

2013 WESTERN BRIDGE ENGINEERS' SEMINAR

Innovative Methods for Inspection of Cable-Stayed Highway Bridges, Old and New

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Introduction

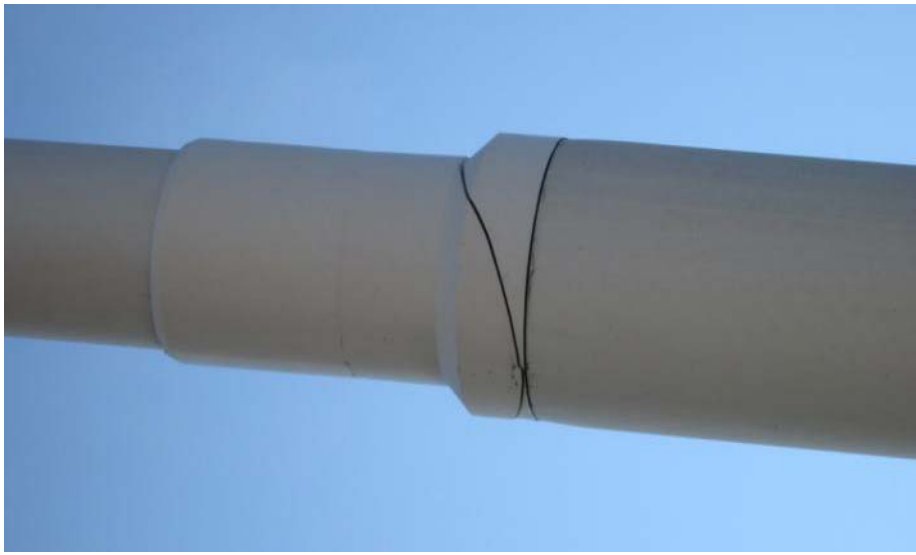
- Evaluation of Cables
  - Primary Tension Members
  - Non Redundant
  - Fracture Critical

Stay Cable Array Evaluation

- Global Integrity and Vulnerability
  - Preliminary Inspection
  - Force and Damping Measurement
  - Geometry Measurements
- Local In-Depth Damage Detection
  - Hands-on Detailed Inspection
  - NDE Testing
  - Dissection and Sampling
- Instrumentation and Health Monitoring

Preliminary Inspection

- Overall visual inspection
  - Anchorages
  - Limited Cable Free Length
  - Other potential Problem Areas
- Limited special access
- IDENTIFY PROBLEM AREAS

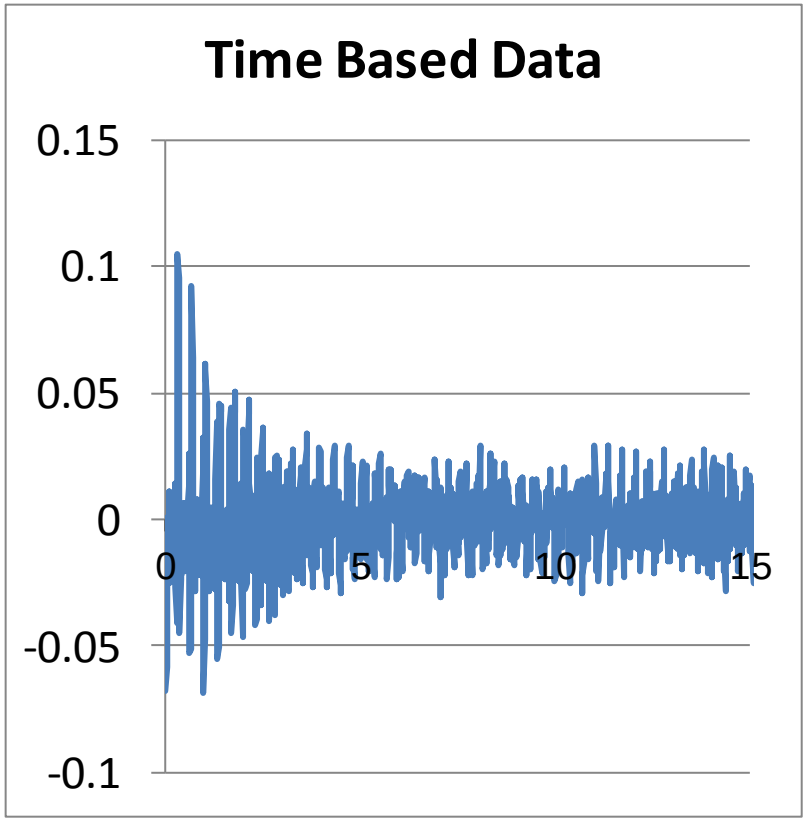


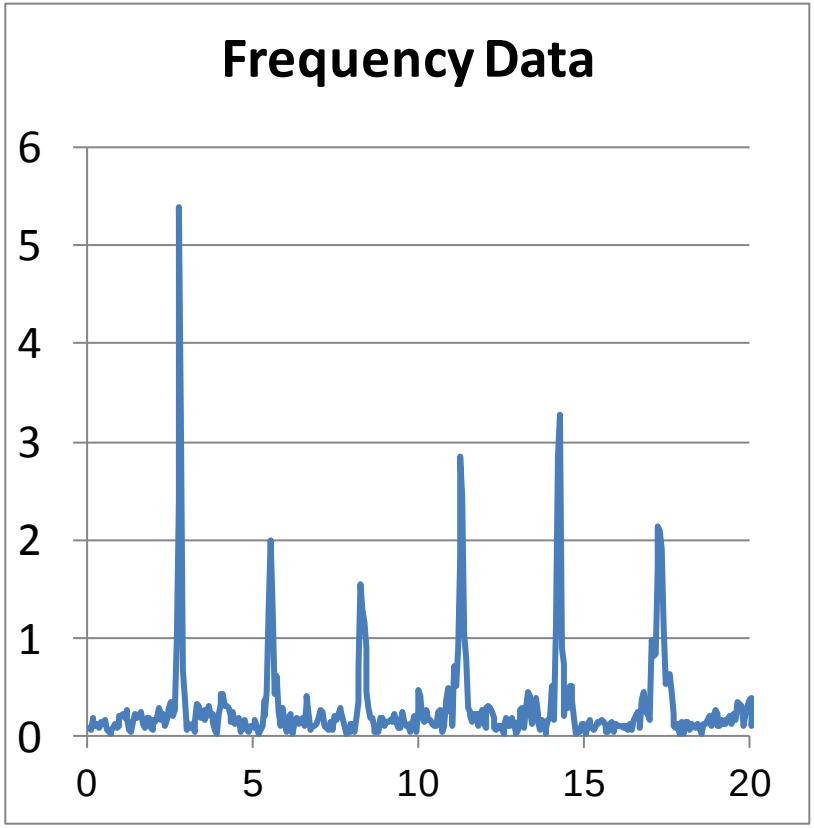
Preliminary Inspection

Force and Damping Measurements

- Background
  - Measure Transverse Vibrations
    - Accelerometer
    - Laser Vibrometer
  - Calculate Force/Damping
  - Compare to previous measurement / theoretical data

Transverse Vibration Measurements





Force Estimation – Stay Cables

- Sag-Extensibility Parameter

$$\lambda^2 = \frac{\left(\frac{mgL}{H}\right)^2 LEA}{HL_e}$$

Parameter

$$\xi = L\sqrt{\frac{H}{EI}}$$

- Parametric Study

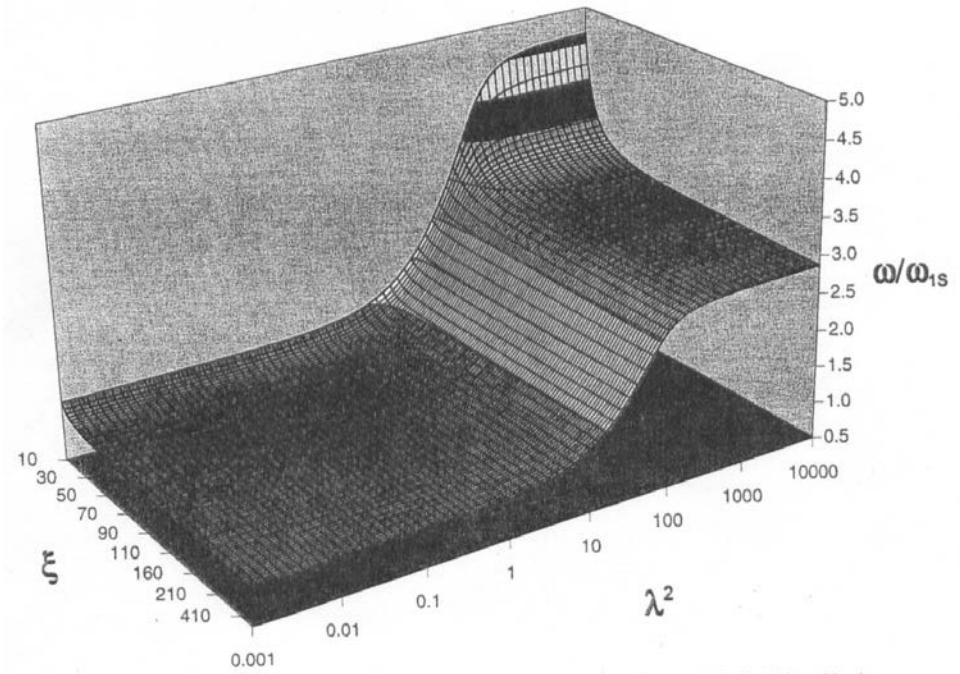
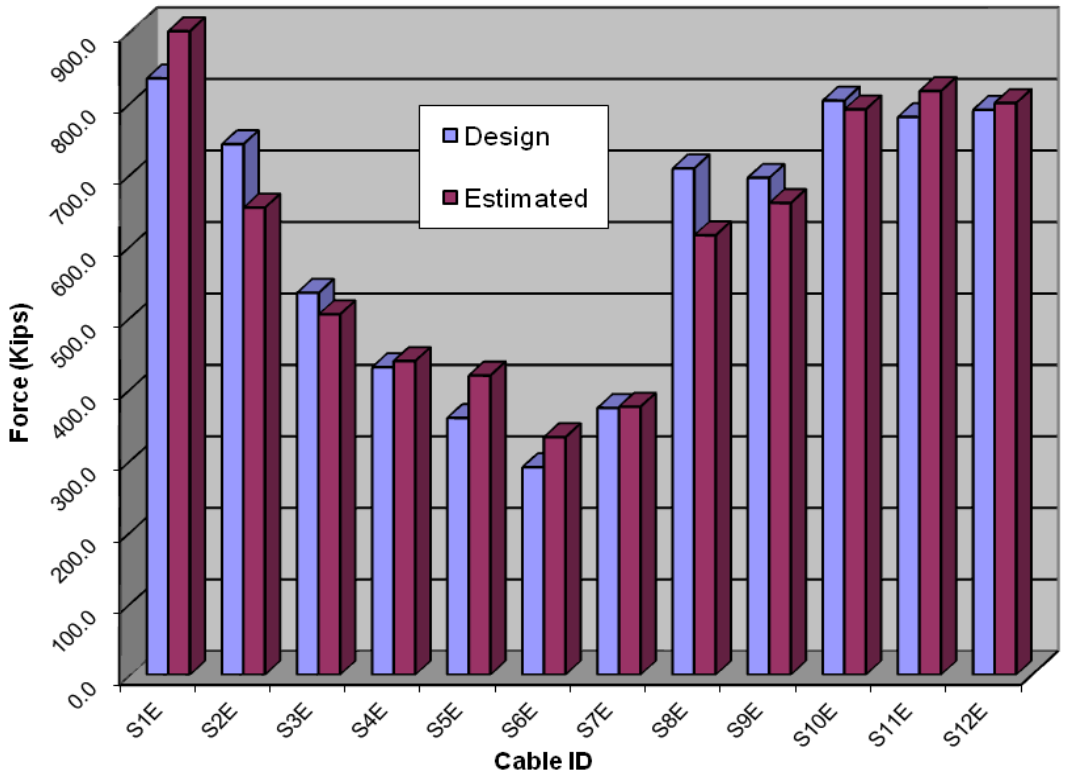


FIG. 5. Interaction Surface for Frequency Ratio of First Symmetric In-Plane Mode

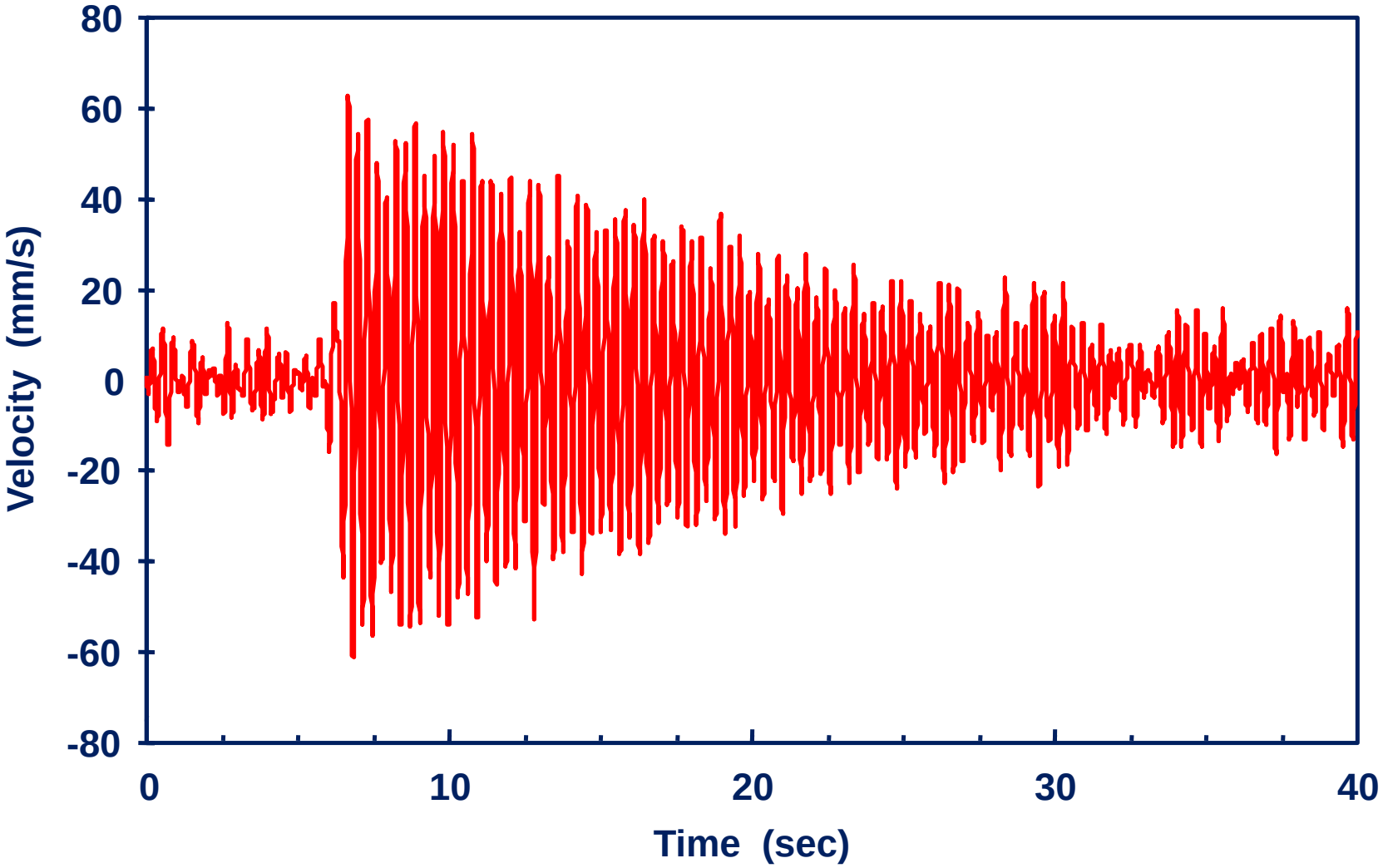
Comparison of Measured Forces

Comparison Forces

- Original Design Forces
- Forces from Analytical Model
- Historical or Baseline Data

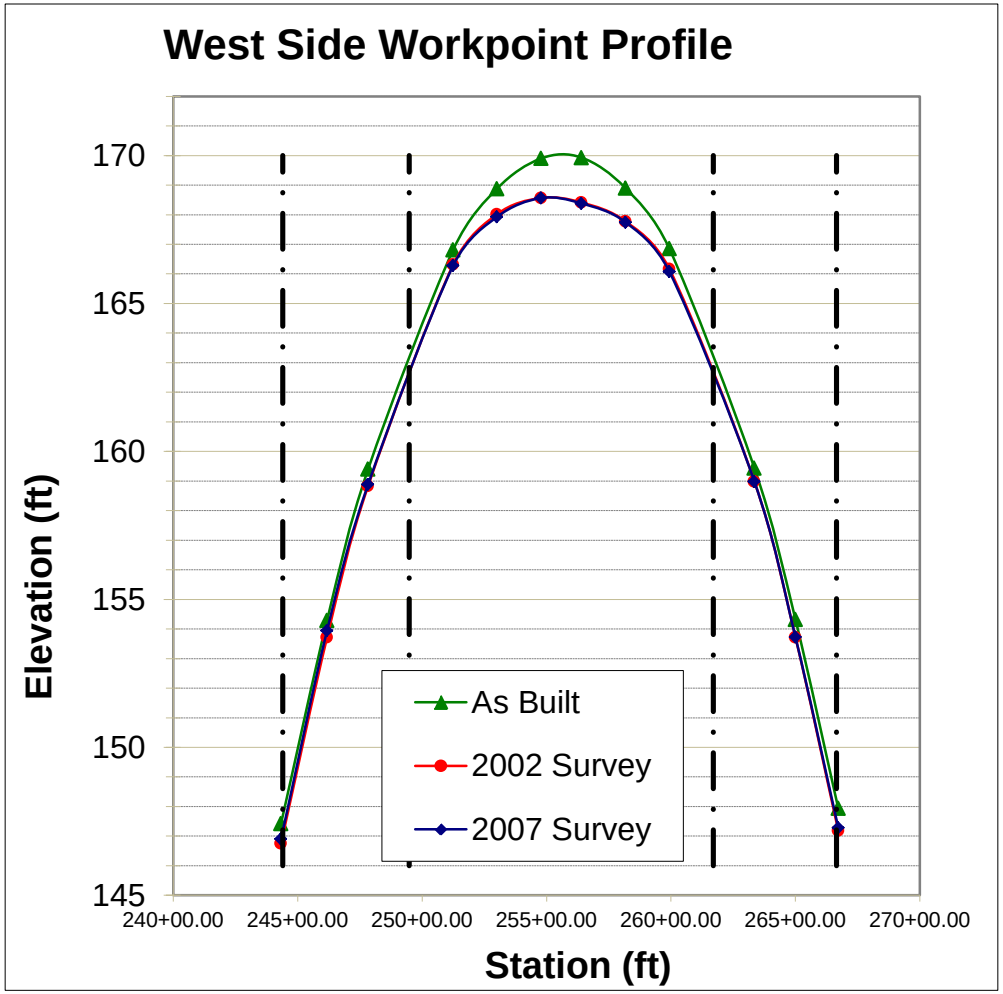


Damping Measurements



Geometry Measurements

- Survey Data
  - Profile Survey
  - Compare to baseline or as-built data
  - Account for
    - Thermal
    - Prestress Losses
    - Creep



In-Depth Damage Detection

- Locations
  - Anchorages
  - Cable Exit Points
  - Cable Free Length
  - Corrosion Protection Systems
  - Cable Appurtenances
- Methods
  - Hands on Detailed Inspection
  - NDT Methods
  - Minimally Intrusive Methods
  - Material Sampling and Testing
  - Specialized Access/Equipment

Cable Anchorages

Cable Anchorages

- Visual
  - Grease / Grout Fill
  - Excessive leakage

Cable Anchorages

- Visual
  - Water Leakage, Internal and External

Cable Anchorages

- Visual
  - Corrosion within Anchorage sockets or beneath Caps

Cable Anchorages

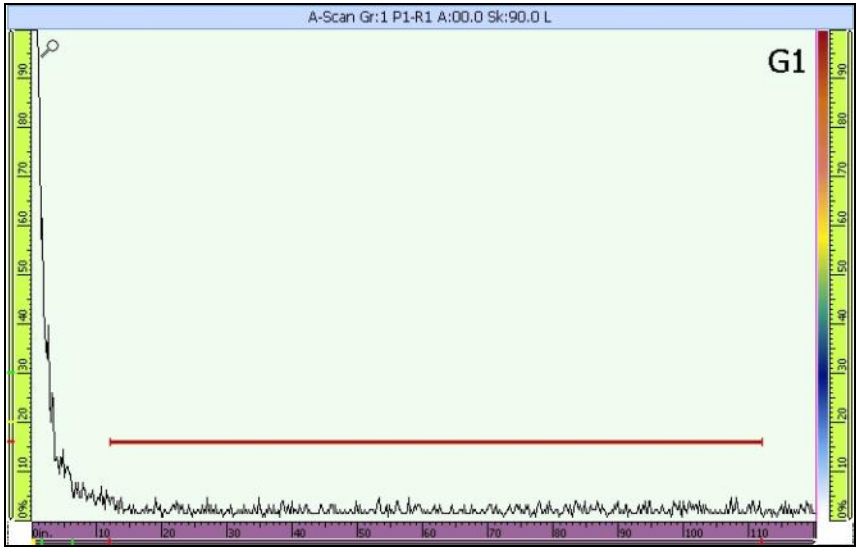
- Visual
  - Corrosion within Anchorage sockets or beneath Caps

Cable Anchorages

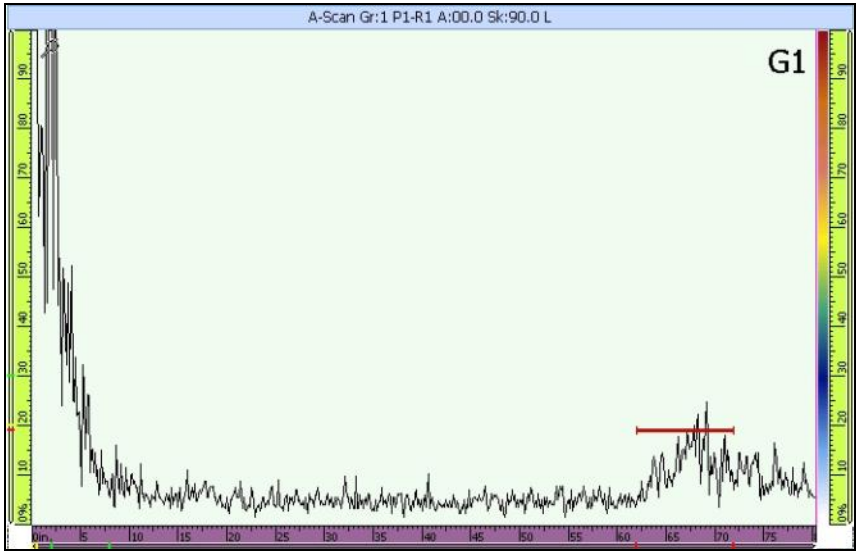
- NDT
  - Ultrasonic Pulse-Echo (UTPE)
    - Strand damage in Anchorage Zone

UTPE Typical Results

Field

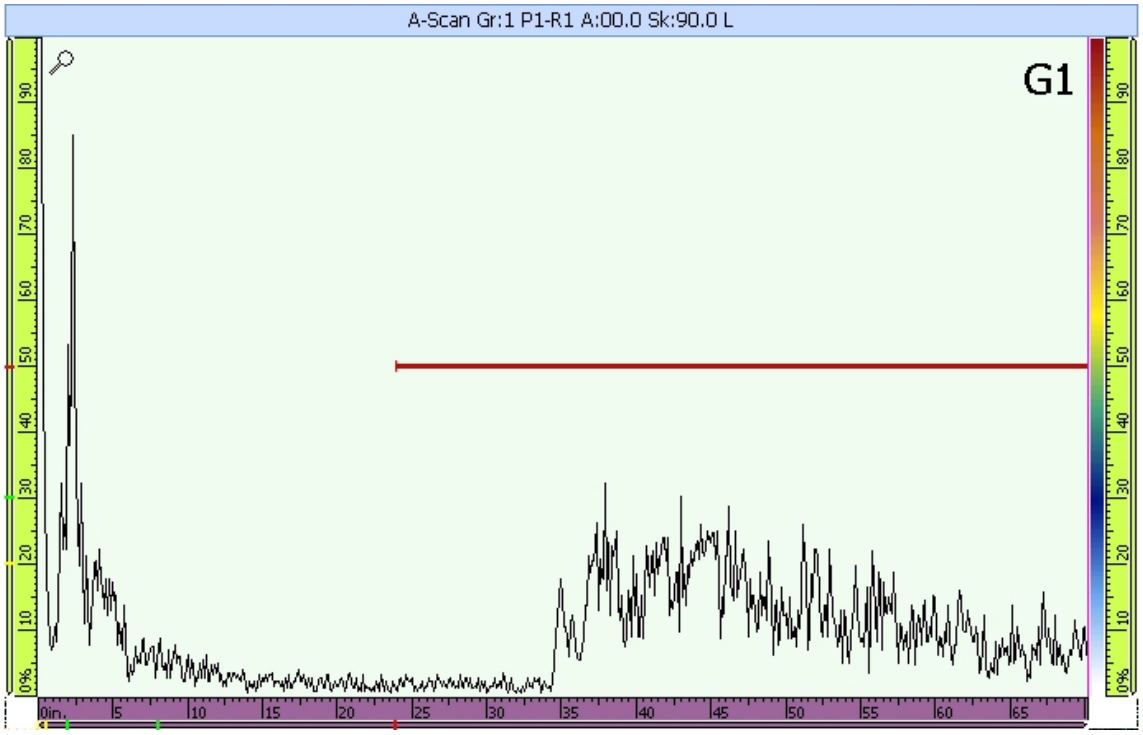


Calibration



UTPE Fractures

Calibration Strand with Fracture at 37-in



Cable Exit Points

Cable Exit Points

- Visual
  - Damaged Guide Pipes
  - Missing Clamps

Cable Exit Points

- Visual
  - Damaged Boots
  - Misaligned cables

Cable Exit Points

- Visual
  - Damage to Neoprene rings
  - Damage to cable sheathing
  - Vibration damage

Cable Free Length

- Visual
- NDT
- Material Sampling and Testing

Cable Free Length

- Visual
  - Damage to UV Protection Layer
  - Damage to Helical Spiral
  - Damage to HDPE

Cable Free Length

- Visual
  - Cracks / Splits in Sheathing Pipes

Cable Free Length

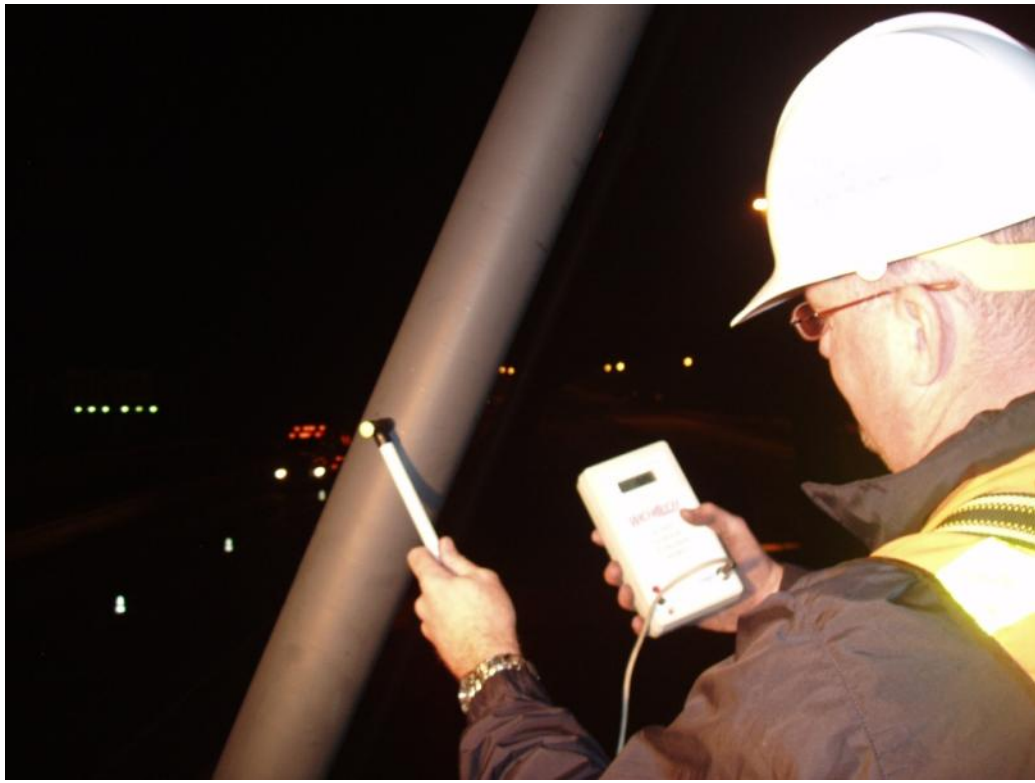
- Visual
  - Exposed Grout

Cable Free Length

- Visual
  - MTE Exposed / Corroded

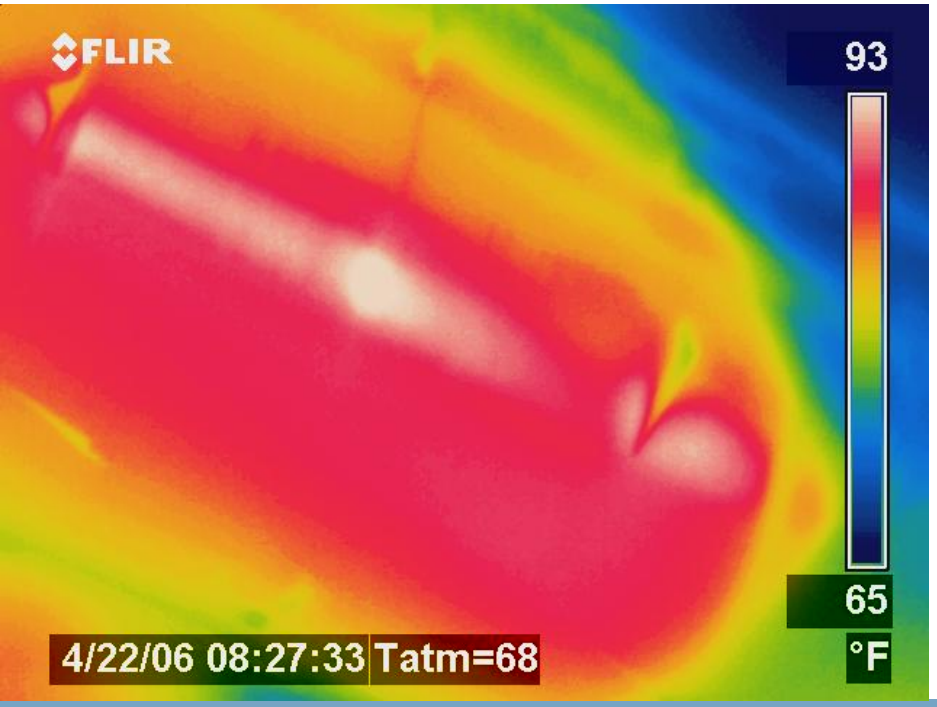
Cable Free Length

- NDT
  - Sounding / Tap Testing
    - Sheathing Damage
    - Grout Voids



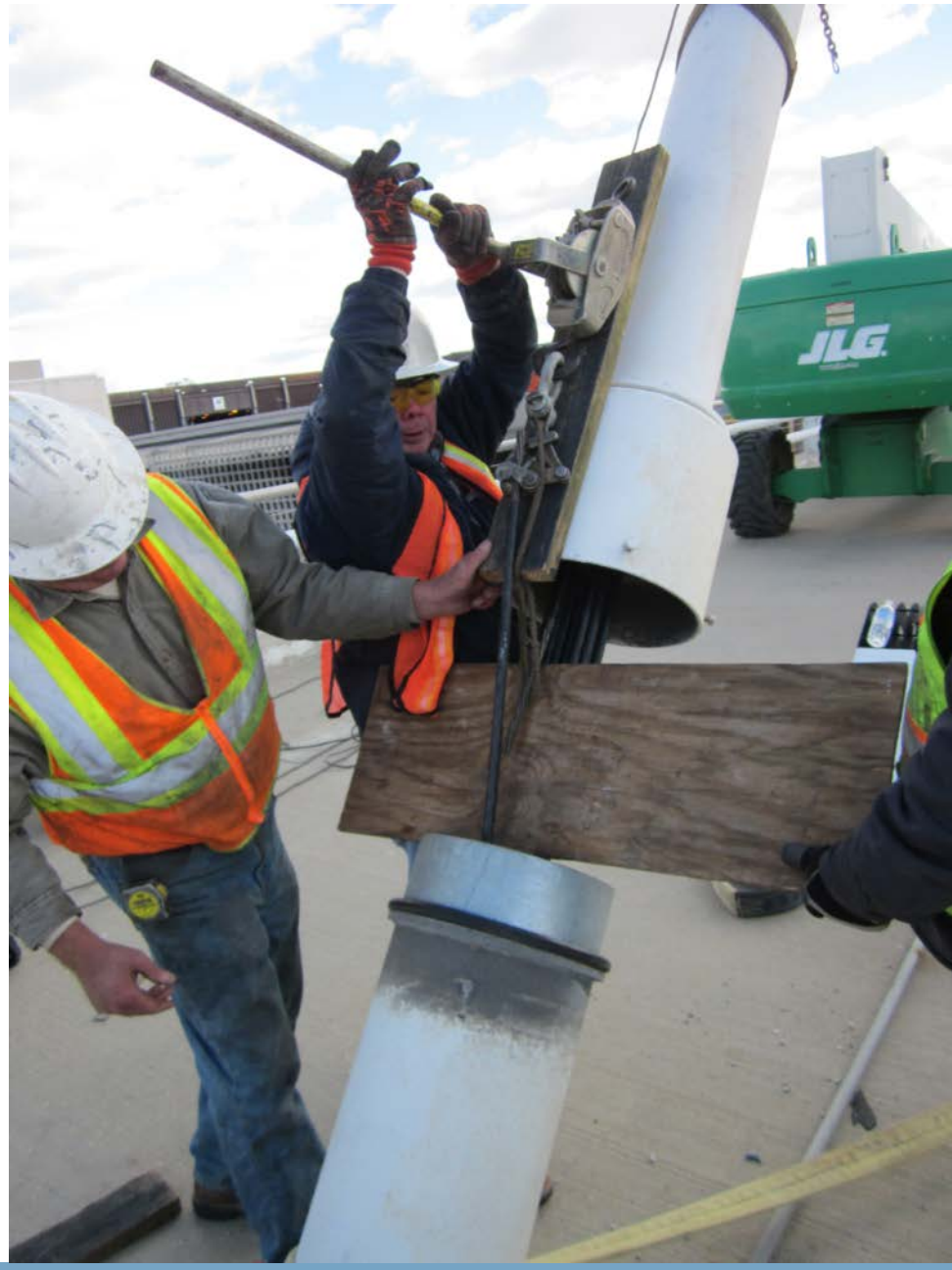
Cable Free Length

- NDT
  - Infrared Thermography



Cable Free Length

- Material Sampling and Testing
  - Reference Strands

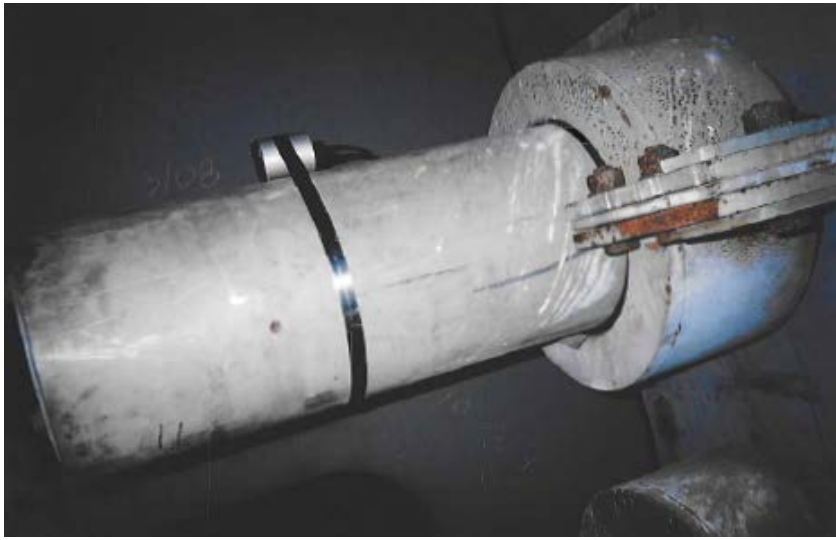


Cable Free Length

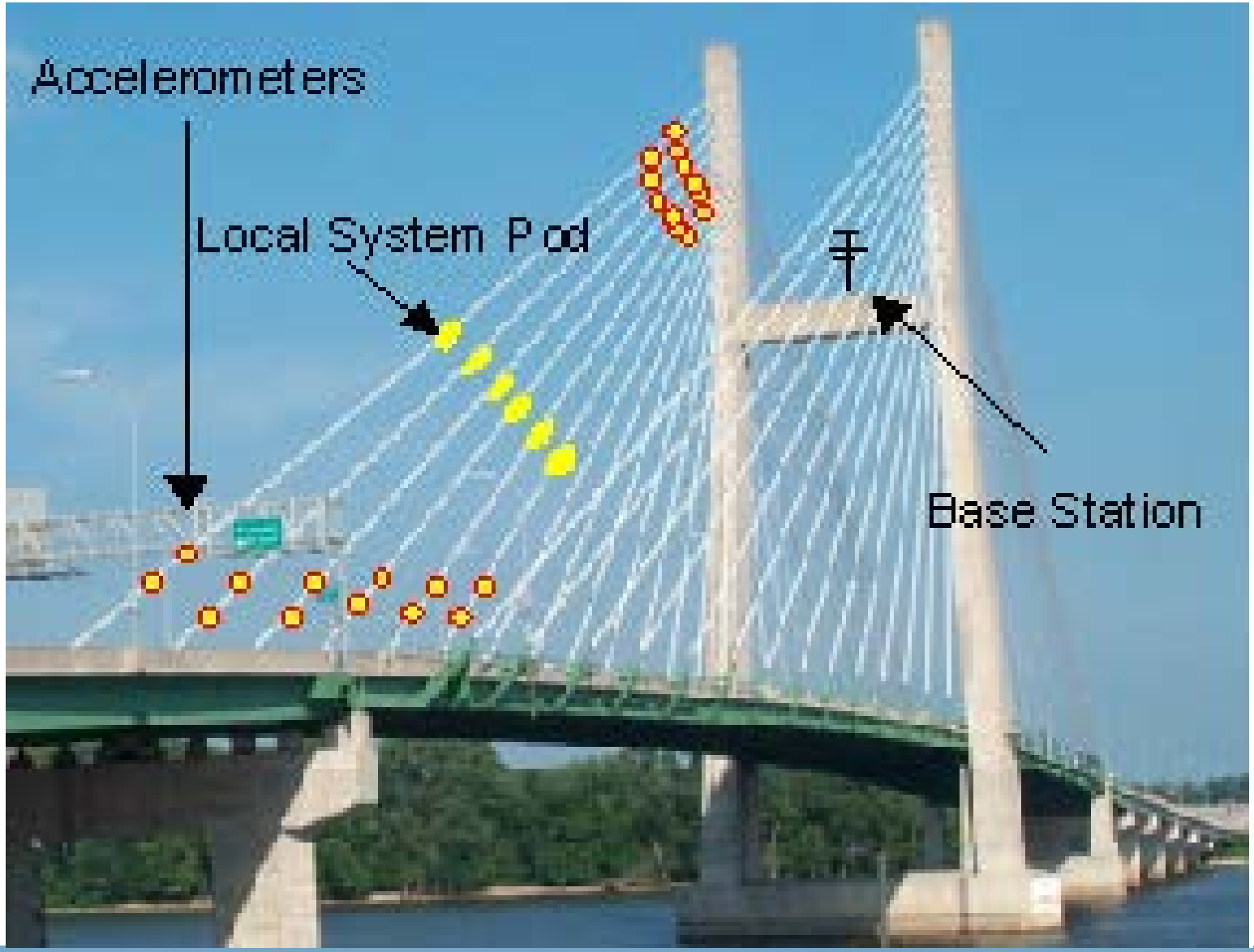
- Material Sampling and Testing
  - Grout windows

Health Monitoring

- Wire Break Detection
  - Permanent acoustic sensor
  - Real time detection of wire breaks
  - Web interface



Instrumentation and Health Monitoring



Thank You!