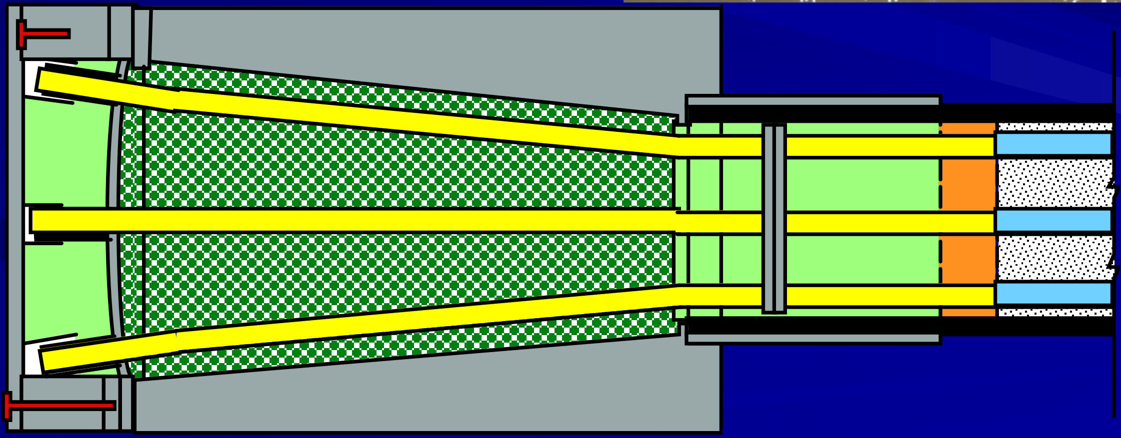
Luling Bridge Stay Cable Replacement

Armin Mehrabi
Bridge Engineering Solutions

LTRC Seminar Series, Bridge Structures
February 20-21, 2008, New Orleans, LA


05 . 25 . 2006

Stay Cables



Lower Anchorage

Upper Anchorage

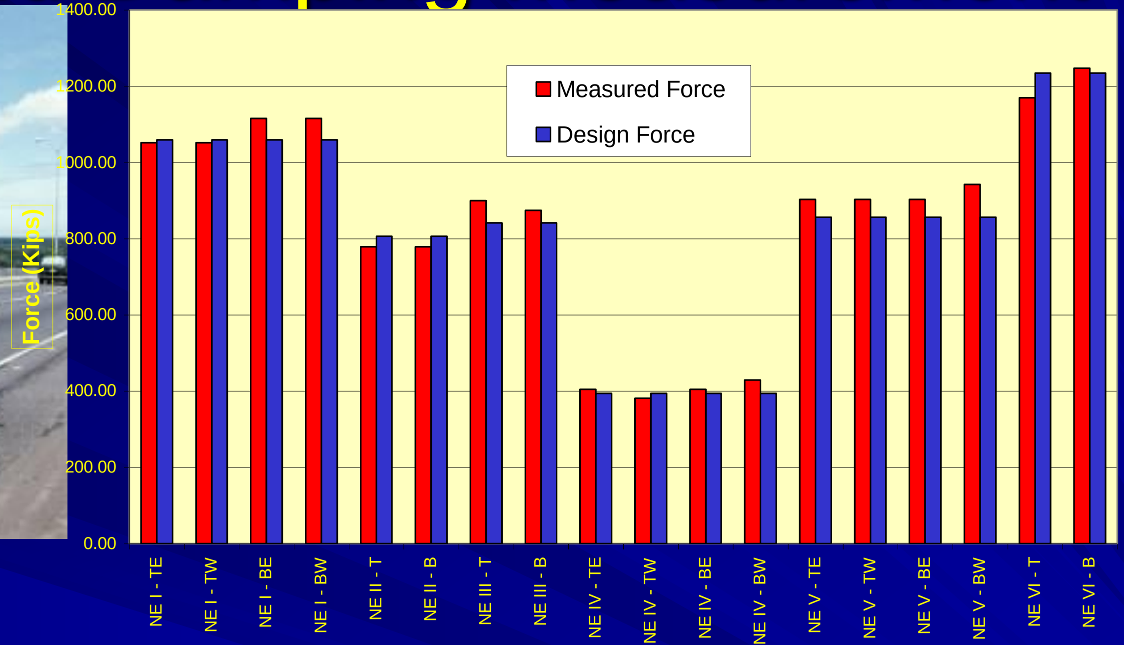
Statement of Problem

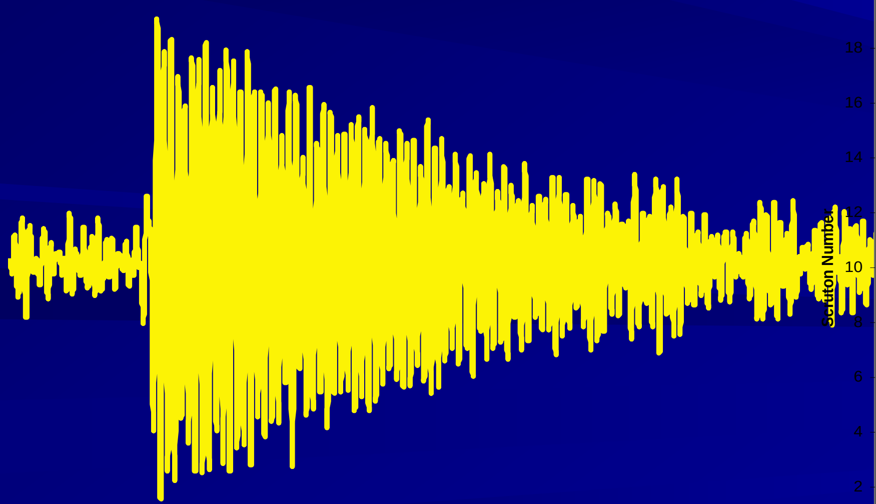
- Rusting and water leakage in anchorage zones
- Cracking/splitting of cable cover pipes
- Signs of compromise in cables safety
- In 2002, LADOTD initiated a project for Structural Evaluation of the Stay Cables

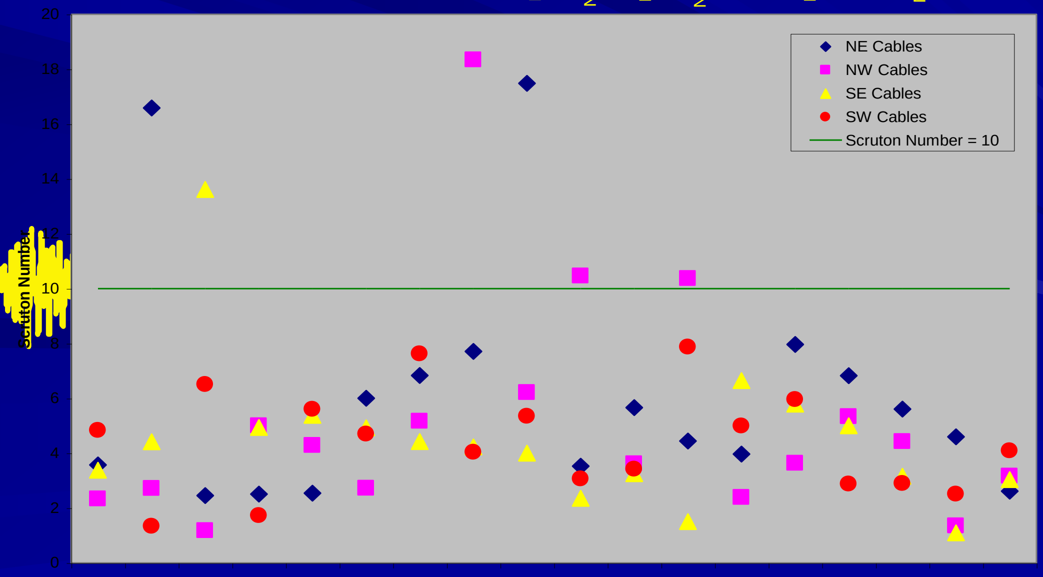
Three Phases of Investigation

- Phase I: Assessing extent of problems and the overall integrity
- Phase II: Hands-on inspection of the suspect locations and critical elements
- Phase III: Detailed design of repairs, and monitoring

Phase I
Cable Force and Damping Measurement

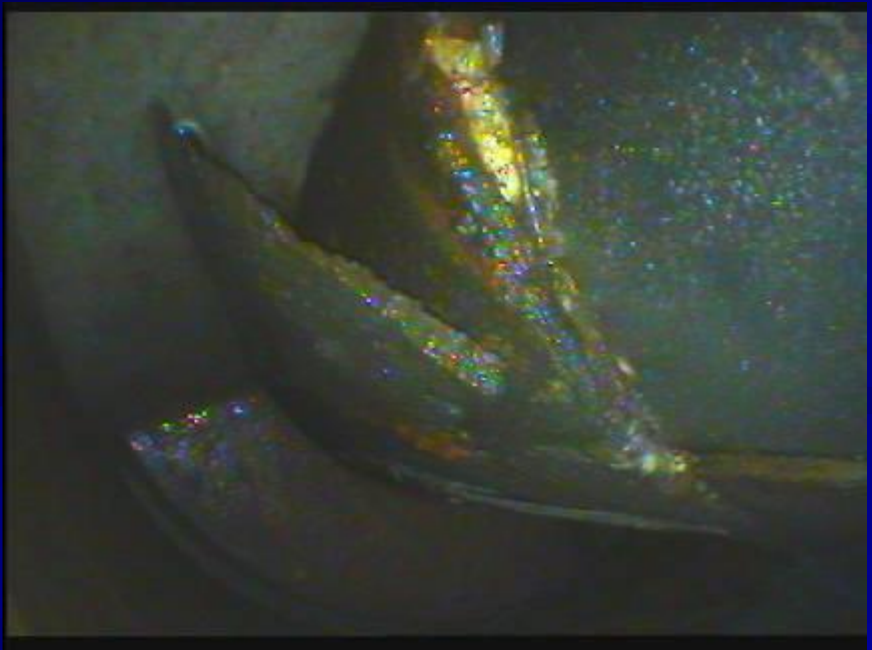




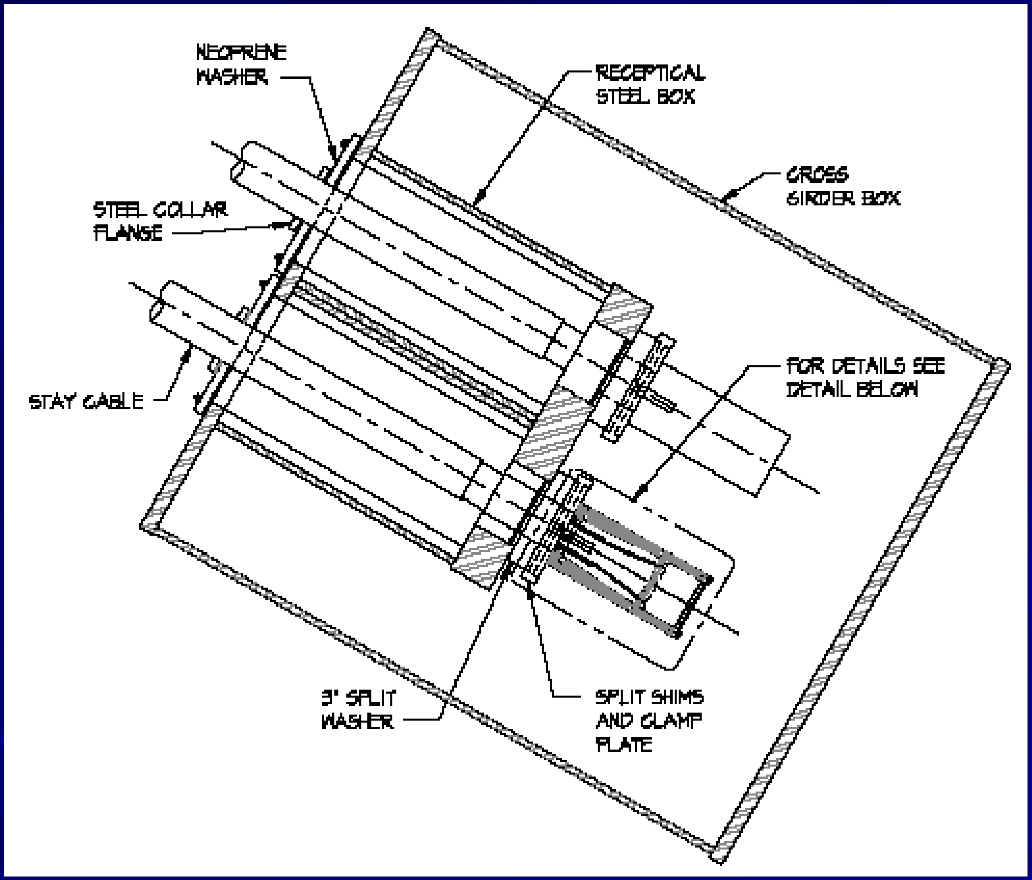


Phase II- Inspection

Inspection of Deck Anchorage Boxes



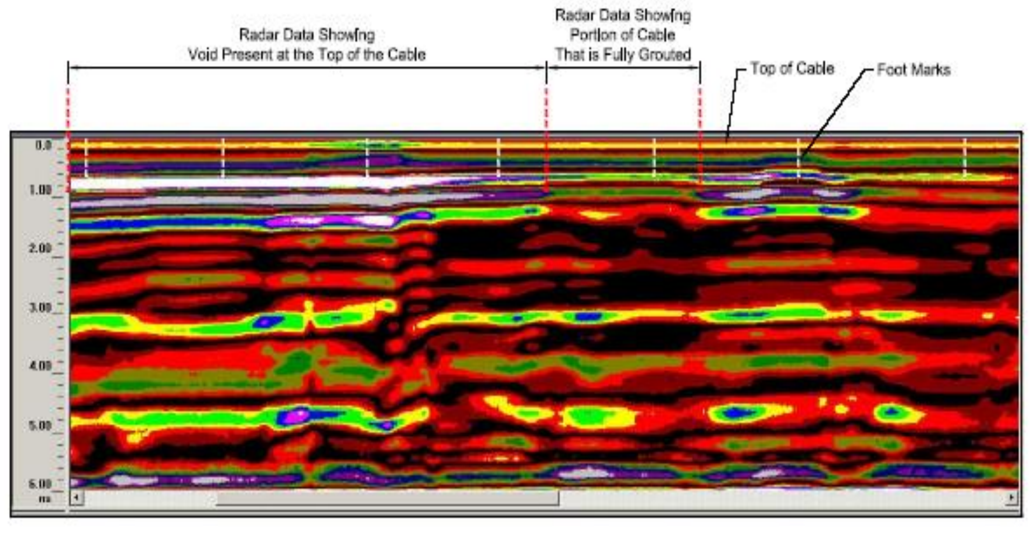
Source of Problem



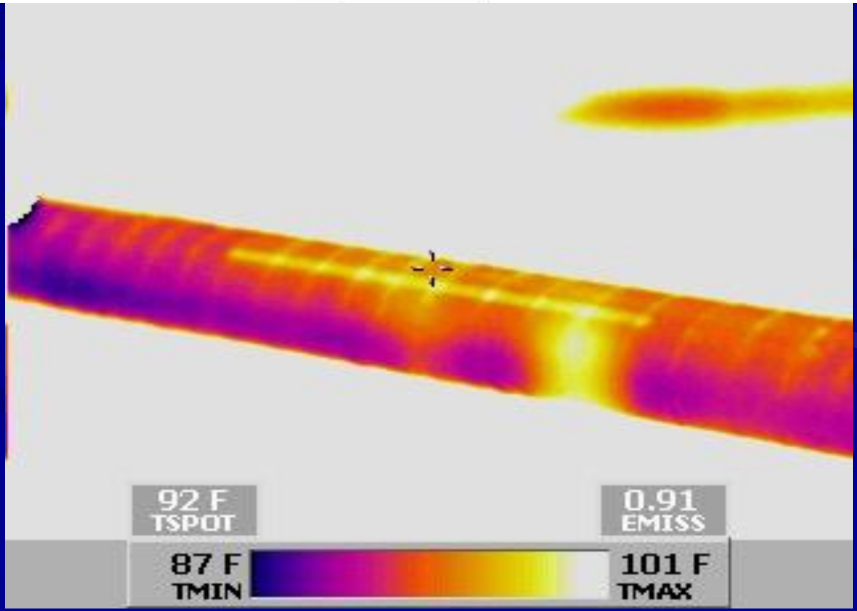
NDE Method for Free Length Inspection

Impulse Radar

Thermal Imaging



Sample Radar Scan



Cable Inspection Vehicle

Cable Free Length Inspection

Cable Free Length Inspection

Hands-on inspection and Tap Testing

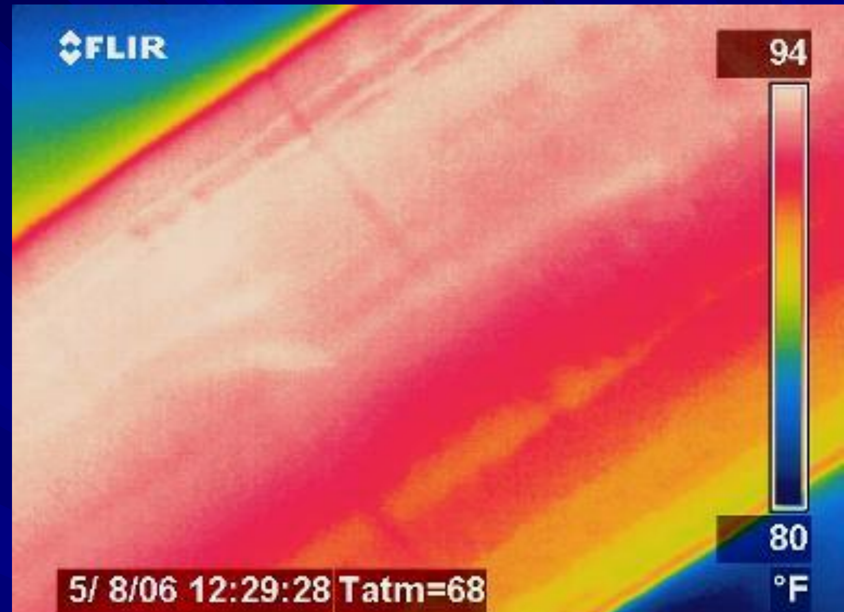
Cable Free Length Inspection

Thermography

Inspection findings
Damage Severity Levels

Severity Level	Status	Description
1	Satisfactory	Minor deterioration and anomalies noted
2	Poor	Deterioration of the protective elements and potential for degradation. Cables with this level of damages need to be routinely monitored and corrective action needs to be planned.
3	Critical	Deterioration or potential for deterioration of the main tension elements (steel wires) exists. Action (repair) is necessary. Cables with this level of damages shall be closely monitored until repairs are applied.

Severity Level 1, Epoxy and Weld Repair



Severity Level 2, Tape Damages, Wrinkle, Void, Moderate Rust


Severity Level 3, Exposed Grout and Steel Wires, Heavy Rust

Summary

- All cables have at least damage Level 2
- 39 out of 72 cables are rated critical
- Damage causes still present
- Increasing rate of deterioration is evident
- Damages need to be monitored closely
- Timely corrective action is needed
- Alarming similarity with Zarate-Brazo Largo

Decision Making
Life Cycle Cost Analysis

- Define planning horizon
- Define repair/replacement strategies
- Estimate costs
- Calculate present values for strategies
- Select preferred strategy

Repair/Replacement Strategies

- Base Case
- Repair all
- Repair-Replace 1
- Repair-Replace 2
- Replace all

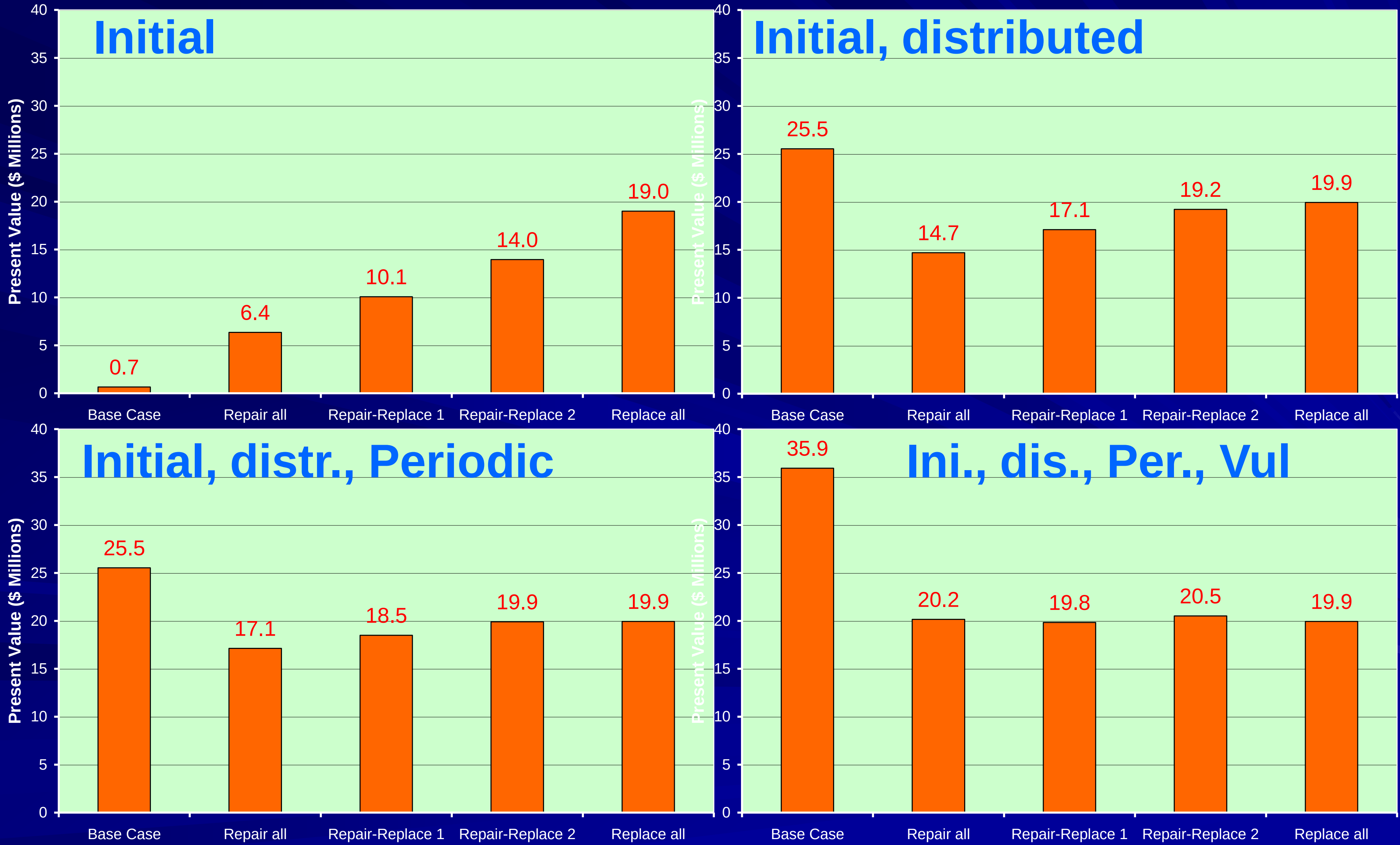
Cost Structure

- Initial Costs
  - Initial repair and replacement
  - Monitoring system
- Distributed Annual Costs
  - Inspection and force measurement
  - Maintenance of monitoring system
- Periodic Repair Costs
  - Re-repair old repairs and new repairs
- Vulnerability Costs (also distributed annually)
  - Replacement of fatigued cables
  - Storm related repairs

Cost Structure

- Agency Costs
  - External costs-contracts, estimated based on past experience and industry input
  - Internal costs ignored
- Users’ Costs
  - Delays due to lane closures
    - 3 minutes per vehicle per lane
    - 2/3 of vehicles affected
    - $7/hr for cars and 18/hr for trucks
  - Detours due to load limits and bridge closure
    - One hour detour time

Present Value Estimation
Agency and Users' Costs Comparison



Phase III

- Additional Inspection
  - Critical cables
  - Superstructure
- Monitoring System for potential wire breaks
- Cable Replacement Design

Cable Replacement Design

Cable Replacement Design

Objectives:

- Develop a cost effective cable replacement design that requires minimal engineering by contractors.
- Minimize impact to traffic and Maintenance of Traffic (MOT).
- Analyze for live load, wind force, and construction load effects.

Scope

- Assess current conditions
- Replacement cable design
- Temporary cable design
- Construction sequence & Structural analysis
- Design for peripherals
- Maintenance of traffic design
- Cost Estimate and Plan Preparation

Assess current conditions

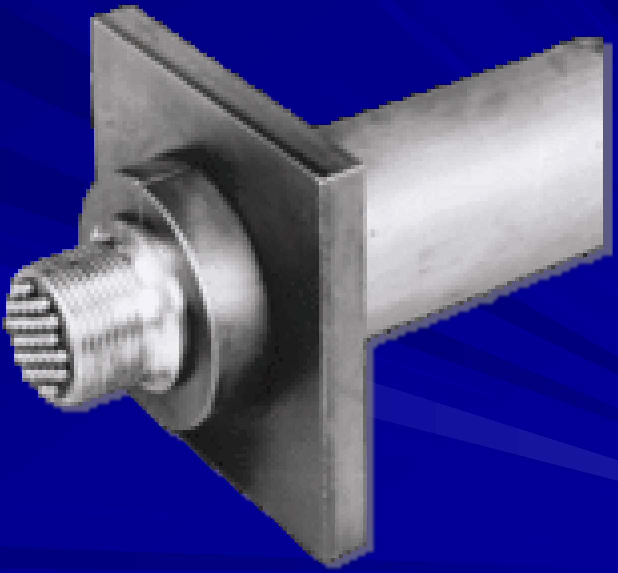
- Existing Cable Forces
- Geometry Survey

Replacement Cable Design

- Available cable systems

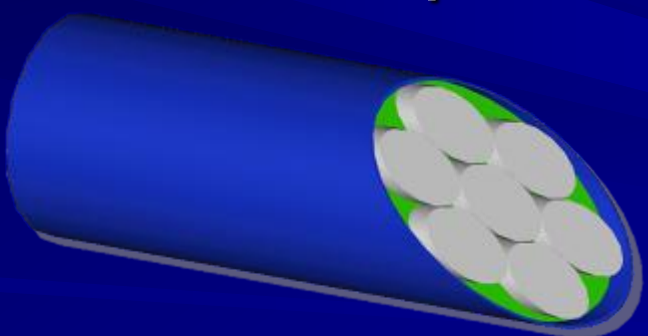
Parallel strand system

Parallel wire system



Replacement cable design

- Parallel strand, preferred system
- Availability, 3 US manufacturers
- Used in most new bridge constructions
- Ease of inspection and replacement
- Corrosion protection system



- No failures documented in bridges using this system

Replacement cable design

Parallel strand, preferred system

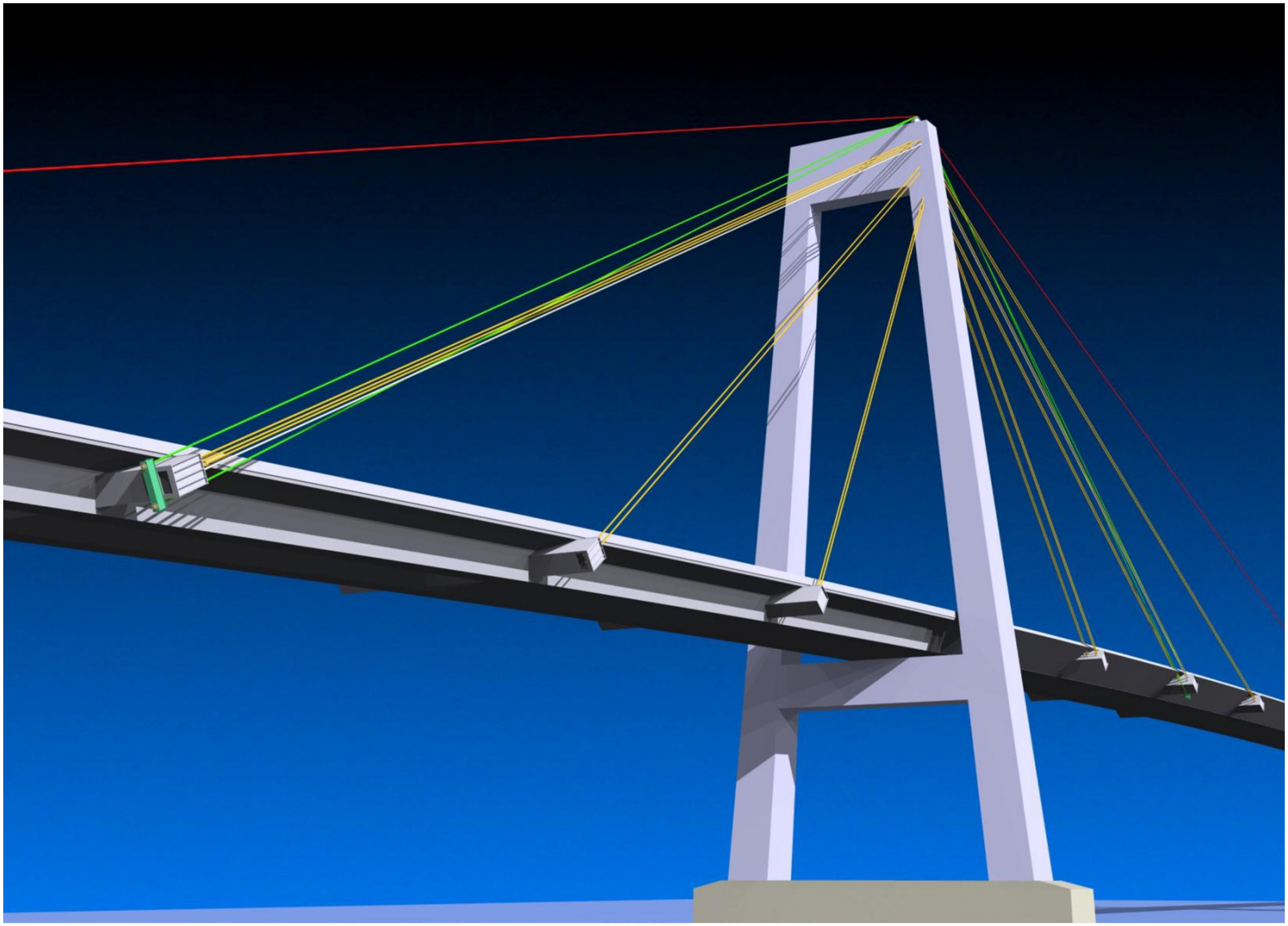
- Larger anchorages may require modifications to structure
- Larger cables increase wind load
- Effects vary with available systems
- Installation method
- Qualification testing
- Equivalent stiffness (27,55,61,75 strand)

Temporary cable design

Need for Temporary cables

- Uncertainty in cable condition
- Large cable group spacing
- Need to maintain traffic w/o load limits

Temporary cable design



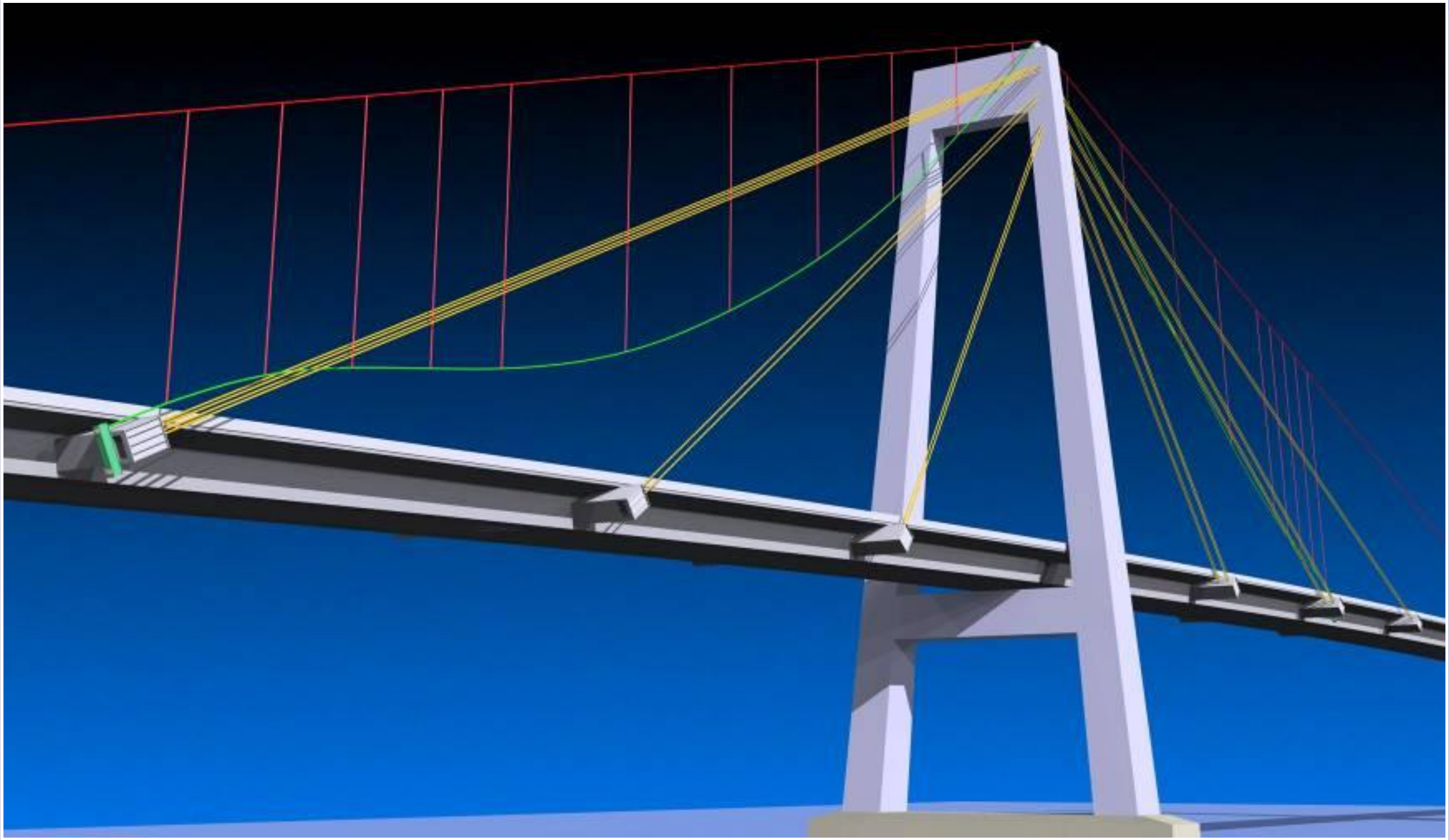
Construction Sequence

Highlights:

- Use of “Highline” or “Cableway” as a means of supporting and lifting cables
- Limiting operation to one side of bridge
- Need for minimal space on deck for construction
- Most of operation at deck level
  - Use of saddle as top support
  - Lower ends as live ends

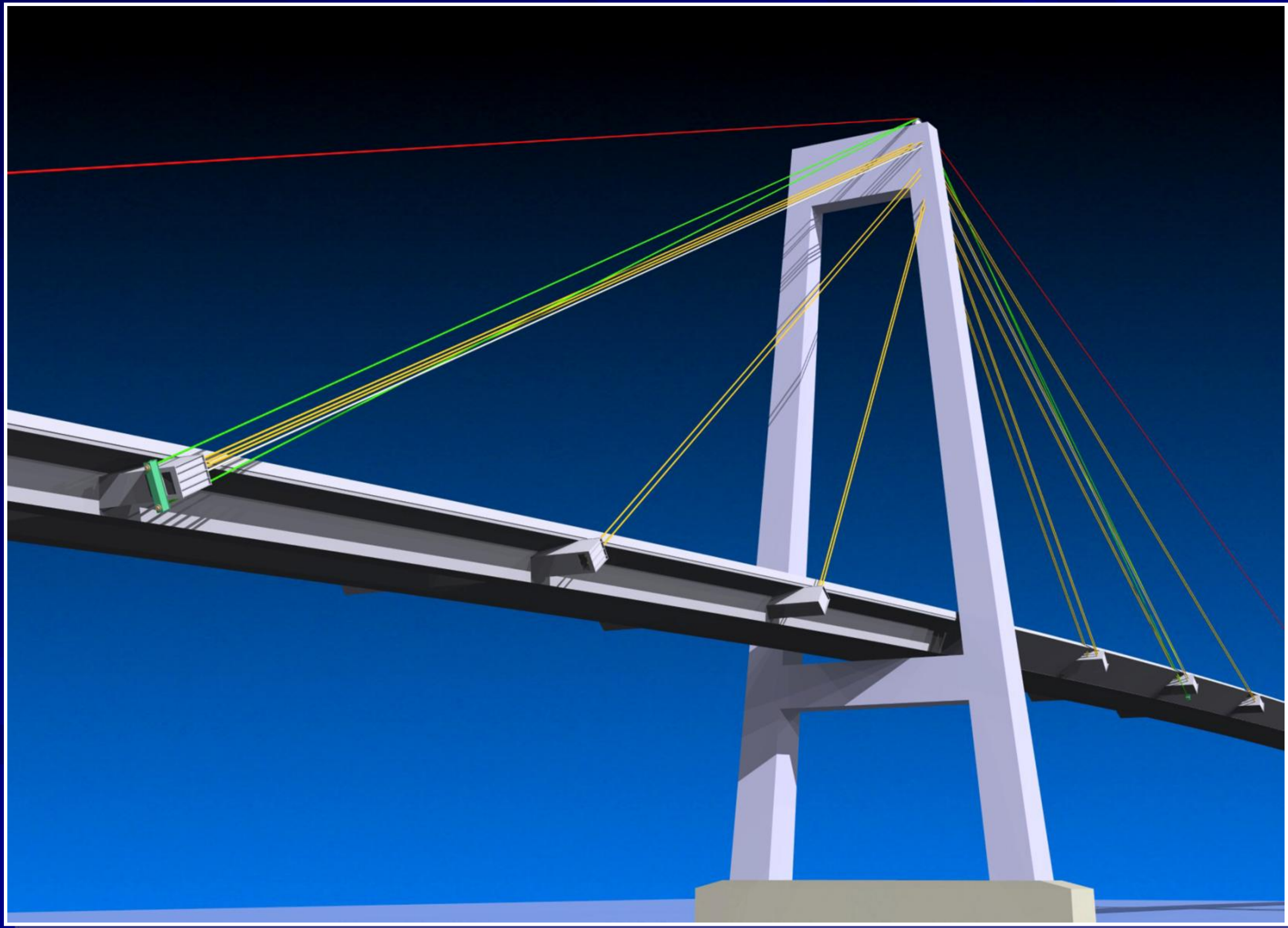
Construction Sequence

Construction Sequence



Construction Sequence

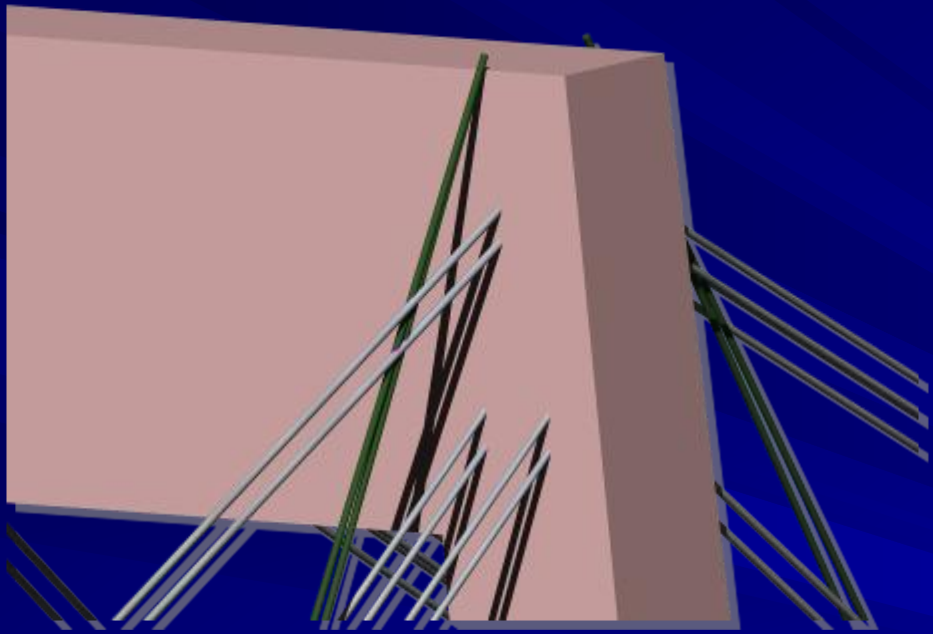
Construction Sequence

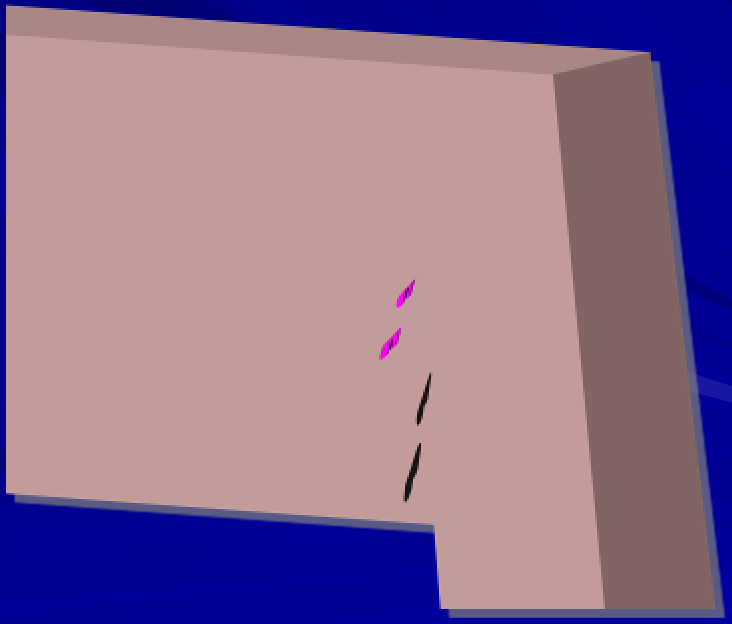


Modeling & Structural Analysis

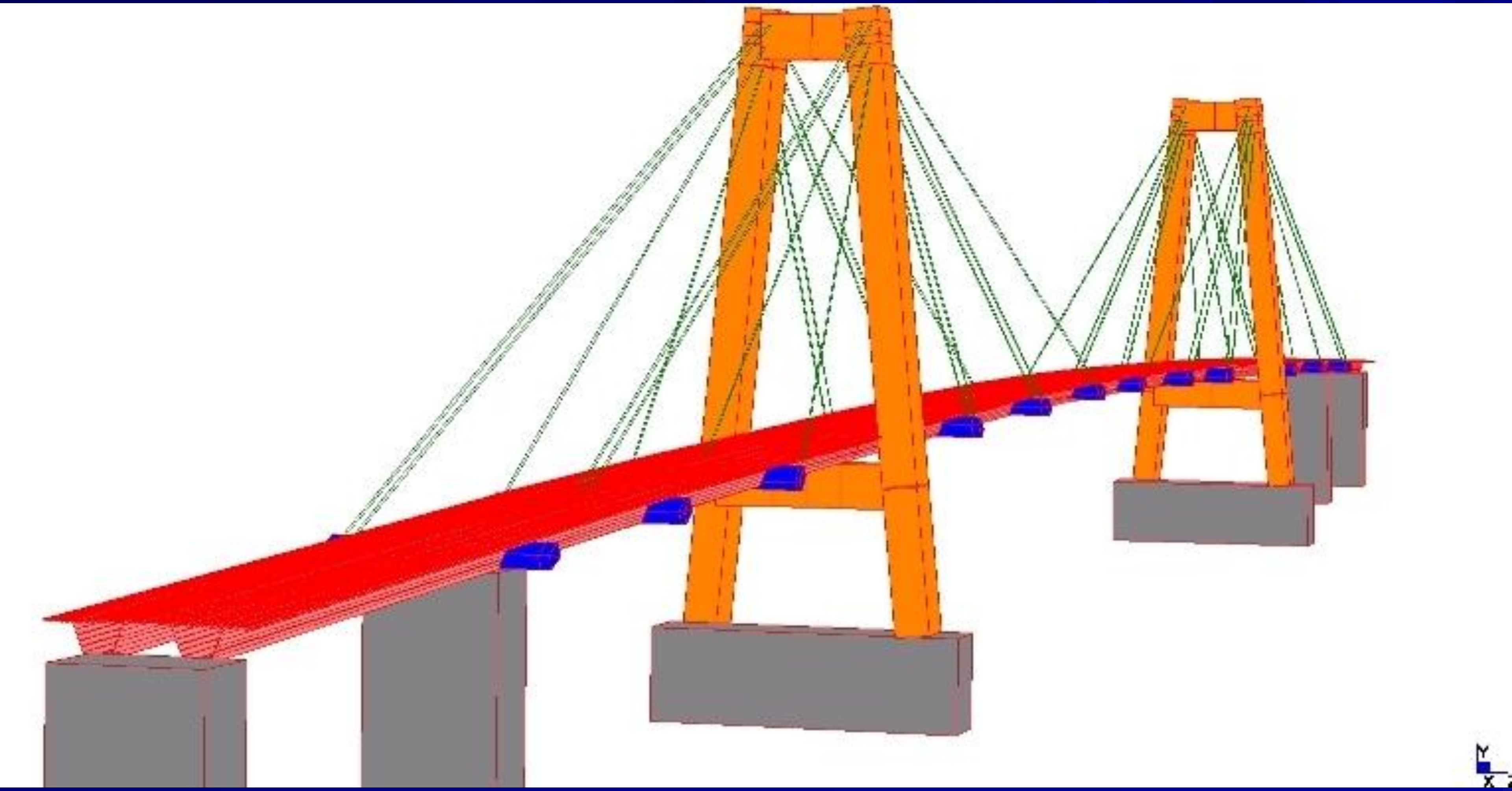
- CAD model to determine geometry conflicts
- Finite Element Model for structural analysis

CAD Model





Finite Element Model



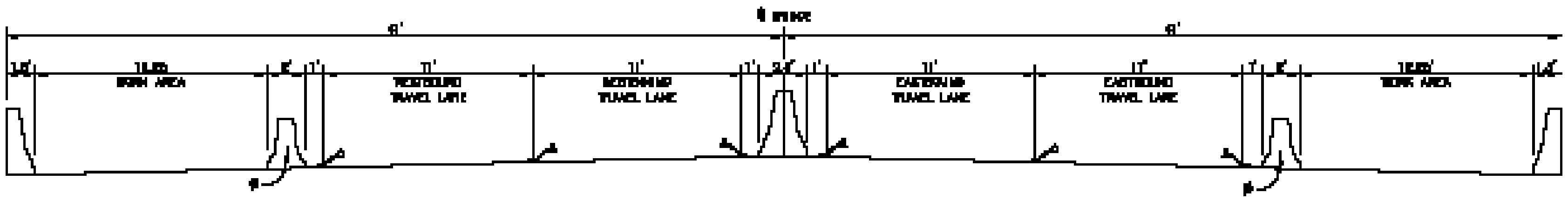
Finite Element Analysis

- Analyze each stage of construction
- Generate member action envelopes for all load combinations
- Analyze Live load and wind load effects
- Finalize design of permanent elements
- Finalize design of temporary elements

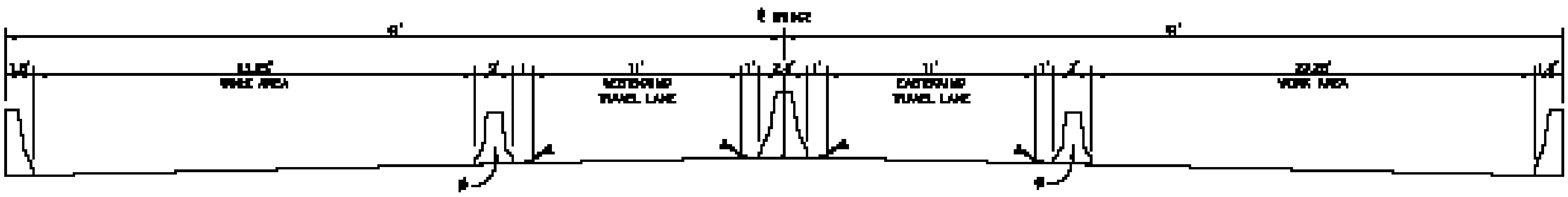
Design for Peripherals

- Cable damper design
- Anti-vandalism and security
- Anchorage drainage design

Maintenance of Traffic



CASE 3
TWO LANE, ONE WAY OPERATION
DAY TIME OPERATION



CASE 2
ONE LANE, ONE WAY OPERATION
WITHOUT PROVISION FOR PASSING STALLED VEHICLE
NIGHT TIME OPERATION


Questions?
06 . 11 . 2006