National Highway Bridge Inspections in the United States

Sreenivas Alampalli

Indian Institute of Science
Bangalore, India
March 27, 2019

Disclaimer

This presentation does not represent views or policies or philosophies of any organization I am affiliated with.

Outline

- Introduction
- National Bridge Inspection Program
- Using Bridge Inspection Data
- Looking into the Future

Asset Management

- Meeting performance levels
  - Safety
  - Mobility
  - Reliability
  - Economic Development
  - Resiliency
  - Sustainability
  - …….
- Reasonable costs

Asset Management

- What you have?
- What conditions?
- Goals?
- Needs (maintenance vs. capital)?
- Identify actions (balance performance and costs)
- Prioritize
- Implement
- Monitor

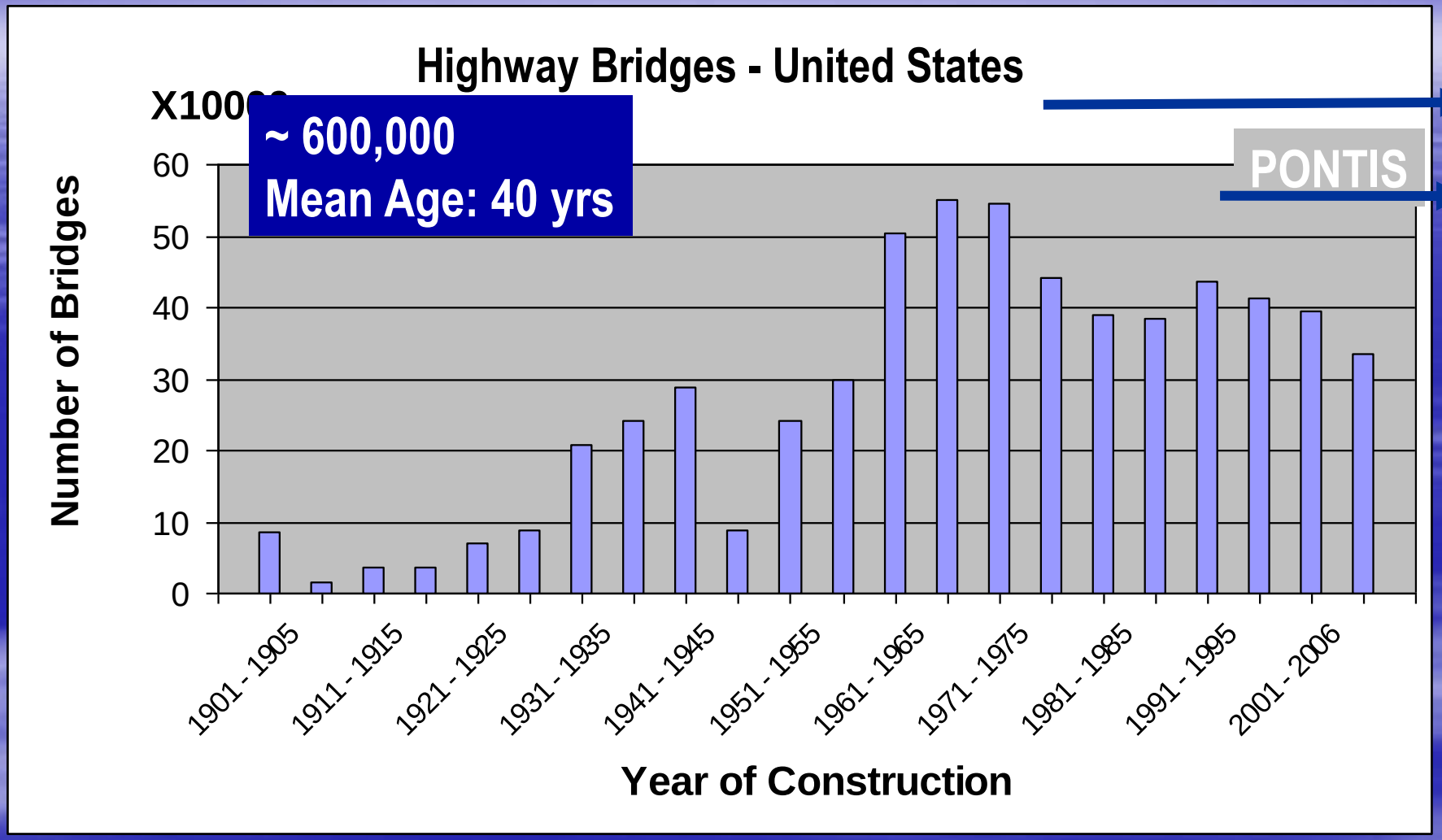
Inspection and Asset Management

- What you have?
- What conditions?
- What is the goal?
- Needs (maintenance vs. capital)?
- Identify actions
  - Immediate, short-term, and Programmed
- Prioritize
- Implement
- Monitor

Current National Bridge Inspection Program
What is a bridge?

- It must be over a depression or an obstruction, such as water or a highway

- It must carry traffic and have an opening (span) of more than ***20 feet***


Highway Bridges - United States
~ 600,000
Mean Age: 40 yrs
PONTIS
Number of Bridges
60
50
40
30
20
10
0
1901 - 1905
1911 - 1915
1921 - 1925
1931 - 1935
1941 - 1945
1951 - 1955
1961 - 1965
1971 - 1975
1981 - 1985
1991 - 1995
2001 - 2006
Year of Construction

Brooklyn Bridge

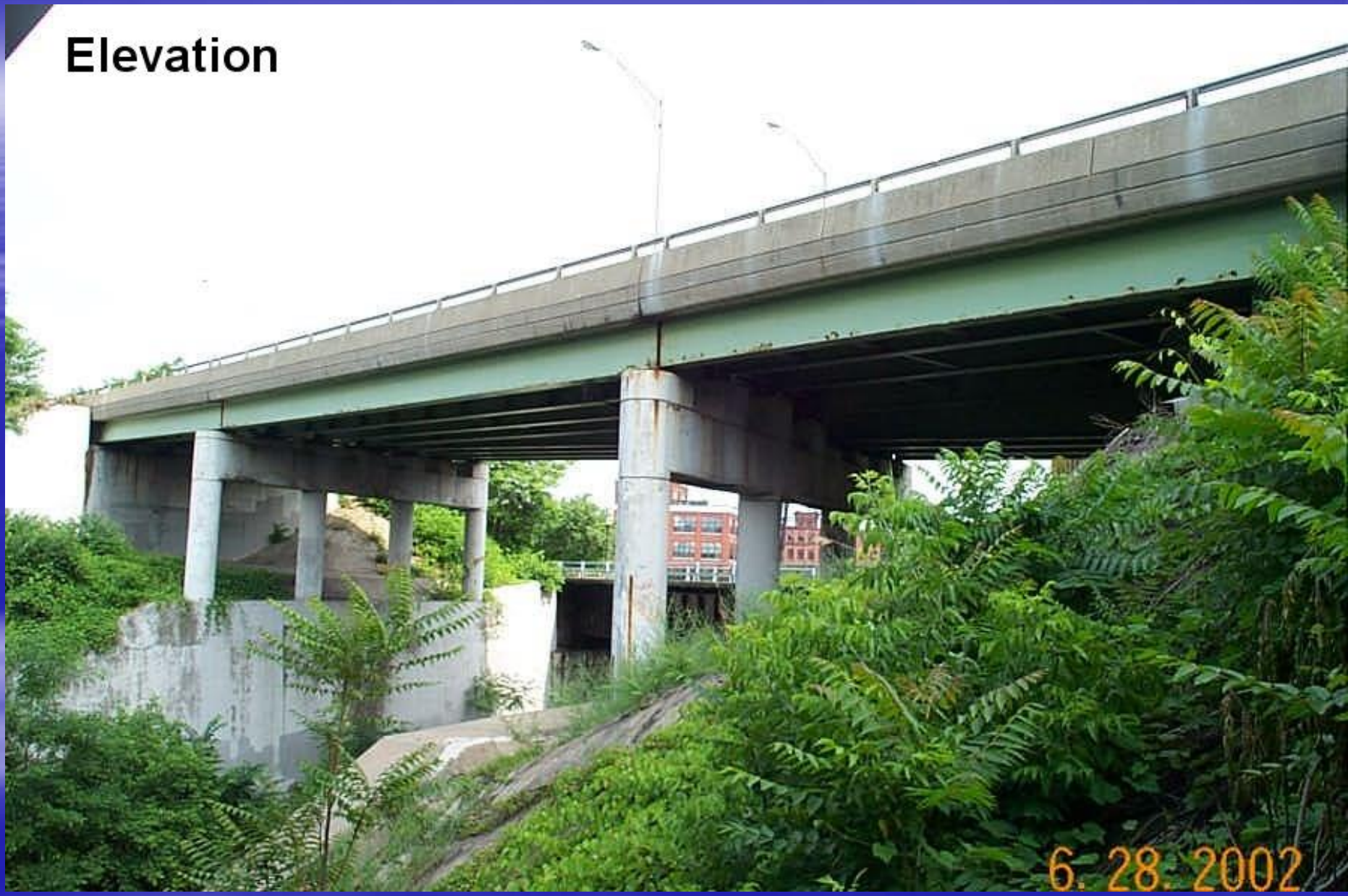
Manhattan Bridge from Brooklyn Bridge

George Washington Bridge

Twin Arches

Latham, NY

Elevation




6. 12. 2003


MAR 31 2003


6. 26. 2001

NBIS History

- 1916 Act: Federal Aid to Highways
  - Inspections of highway structures was part of maintenance work by states and others
  - More detailed program under Public Roads Administration during 1930-40s

Silver Bridge Collapse

NBIS History

- 1967: Ohio River Bridge Collapse
  - President Johnson formed a task force charged to determine procedures available to preclude future disasters and implement changes, if needed

NBIS History

- March 1968 FHWA Memo
  - Initiated review and inventory of all existing structures, to be completed by January 1970
  - All structures reviewed once in five years
  - Two-year inspection interval for important structures
  - Need qualified personnel
  - 1964 AASHTO “Information Guide for Maintenance Personnel”
  - Resulted in complete inventory
  - Identified and fixed serious deficiencies

NBIS History

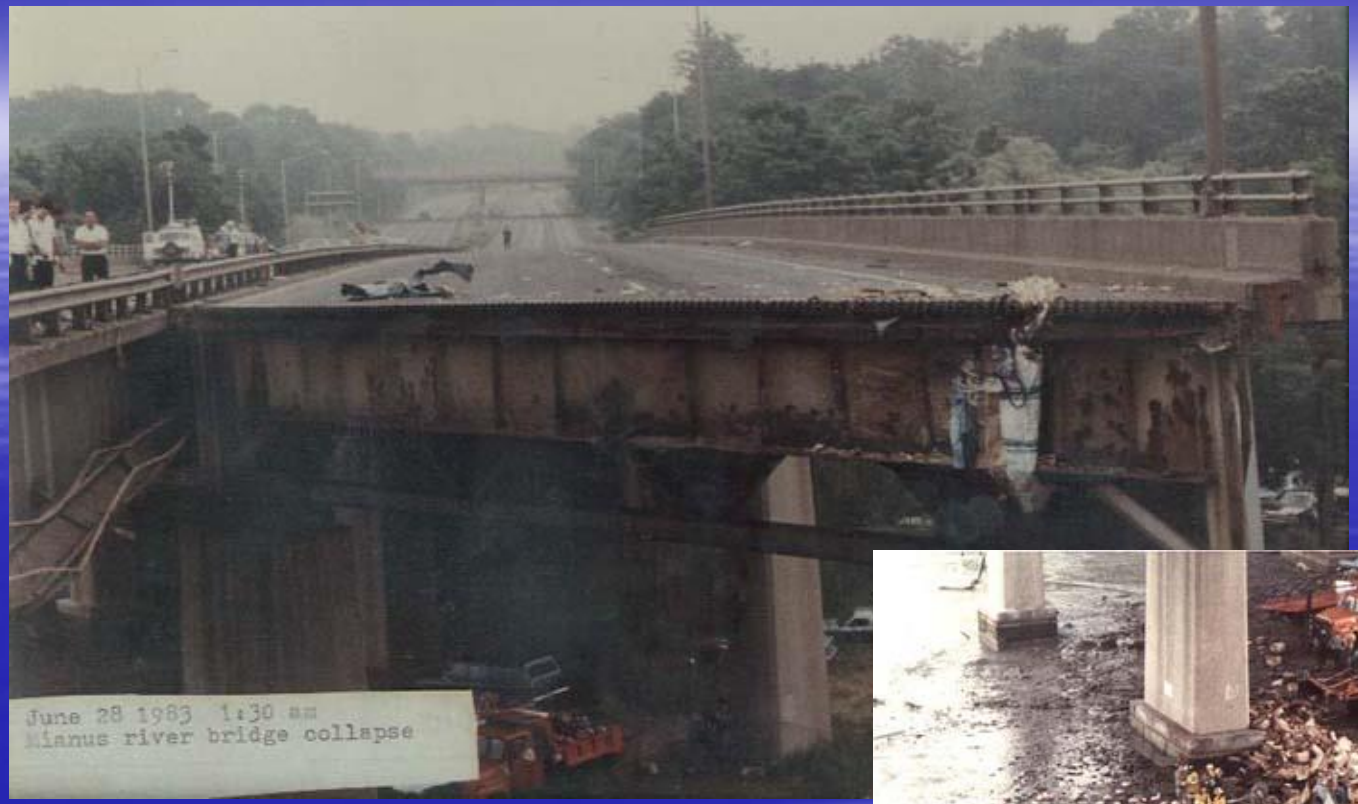
- 1968 Act: Required establishment of NBIS
  - Limited to Federal-aid Highway System
  - Inspection Frequencies
  - Inspector Qualifications
- 1970: Manual Development
  - AASHTO Manual for Maintenance Inspection of Bridges
  - FHWA Bridge Inspectors Training Manual
- 1970 Act: Establishment of NBIS in 1971

NBIS History

- 1971 NBIS: Uniform guidelines and criteria
  - A licensed engineer in each organization
  - 2-year inspection cycle (first cycle by July ’73)
  - Detailed reporting format, appraisal ratings (present vs. current desirable), and sufficiency ratings
  - Inspection types: inventory, routine, damage, in-depth, and interim
  - Rating and measurements

NBIS History

- 1978 Surface Transportation Act:
  - Establishment of HBRR Program
  - Improve significantly important and unsafe bridges
  - R&R based on structural deficiencies, physical deterioration, and functional obsolescence
  - Extension of inspection program to non-federal aid system
  - Classification of bridges for prioritization



Mianus River Bridge Span Collapse, 1983 due to Hanger-Pin Failure

Schoharie Bridge Collapse

NBIS History

- 1988: NBIS revised
  - States can vary frequency of routine bridge inspections when certain conditions are met
  - Establishment of fracture and scour critical bridges requiring 2-yr max inspection interval
  - Special requirements for fracture critical member inspections and appropriate NBI designations
  - Underwater bridge inspection requirements

NBIS History

- 1988: NBIS revised
  - Alternative procedures for certifying bridge inspection Team Leaders and required competence levels
  - Change in reporting requirements: 180-days for local bridges
- 1992 US Court of Appeals, D.C. Ruling
  - 1993 NBIS Revision: Maximum inspection interval of 4 years

NBIS History

- 2004 NBIS Revisions: Effective Jan. 2005
  - State DOT is responsible for making sure inspections are done within the state
  - More ways to qualify to be a Team Leader
  - Two year interval defined as 24 months
  - Max inspection interval cannot exceed 48 months
  - Max interval for underwater inspection is 72 months
  - Follow-up on critical findings
  - Complex bridges
  - QC/QA
  - Training for Divers
  - Refresher training

Minnesota Bridge Collapse

- Bridge Details
  - Carries I-35W, 8 lanes with 140,000 AADT
  - Deck truss bridge
  - Under construction (deck repair)
  - Rated “structurally deficient” by federal standard
- Failure
  - August 1st, 2007
  - 13 people killed during rush hour traffic


Holiday Inn

NTSB Findings

- Reasons for the collapse
  - Inadequate load capacity of connection due to a design error of the gusset plates
  - Failure under a combination of:
    - Substantial increases in the weight of the bridge, which resulted from previous bridge modifications
    - Traffic and concentrated construction loads on the bridge the day of the collapse
  - Recommended that owners assess the truss bridges in their inventories to identify locations where visual inspections may not detect gusset plate corrosion and use of NDE to assess gusset plate condition
- FHWA issued a technical advisory recommending NDE methodology, where needed, to meet the above recommendation

NBIS History

- 2009 Final Rule: Incorporated AASHTO Manual for Bridge Evaluation, First Edition, 2008 by reference in regulations effective January 25, 2010.
- 2011: Implementation of Nationwide NBIS Review format: Twenty-three metrics

http://www.fhwa.dot.gov/pgc/results.cfm?id=5532

NBIS History

- MAP (21): FHWA requires collection of AASHTO Element Data from October 1, 2014 for all NHS bridges
  - Both condition data and quantities will be collected to assist in better bridge management

Condition State	1 (Good)	2 (Fair)	3 (Poor)	4 (Severe)
RC Deck (sq. ft.)	6000 (60%)	1500 (15%)	2000 (20%)	500 (5%)
Pot Bearings (each)	9 (45%)	5 (25%)	4 (20%)	2 (10%)
Steel Girder (ft.)	500 (50%)	100 (10%)	300 (30%)	200 (20%)

Current National Bridge Inspection Program

- Statutory Requirements:
  - Federal Regulations: National Bridge Inspection Standards (NBIS), 2004
- Reference Manuals
  - FHWA "Bridge Inspector's Reference Manual" (BIRM - 2012) http://www.fhwa.dot.gov/bridge/nbis/pubs/nhi12049.pdf
  - FHWA Recording and Coding Guide (1995)

Current National Bridge Inspection Program

- Reference Manuals
  - FHWA Specification for the National Bridge Inventory Bridge Elements

    http://www.fhwa.dot.gov/bridge/nbi/131216_a1.pdf
  - FHWA Underwater Bridge Inspection Manual

    http://www.fhwa.dot.gov/bridge/nbis/pubs/nhi10027.pdf

Current National Bridge Inspection Program

- Reference Manuals
  - AASHTO Manual for Bridge Element Inspection
  - AASHTO Manual for Bridge Evaluation

Current National Bridge Inspection Program

- All publicly owned highway bridges are covered
- Most bridges inspected at least once in two-years
- Diving inspections at least once in five years
- Team Leaders' qualifications are defined
- Refresher training required

Current National Bridge Inspection Program

- Evaluate the entire structure to as-built condition
- Rate few elements, indicative of entire structure, not for localized deterioration
  - Superstructure
  - Deck
  - Substructure
  - Channel and channel protection
  - Culverts
  - Capacity
- Element Data

Need a global understanding of structural behavior and failure mechanisms

Current National Bridge Inspection Program

- Federal ratings (0 to 9 Scale)
  - 9 Excellent; 7 Good; 5 Fair; 3: Serious; 0 Failed
- Element ratings with quantities (1 to 4 Scale)
  - 1 Good; 4 Severe (needs review)
- Structurally Deficient
  - Typically requires significant maintenance and repair to remain in service
  - Need eventual rehabilitation or replacement to address deficiencies
  - In order to remain in service, are often posted with weight limits

3.3.1.5—Element 107—Steel Open Girder/Beam

Description: All steel open girders regardless of protective system.

Classification: NBE **Units of Measurement**: ft

Quantity Calculation: Sum of all the lengths of each girder.

Condition State Definitions

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as	Loose fasteners or pack rust without	Missing bolts, rivets, or fasteners; broken	

EXAMPLE -

Condition State 1

Superstructure Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
107	Steel Open Girder/Beam	ft	420	420				
Notes	The girder steel is in like new condition.							

EXAMPLE -

Condition State 2

- **Steel Open Girder/Beam (Element 107)**

  2 Girders spaced 45', Span 60' => Total Quantity 120'

- **Steel Stringer (Element 113)**

  8 intermediate stringers spaced @ 5' O.C. => Total Quantity 480'

Steel Floor Beam (Element 152)

6 F.B.'s numbered 0-5 spaced @ 12' O.C. => Total Quantity 270'

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	

Superstructure Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
107	Steel Open Girder/Beam	ft	120		120			
Notes	Rust bubbles, bleed through, and localized failure of the paint system is evidence of widespread surface corrosion of the steel. No section loss is present.							
113	Steel Stringer	ft	480		480			
Notes	Rust bubbles, bleed through, and localized failure of the paint system is evidence of widespread surface corrosion of the steel. No section loss is present.							
152	Steel Floor Beam	ft	270		270			
Notes	Rust bubbles, bleed through, and localized failure of the paint system is evidence of widespread surface corrosion of the steel. No section loss is present.							

EXAMPLE -

Condition State 2 & 3

Superstructure Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
107	Steel Open Girder/Beam	ft	200		199	1		
Notes	The girders have full length corrosion along the bottom of webs and bottom flanges **(C.S. 2)**. G1, Stiffener 1 has a 2” x 2” hole at the bottom **(C.S. 3)**.							

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	

EXAMPLE -

Condition State 4

Superstructure Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
107	Steel Open Girder/Beam	ft	550	545			5	
Notes	5 cracks are present near the bottom flange in the G1 web as a result from out-of-plane bending. These 2 inch long cracks are considered working cracks and likely to propagate. The remainder of the steel is in good condition.							

EXAMPLE -

Condition State 1

Bearing Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
314	Pot Bearing	each	10	10				
Notes	The bearings are in like new condition and behaving as designed.							

EXAMPLE -

Condition State 2

Bearing Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
310	Elastomeric Bearing	each	12	6	6			
Notes	The bearings are in like new condition; however, the end expansion bearings **(C.S. 2)** are abnormally overextended by ½" for the ambient air temperature of 28°F.							

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	
Movement (2210)	Free to move.	Minor restriction.	Restricted but not warranting structural review.	
Alignment (2220)	Lateral and vertical alignment is as expected for the temperature conditions.	Tolerable lateral or vertical alignment that is inconsistent with the temperature conditions.	Approaching the limits of lateral or vertical alignment for the bearing but does not warrant a structural review.	
Bulging, Splitting, or Tearing (2230)	None.	Bulging less than 15% of the thickness.	Bulging 15% or more of the thickness. Splitting or tearing. Bearing's surfaces are not parallel. Does not warrant structural review.	
Loss of Bearing Area (2240)	None.	Less than 10%.	10% or more but does not warrant structural review.	

EXAMPLE -

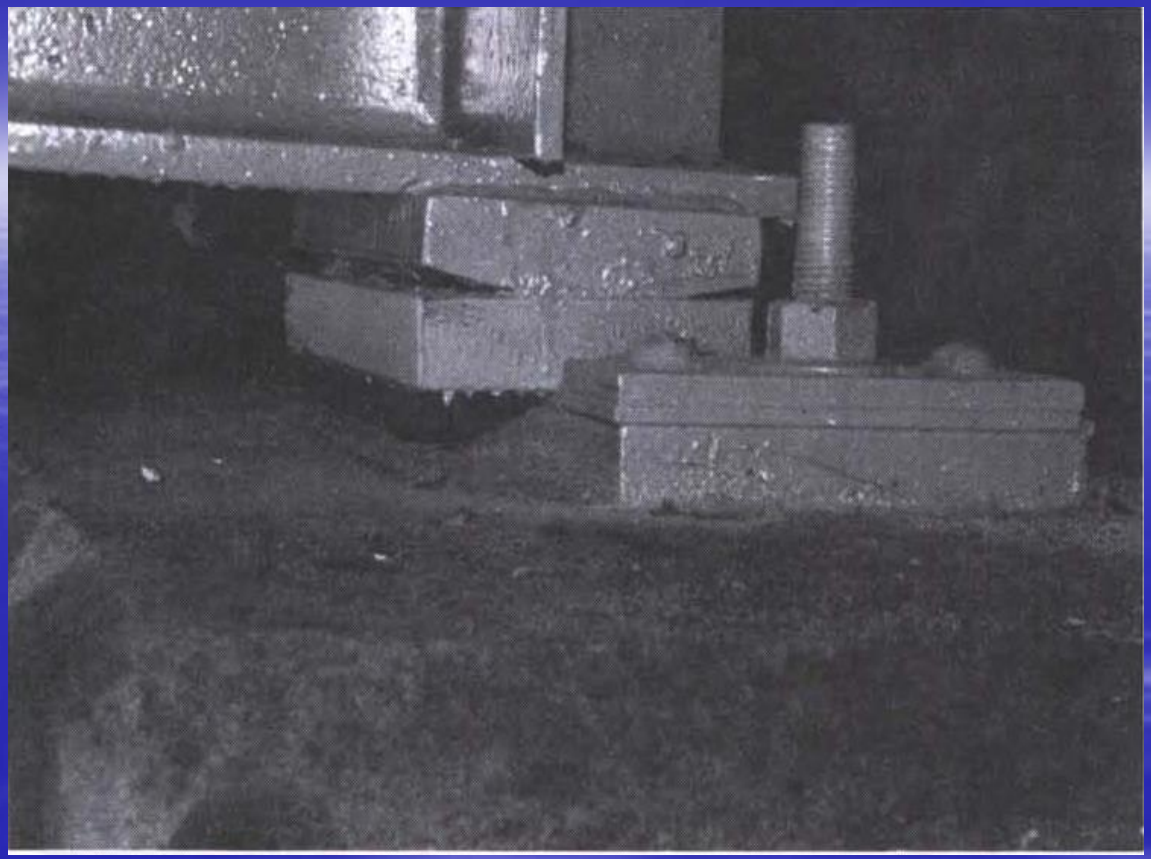
Condition State 3

Bearing Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
310	Elastomeric Bearing	each	8		7	1		
Notes	Bridge begins G3 bearing is cracked and torn but still allows movement **(C.S. 3)**. The remaining bearings are slightly bulged (<15%).							

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	
Movement (2210)	Free to move.	Minor restriction.	Restricted but not warranting structural review.	
Alignment (2220)	Lateral and vertical alignment is as expected for the temperature conditions.	Tolerable lateral or vertical alignment that is inconsistent with the temperature conditions.	Approaching the limits of lateral or vertical alignment for the bearing but does not warrant a structural review.	
Bulging, Splitting, or Tearing (2230)	None.	Bulging less than 15% of the thickness.	Bulging 15% or more of the thickness. Splitting or tearing. Bearing's surfaces are not parallel. Does not warrant structural review.	
Loss of Bearing Area (2240)	None.	Less than 10%.	10% or more but does not warrant structural review.	

EXAMPLE -

Condition State 4



Bearing Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
311	Movable Bearing	each	12	6			6	
Notes	The end abutment sliding plate bearings are severely contracted. Each bearing overhangs their masonry plate by 3 inches. They should be in an expanded position for the ambient air temperature of 80°F (27°C).							

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	
Movement (2210)	Free to move.	Minor restriction.	Restricted but not warranting structural review.	
Alignment (2220)	Lateral and vertical alignment is as expected for the temperature conditions.	Tolerable lateral or vertical alignment that is inconsistent with the temperature conditions.	Approaching the limits of lateral or vertical alignment for the bearing but does not warrant a structural review.	
Bulging, Splitting, or Tearing (2230)	None.	Bulging less than 15% of the thickness.	Bulging 15% or more of the thickness. Splitting or tearing. Bearing's surfaces are not parallel. Does not warrant structural review.	
Loss of Bearing Area (2240)	None.	Less than 10%.	10% or more but does not warrant structural review.	

EXAMPLE -

Condition State 5

NY Example 3.5-20

A full height wingwall crack exists with up to 2 inches of horizontal displacement and forward rotation. The wall displacement and rotation indicates the footing has uneven settlement. The footing is not visible. Element 220 assessed CS-5.

Bearing Example				Condition States				
Element Number	Element Description	Unit of Measure	Total Quantity	1	2	3	4	5
				Good	Fair	Poor	Severe	Unknown
220	Pile Cap/Footing	Ft	70					70
Notes	Full height crack in wall but footing is buried below soil.							

Current National Bridge Inspection Program

- Several states go beyond FHWA requirements and conduct element level inspections
  - Varies from state to state significantly
- Condition Ratings
  - Generated directly through inspection
  - State data converted through translator


Sight
Sound
Touch
04/24/2007

Inspection

- All inspections completed by a Team Leader (PE) and an Assistant Team Leader
  - Examine and evaluate all elements of the bridge
  - Rate all elements, on a span basis
  - Measure and sketch deterioration and scour as necessary
  - Update load rating and inventory data
  - Flag serious bridge deficiencies that require fast attention, or to report conditions that are or may be a clear and present danger

Bridge Data Information System (BDIS)

- Advanced Inspection System
- Built in Access Regulation (Security)
- Record Ratings to the Sub-element Level
- Built-in Business Rules
- Flexible in Terms of Formula Editing
- Allows Online and Offline Inspection Recording

Bridge Data Information System (BDIS)

- Complete Inspection System (Real Time Access)
  - Includes Modules for Bridge, Diving and Large Culverts
  - Inventory
  - Scheduling of Inspections
  - Flags
  - Load Rating
  - Vulnerability Assessments
- Integrates with GIS, Maintenance Management and More

Elements

- National Elements
  - Primary Structural Components of Bridges
- Bridge Management Elements
  - Components of Bridges Usually Managed by Bridge Management System
- Agency Defined Elements
  - Scour, Stream Hydraulics, Backwall, Abutment Pedestal, Pier Pedestal, Secondary Members, Steel Beam End, Sidewalk, Curb, Wingwall, Culvert Headwall & Culvert Apron

Inspection

- Inspection Types and Intervals
  - General Inspections (every two years or more)
  - Diving Inspections (every five years or more)
  - Special Inspections (as needed)
- Reporting Critical Findings
  - Red Flag
  - Yellow Flag
  - Safety Flag

RED FLAG

- Most severe
- Requires quick action (max. 42 days)

YELLOW FLAG

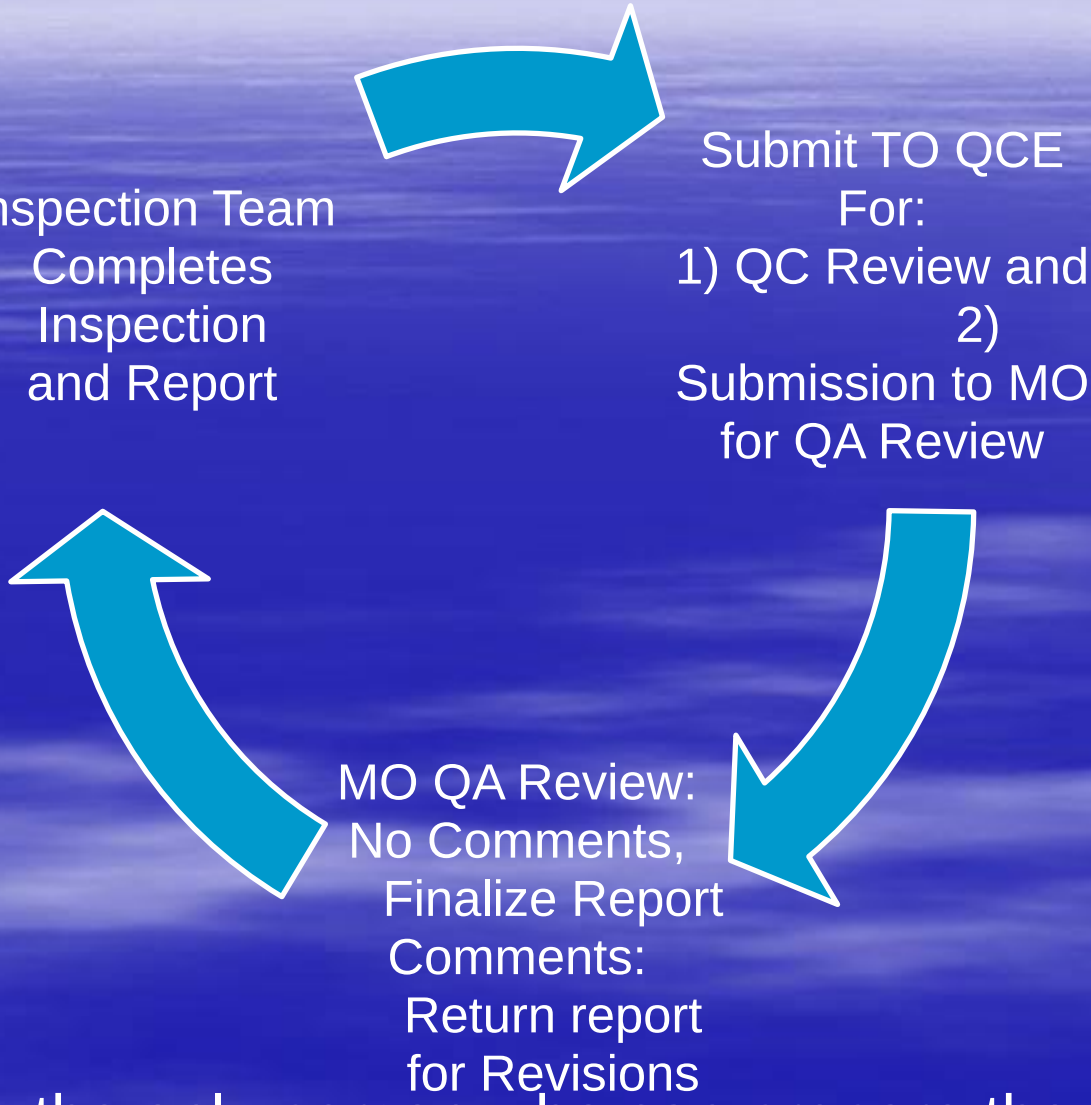

2006 8 4


35mm x 15mm
15mm
16mm
SPAN 2
14mm
13mm
12mm dia.
07.28.2006

SAFETY FLAGS

Non-Structural

Inspection Process



Inspector is the only person who can prepare the inspection report

NYS vs. NBIS: Inspection Types

- Fracture Critical Member (FCM) Inspections
  - *A Member in Tension, or with a tension element, whose failure would probably cause a portion of the structure to collapse*
  - NBIS: Steel Member in Tension
  - NYS: Non- Redundant and FCM
    - 3 Girder System
    - Certain concrete deck haunches
    - Details vulnerable to Out-of-Plane distortion
- In-Depth Inspections

Uses of Inspection Data

- Maintaining Current Bridge Data
  - Element condition based queries
  - Inventory based queries
  - Element / Feature Combinations
- Assuring Safety of Traveling Public and Structure
  - Critical Findings (Structural and Safety related)
  - Emergency Repairs
  - Closures (Post-Event)
  - Flood Watch
  - Postings and Closings

Load Rating

- Load rating is the determination of the safe live load capacity of a bridge
- Used for determining what loads can go on a bridge
- Updated after every inspection and as needed
- LL Capacity = (Capacity – DL Effect)/SF


MAIN-CARE

Load Rating

- Done using bridge structural element database and software such as AASHTOWare® VIRTIS
  - Deterioration data collected from inspections
- Load testing is another option
  - Diagnostic tests
  - Proof load tests

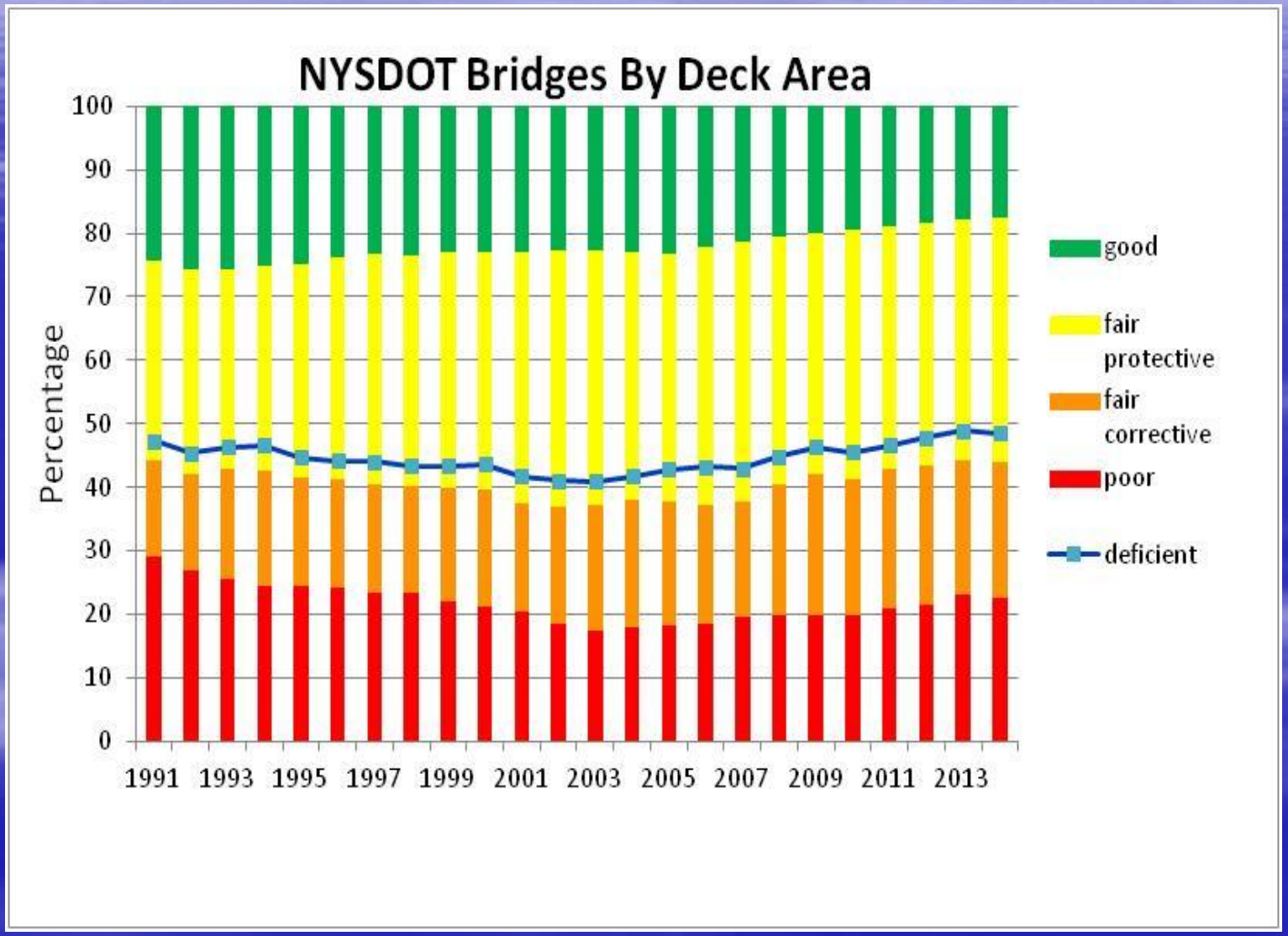
Uses of Inspection Data

- Scheduling Maintenance Activities
  - Emergency Repairs
  - Flag Repairs
  - Corrective Maintenance
  - Preventative Maintenance
- Satisfying Federal and State Reporting Requirements
  - Annual “Federal Tape”
  - Annual NYS “Report of Bridge Management and Inspection Programs” – Graber Report

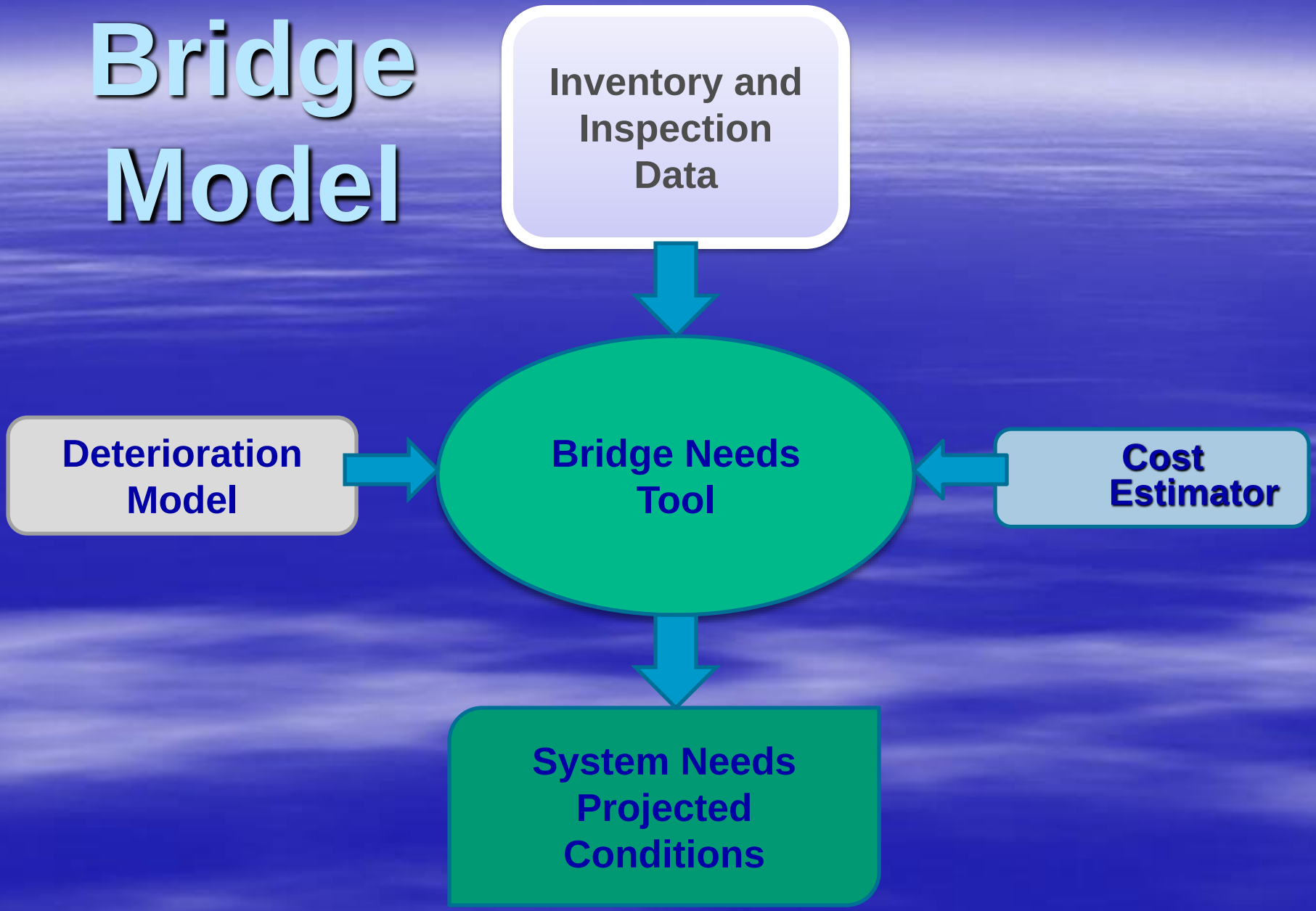
Uses of Inspection Data

- Providing Data for Capital Program Planning
  - Used for developing capital program by using data with BMS software
  - Used to compute “Sufficiency Rating” (measure of the bridge’s ability to remain in service) to determine federal funding eligibility

Uses of Inspection Data



Bridge Model



Uses of Inspection Data

- Supporting Design Functions
  - Inspection report used as a basis for structural integrity evaluations, load rating, and other functions
  - Inspection report documentation as a reference

Uses of Inspection Data

- Permits
- Post-event assessment
  - Needed to make decision on opening or closing a bridge
  - Prioritization of funding
  - Appropriate repair actions
- Vulnerability Assessment


OVER SIZE LOAD


31 12:41 PM

Uses of Inspection Data

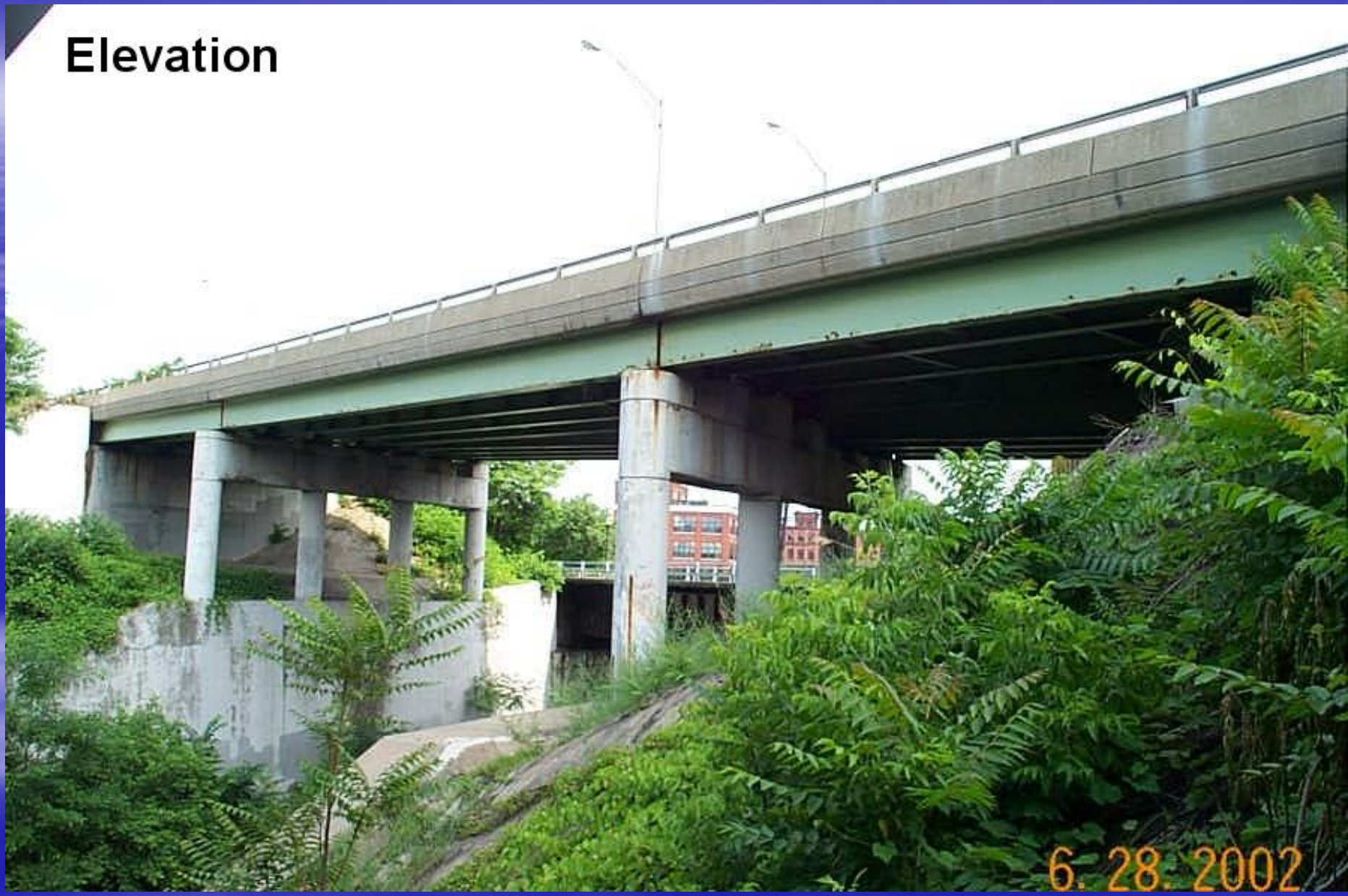
- Permits
- Post-event assessment
  - Needed to make decision on opening or closing a bridge
  - Prioritization of funding
  - Appropriate repair actions
- Vulnerability Assessment

IMPACT HAZARD

Issues

- Designed for routine bridges and does not cover adequately
  - Special bridges
  - New materials
  - New designs
  - Complex bridges
- Completely visual and hence, hard to evaluate concealed elements
- No rational basis for inspection interval
- Appraisal ratings' definitions do not reflect current state-of-practice

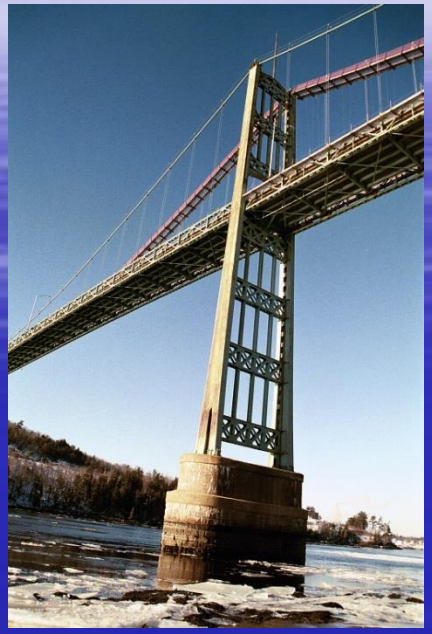
Elevation

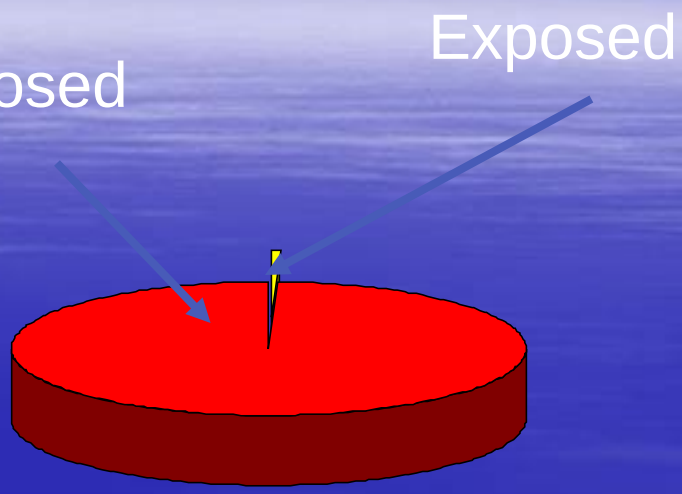


Issues

- Designed for routine bridges and does not cover adequately
  - Special bridges
  - New materials
  - New designs
  - Complex bridges
- Completely visual and hence, hard to evaluate concealed elements
- No rational basis for inspection interval
- Appraisal ratings definitions do not reflect current state-of-practice

How Much of the Cable is Inspected?





Inspecting a 20-foot length of cable with wedging at 8 points exposes less than 0.1% of the wire for a typical suspension bridge (4,000 foot main cable with 15,000 wires).

(Robert Nickerson (1998), “Safety Appraisal of Suspension Bride Main Cables”, National Cooperative Highway Research Program, Transportation Research Board, Contractor’s Report for a Workshop in Newark, NJ)

Courtesy of Mike Higgins

FRP Bridge Deck

Issues

- Limited data: Not effective for bridge management practices
  - Qualitative and does not lend to deterioration rate estimations for significant elements
  - Need extent of damage for financial estimations
  - No link to bridge maintenance practices and inspection data, but is improving significantly
- Not hazard specific (reactive not pro-active)

Looking into Future

- Identifying and recording data needed to evaluate and improve performance
  - Environmental data
  - Operational data: deicing salts, etc.
  - Load data
  - Material data
  - Maintenance, R&R data
- Evaluate how data is used and how it can be used more effectively
  - Identify elements needing improvement
  - Focus on maximum benefit with associated cost

Looking into Future

- Account for structure type and complexity
  - Inspection interval
  - Inspector qualifications
  - Inspection extent
  - Data collected
  - Supplement with NDT methods as needed
  - Resources
  - Addressing critical findings

Brooklyn Bridge


MAR 31 2003

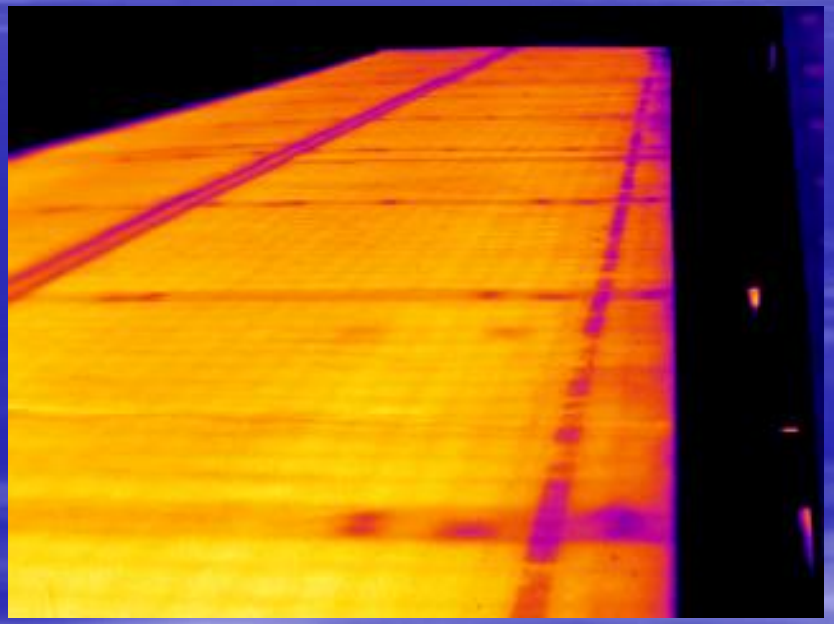
Looking into Future

- More uniformity and consistency in ratings
  - Reference bridges
  - Uniform QC/QA procedures
  - Uniform qualifications, training, and continuing education
  - Better manuals
  - Quantitative data
  - Deterioration extent
  - Recording maintenance data
  - Certification and calibration of inspectors

Looking into Future

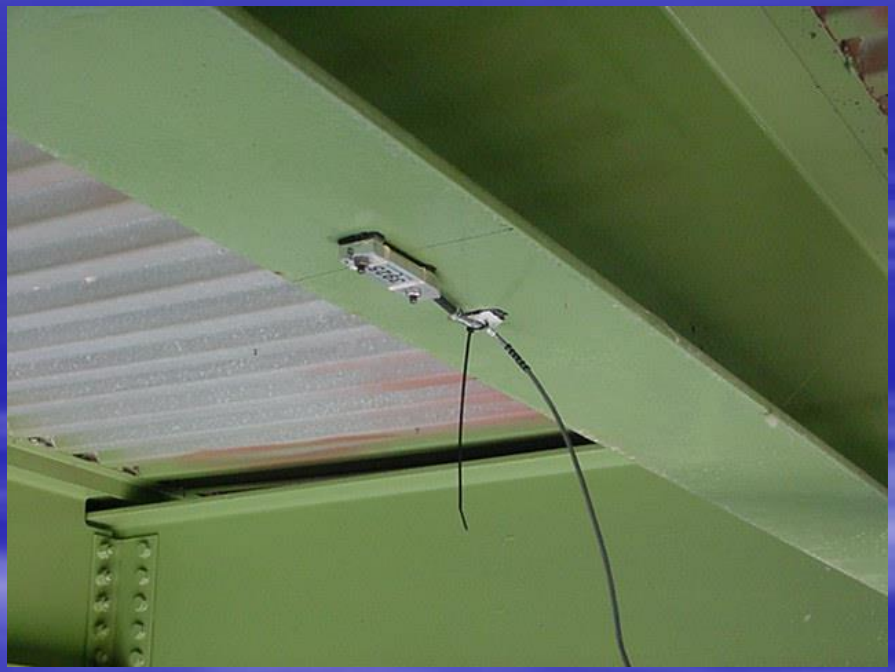
- Pro-active inspection and assessment
  - Design and construct for inspection ease
  - Multi-hazard approach
  - Leveraging current sensor and computing technologies
    - Passive sensors
    - New test methods
    - Smart structures

Thermographic Inspection

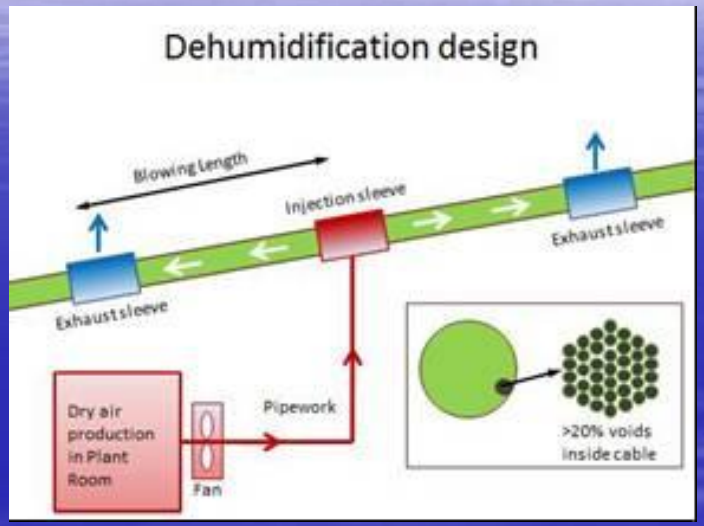


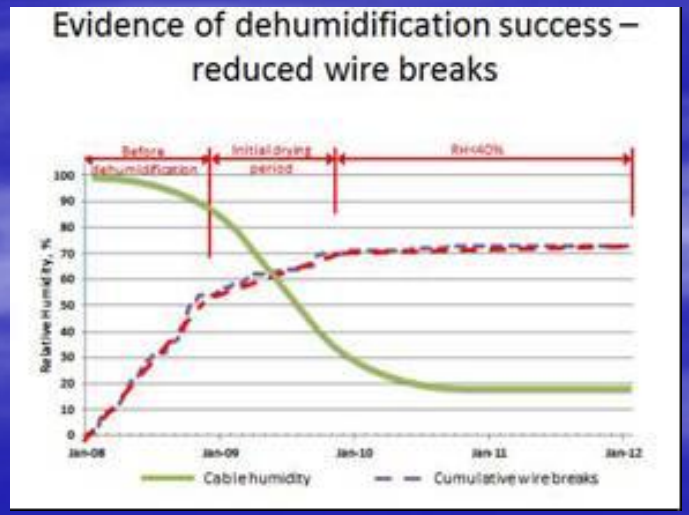
Fatigue Evaluation of Patroon Island Bridge

(Assists in making a decision on repair vs. replacement options)



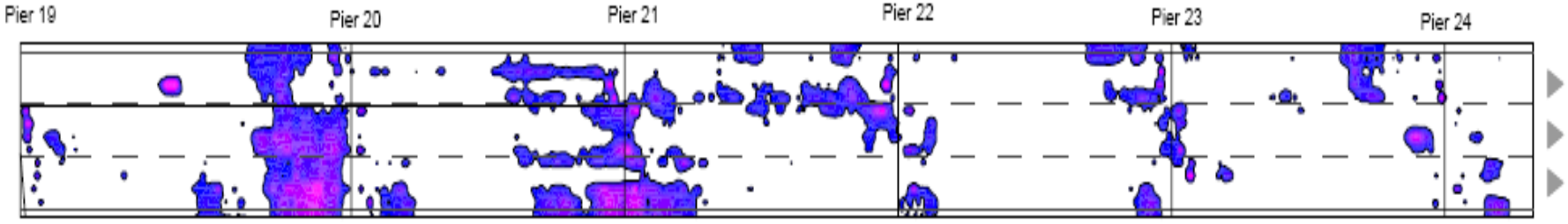
Suspension Bridges





Courtesy: Barry Colford, Forth Road Bridge, Scotland

Deck Evaluation



Technology Fusion and Visualization
IE Delamination Map Superimposed on LiDAR Bridge Scan

Courtesy: Dr. Hamid Ghasemi, FHWA

Looking into Future

- Points to Remember
  - SAFETY FIRST
  - Decision-making process should drive the programs
    - Do not collect data which you are not going to use
    - Do not use technologies just because they exist
    - Cost-benefit analysis
    - Risk analysis
    - Reliability evaluation of technologies

Contact Information

Sreenivas Alampalli, Ph.D., P.E., MBA,
Director, Structure Management Bureau
NYSDOT
Albany, NY 12232
Sreenivas.Alampalli@dot,ny.gov