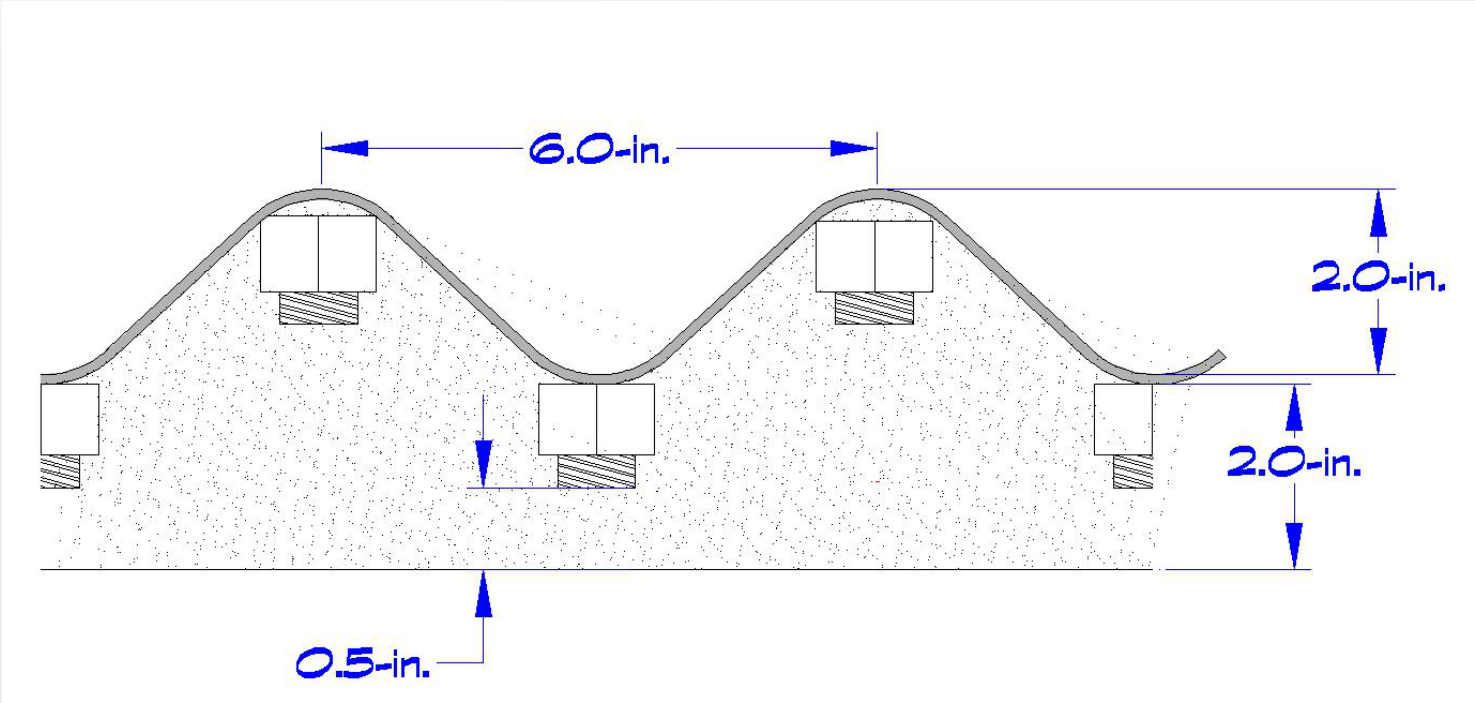
Internal crystalline membrane technology



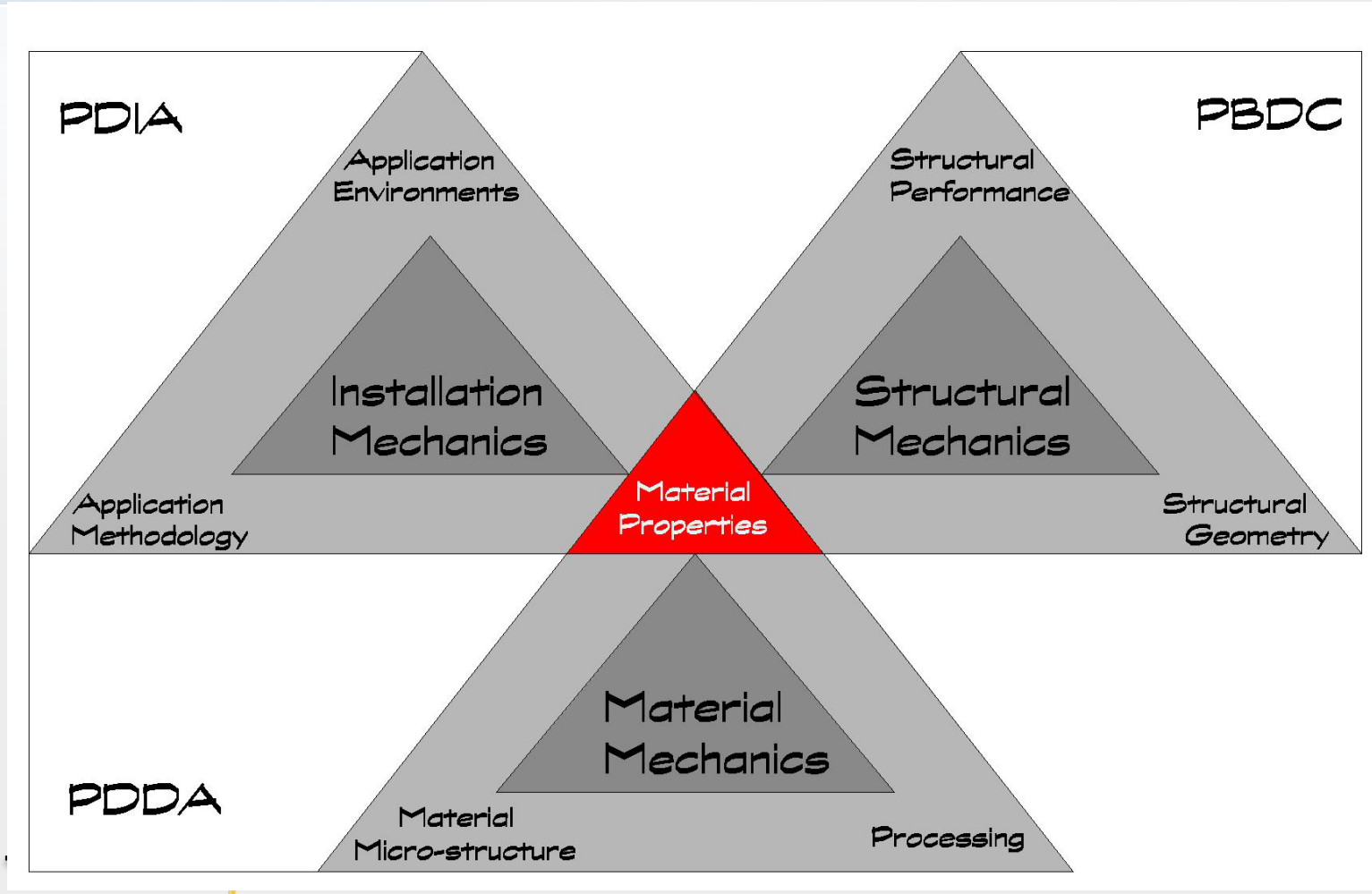
Toughness **= the ability to absorb energy up to fracture**
= the total area under the strain-stress curve up to fracture

Corrugation profile

- Minimum thickness measured from peak of the corrugation
- Min. ½" cover over bolt penetrations



Concept of Integrated Structures and Materials Design (ISMD)



Victor Li, Journal of Advanced Concrete Technology, 2003

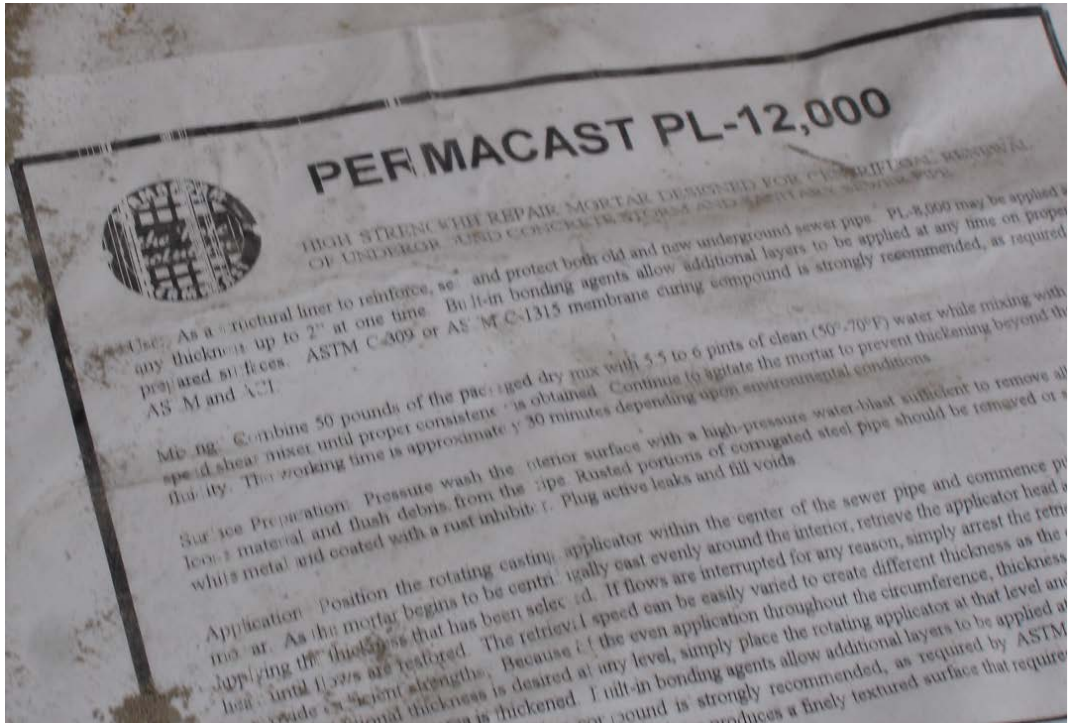
FDOT SR-16: Coffer Dam

FDOT SR 16: Dewatering

FDOT SR-16: Framing and Pouring Wing Walls

CENTRI-PIPE

FDOT SR-16: Filling and Stabilizing Invert



FDOT SR-16: Staging and Pumping Material

FDOT SR-16: Applying Material to Interior Walls

FDOT SR-16: Completed Interior

FDOT SR-16: Completed Exterior

FDOT SR-16: Six Year Inspection

- January 2016
- Impeccable condition

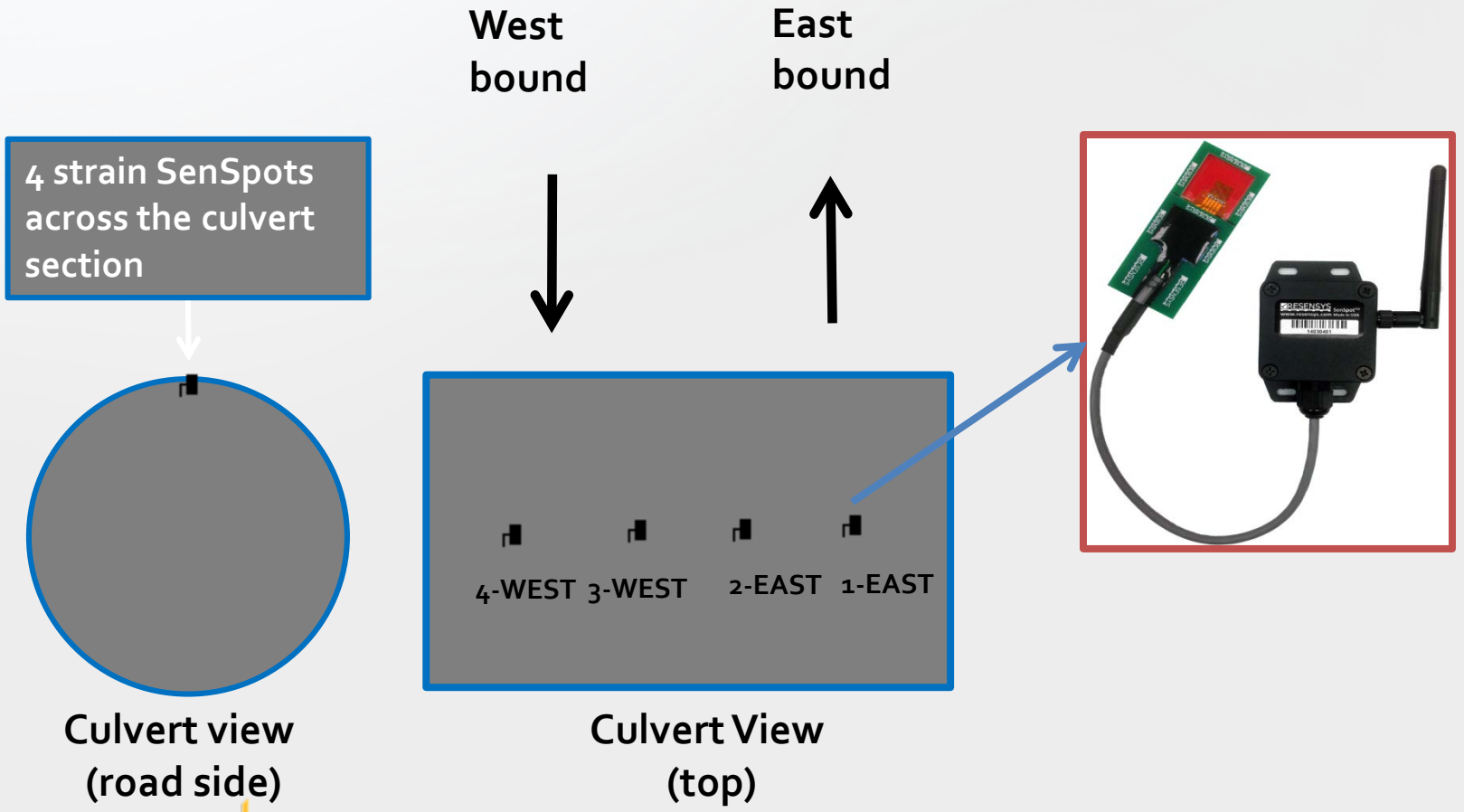
6 year Inspection

SR-16 – 2016 Inspection

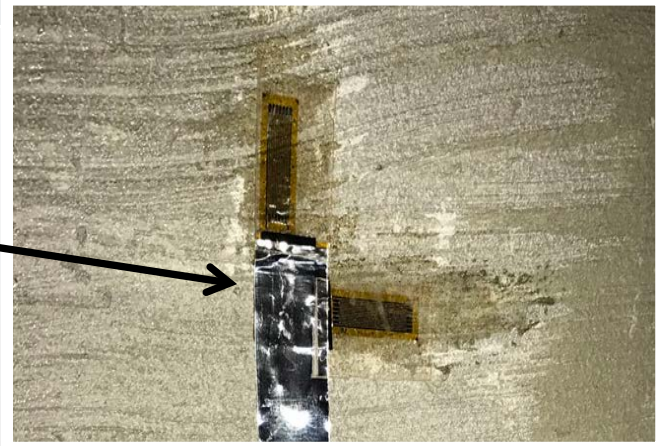
Follow-up Strain Gauge Testing

- Stress testing was conducted in November 2016 to assess the structural integrity, strength, and ductility of the rehabilitated pipe.
- Sensor manufacturer, Resensys LLC of College Park, MD, utilized a sensor system consisting of four high rate strain SenSpot sensors and one SeniMax data logger and remote communication gateway.
- Live load testing, with a semi-tractor pulling a flat-bed trailer weighing a total of 83,620 pounds, was used to confirm structural integrity and to ensure the bridge's capability to withstand its rated load.

Layout of Strain Gauge Sensors



Installed Strain Gauge

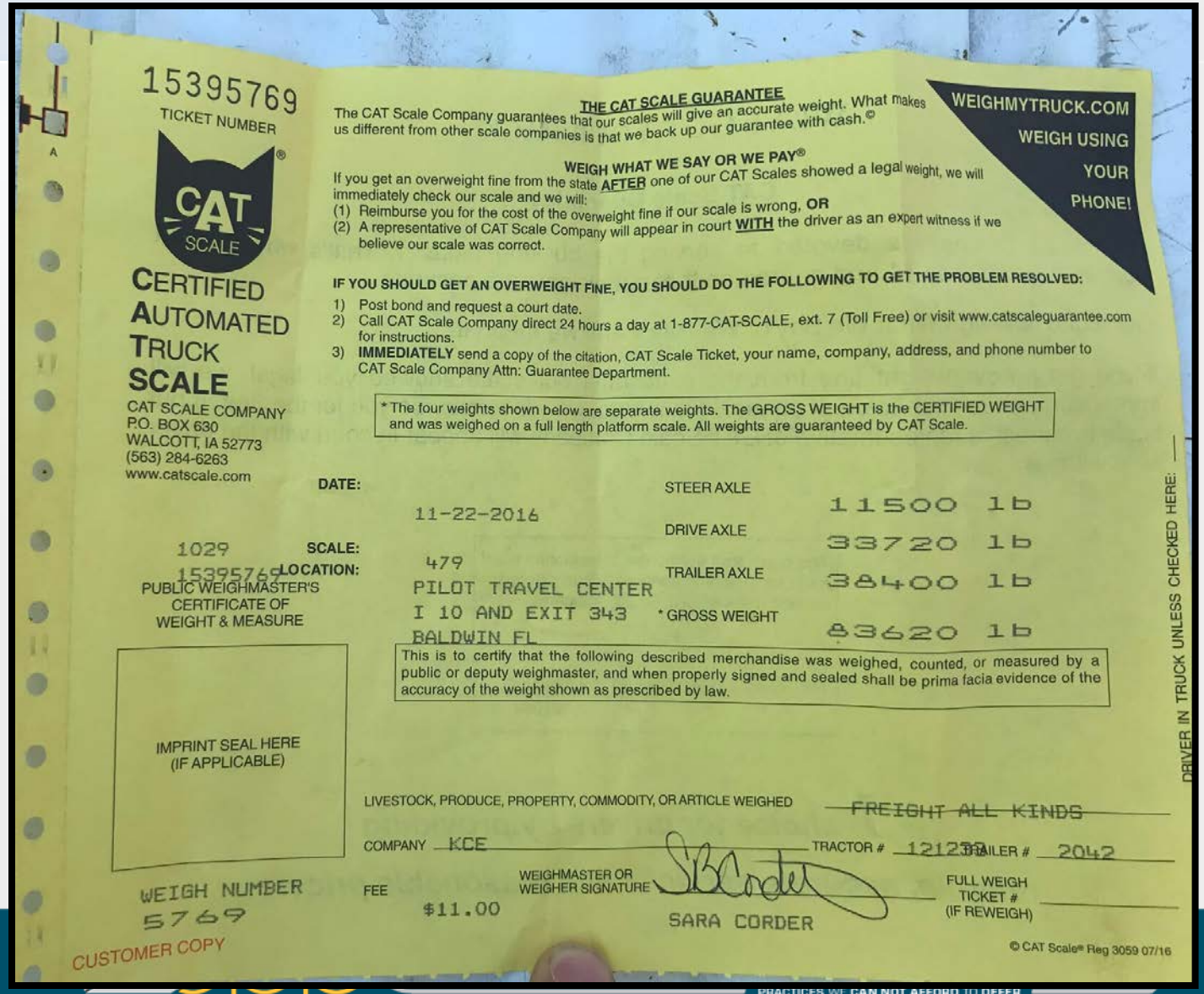


Strain gauge sensor:

- Foil strain gauge, SGD-30/120-LY40, (by Omega Engineering)
- Half bridge (two perpendicular gauges)
- Amplified by zero drift amplifier, gain=125
- Read by 14-bit ADC
- Resolution, 2microstrains

Remote Communication Gateway

Certification of Weight



15395769
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If you get an overweight fine from the state **AFTER** one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

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(2) A representative of CAT Scale Company will appear in court **WITH** the driver as an expert witness if we believe our scale was correct.

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1) Post bond and request a court date.
2) Call CAT Scale Company direct 24 hours a day at 1-877-CAT-SCALE, ext. 7 (Toll Free) or visit www.catscaleguarantee.com for instructions.
3) **IMMEDIATELY** send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale Company Attn: Guarantee Department.

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale. All weights are guaranteed by CAT Scale.

DATE: 11-22-2016

SCALE: 1029

LOCATION: 479
PILOT TRAVEL CENTER
I 10 AND EXIT 343
BALDWIN FL

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

STEER AXLE	11500 lb
DRIVE AXLE	33720 lb
TRAILER AXLE	38400 lb
* GROSS WEIGHT	83620 lb

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

IMPRINT SEAL HERE (IF APPLICABLE)

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED ~~FREIGHT ALL KINDS~~

COMPANY KCE

TRACTOR # 121239 TRAILER # 2042

WEIGH NUMBER 5769

FEE $11.00

WEIGHMASTER OR WEIGHER SIGNATURE SBCorder
SARA CORDER

FULL WEIGH TICKET # (IF REWEIGH)

CUSTOMER COPY

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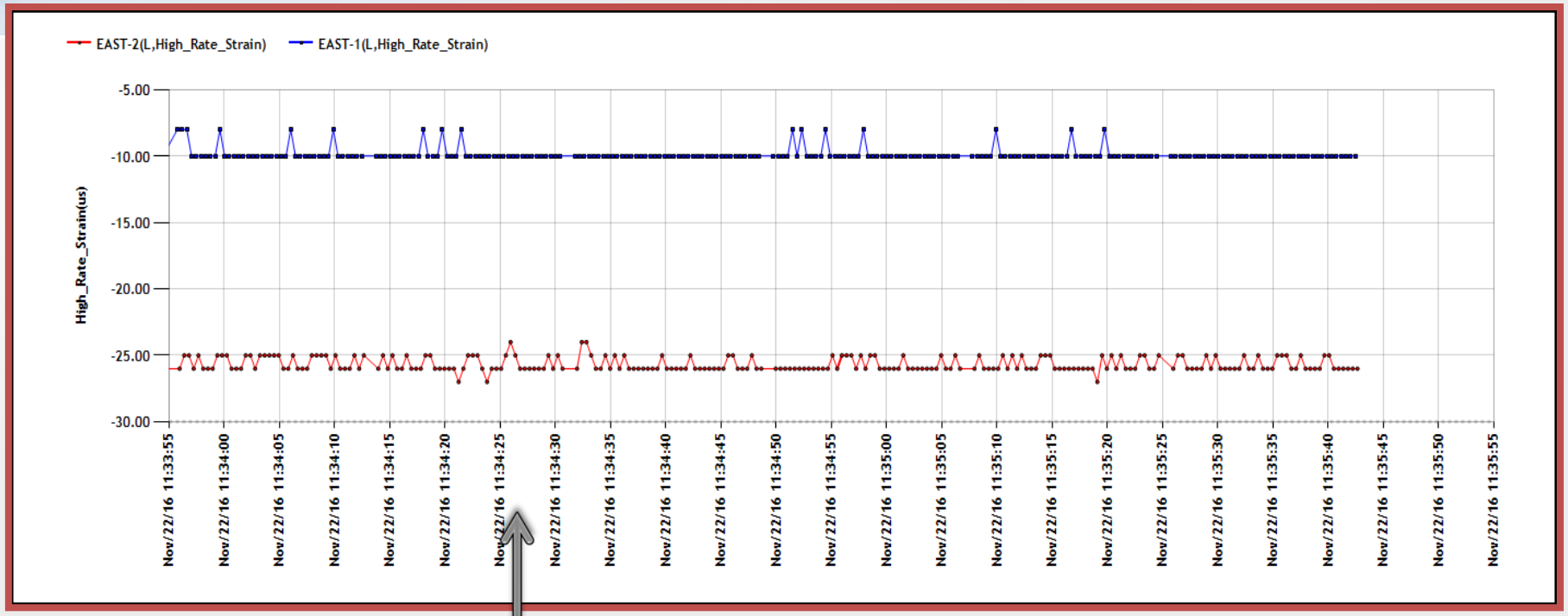
DRIVER IN TRUCK UNLESS CHECKED HERE: ___


PENSKE

Truck Tests

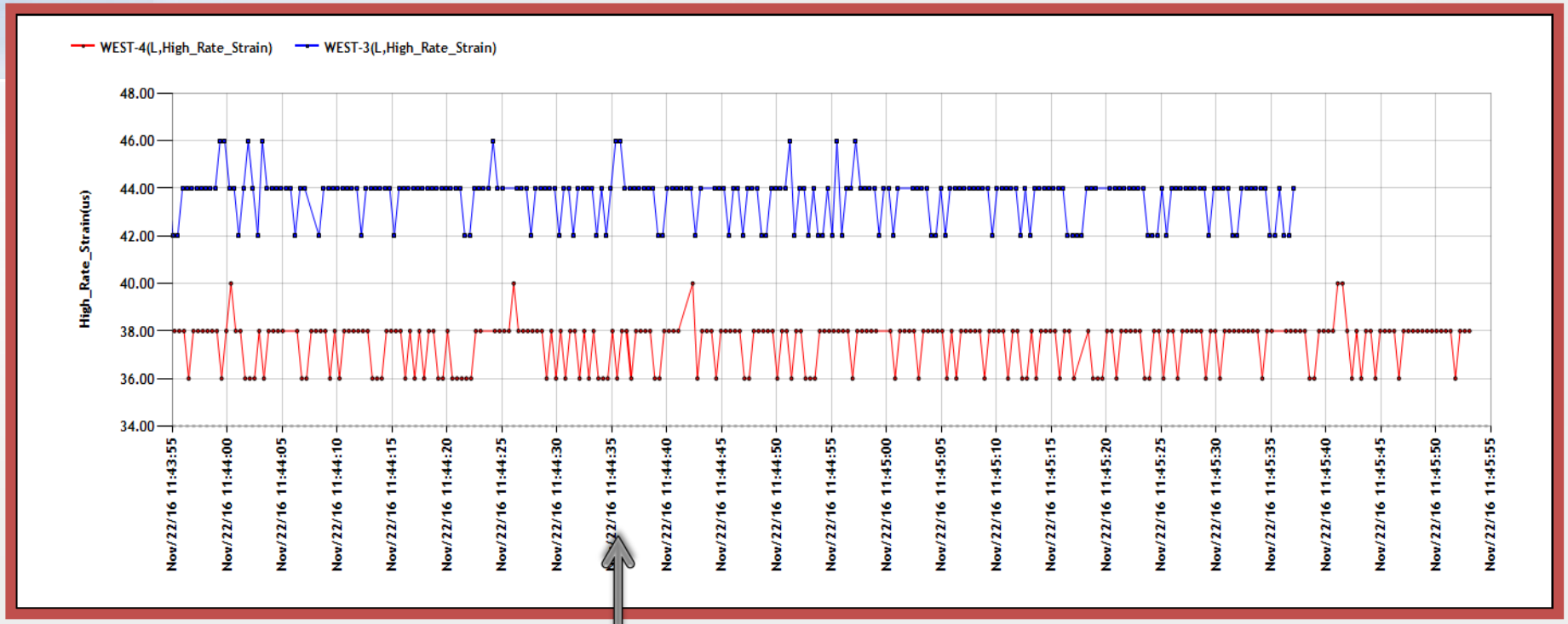
- **Test 1:** truck moving East Bound, 3MPH, at 11:34:26 am
- **Test 2:** truck moving West Bound, 3MPH, at 11:44:35 am
- **Test 3:** truck heading East Bound, front axle located directly on top of the culvert at 11:52:15 am, held for 45 seconds
- **Test 3:** truck heading East Bound, front axle located directly on top of the culvert at 12:09:15 pm, held for 45 seconds

Test 1, East Bound, 3MPH



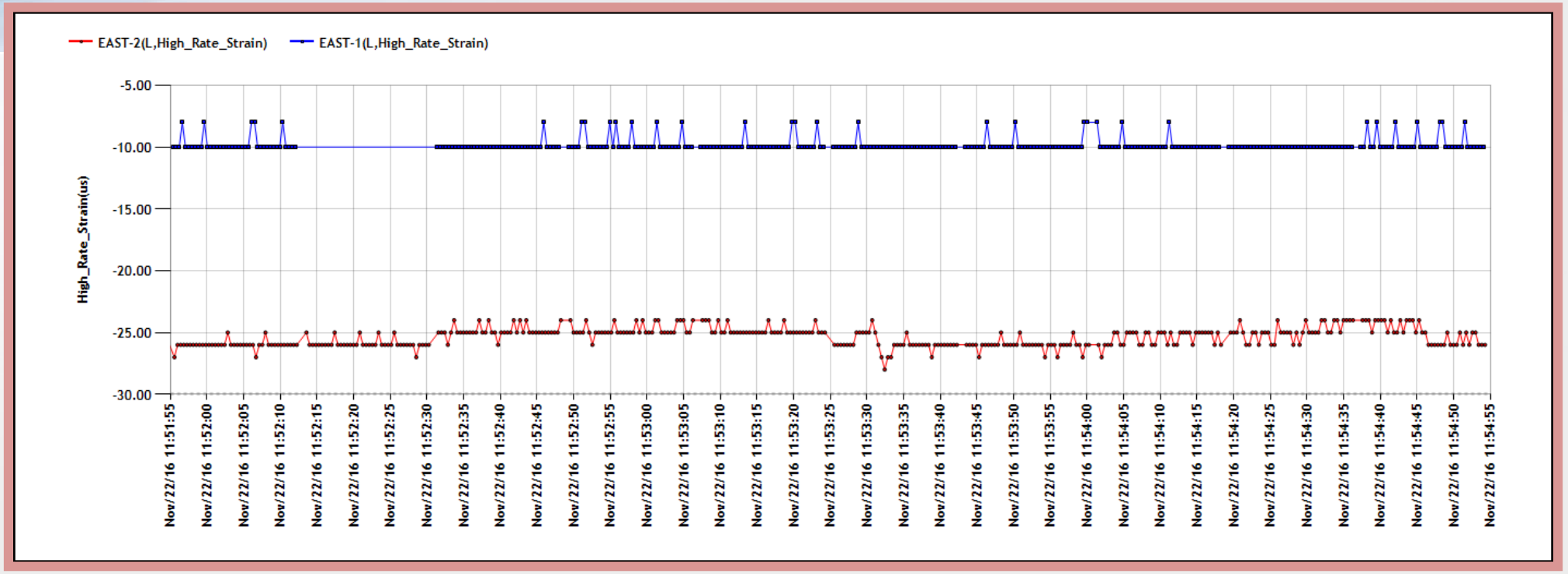
Crossing time: 11:34:26am, strain increase is negligible

Test 2, West Bound, 3MPH



Crossing time: 11:44:35am, strain increase is negligible

Test 3, East Bound, stop on top



Front axles on top of culvert
Strain change is negligible

Rear axles on top of culvert
Strain change, negligible

In Summary…

1. Select FACC lining systems that can deliver the performance required by the design of the proposed liner. **Proven Experience!**
2. Confirm the existing pipe structure is in static equilibrium; and its current geometry, include appropriate repairs to correct voids.
3. Determine the dead and live loads likely to come onto the soil-structure Interaction System.
4. Determine the load response mode via the arch rise parameter, for the SSI system
5. 3rd party performance evaluations prove engineering methods material performance.
6. Strain testing registered well below the engineered capabilities of the liner.

Thank You!

Scott Kelly
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