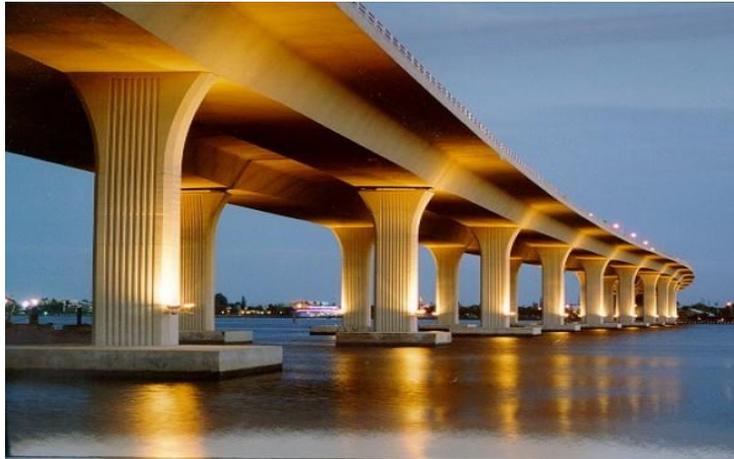


# **Bridge Preservation: Completed, Ongoing and Future Research**



**2011 Southeast Bridge Preservation Partnership  
(SEBPP) Meeting  
Raleigh, North Carolina**

**By  
John Sobanjo  
Florida State University  
Tallahassee, Florida**

**April 14, 2011**



# **Presentation Outline**

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- **Review of completed research.**
- **Classification of documented research.**
- **AASHTO Roadmap.**
- **Ongoing research (TRB RiP).**
- **Future research needs.**
- **Conclusions**



# What is bridge preservation?

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- **Assumed definition of the term<sup>1</sup>:**
  - **“Actions to deter or correct deterioration of an asset to extend its useful life; does not entail structural or operational improvement of an existing asset beyond its originally designed strength or capacity.”**

<sup>1</sup> AECOM, NCHRP Project No. 0869 Draft Final report, Supplement to the AASHTO Transportation Asset Management, Guide: Volume 2 – A Focus on Implementation,



# Literature review

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- **Sources: Engineering research libraries, Google Web, Google Scholar, and the Transportation Research Information System (TRIS).**
- **Limited to recent years (2007 to 2010).**
- **Search keywords: “bridge” preservation” and “cost” (to narrow results down).**
- **According to TRIS: 86 documented studies related to bridge preservation where cost is considered.**



# **Categorizing documented studies**

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- **Brief reviews of the 86 documented studies suggest three (3) types of research on bridge preservation:**
  - **Inspection efforts (26 of 86 reports).**
  - **Treatment/Repair efforts (25 of 86 reports).**
  - **Management efforts (35 of 86 reports).**
- **A few studies fall into multiple categories.**



# **Categorizing documented studies**

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- **Inspection efforts:**
  - Inspection, testing, or monitoring techniques are done as part of the bridge preservation effort, for example structural health monitoring methods.
- **Treatment/Repair efforts:**
  - Studies conducted to evaluate the performance of specific treatment or repair techniques, for example cathodic protection of bridge piers, deck overlay, etc.
- **Management efforts:**
  - Bridge management (decision-support) activities, such as deterioration modeling, estimating service lives, life-cycle costing, optimization modeling, etc.



# **Categorizing documented studies**

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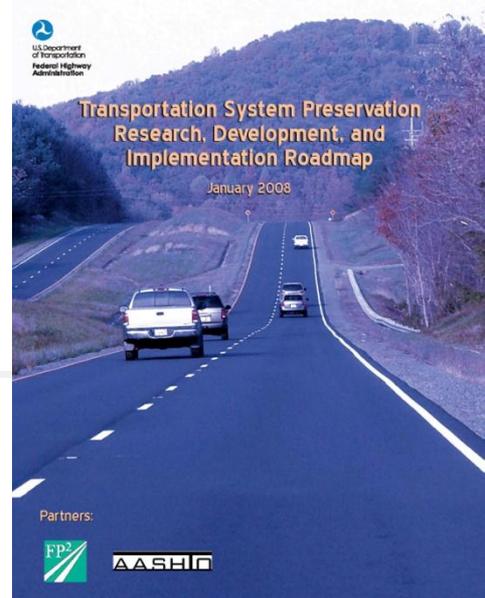
## **Examples:**

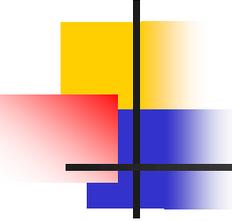
- **Sharp, Stephen R., “Nondestructive Evaluation of Epoxy-Coated Reinforcing Bars in Concrete Using Bi-Electrode Half-Cell Potential Techniques,” Final Report, Virginia Transportation Research Council, 2006, 22p.**
- **Jamali, Amin, and Saadeghvaziri, Ala, “Controlled Composite Action to Eliminate Deck Cracking,” Proceedings of the 2010 Structures Congress and the 19th Analysis and Computation Specialty Conference, Orlando, Florida, May 12-15, 2010, pp 3365-3374.**
- **Morcous, George, “Pareto Analysis for Multicriteria Optimization of Bridge Preservation Decisions,” Transportation Research Record: Journal of the Transportation Research Board, Issue Number: 1991, Transportation Research Board, 2007, pp 62-68.**



# AASHTO Roadmap (2008)

- AASHTO Roadmap (2008) describes in detail, the results from two bridge preservation workshops that were held in 2007.
  - Six categories of preservation research needs identified.
  - List developed on the research need statements.
  - List ranked by DOTs.
- Hopwood (2010) made a presentation on identifying recent/in progress/forthcoming bridge preservation research related to the AASHTO (2008) publication.





# AASHTO Roadmap (2008)

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- Bridge Preservation R&D Needs (Source: Hopwood 2010).

Bridge Preservation R&D Needs Categories and Number of Statements	
Category	# of Statements
Asset Management	7
Substructures	5
Superstructures	5
Decks & Joints	4
Selection of Preservation Actions	2
Performance of Preservation Actions	2
<b>Total</b>	<b>25</b>



# AASHTO Roadmap (2008)

- Asset management research:

ROADMAP ID	TITLE	COST (\$1000)	TYPE CODE*	RANK
Asset 01	Development of a bridge preservation process framework ensuring a standardized repeatable process for bridge preservation	\$300	MGMT	18
Asset 02	Establishment of Uniform Terminology and Definitions for Transportation System Preservation	\$20	MGMT	16
Asset 03	Development Of A Process For Estimating The Remaining Service Life (RSL) Of Bridge Components And The Overall Bridge System Based On Observable Data.	\$200	MGMT	13
Asset 04	Evaluation of the AASHTO Commonly Recognized Elements (CoRe), Ten Years of Data	\$300	MGMT	23
Asset 05	Better Direct and Indirect Cost Models for Bridge Management Systems	\$400	MGMT	20
Asset 06	Modeling Early Bridge Deterioration and Prevention	\$400	MGMT	19
Asset 07	Evaluation, Analysis, and Documentation of Successful Bridge Preservation Practices	\$1,100	MGMT	11

\* INSP -- Inspection; TRTMT -- Specific treatment(s) or repair actions; MGMT -- Asset management or decision support.

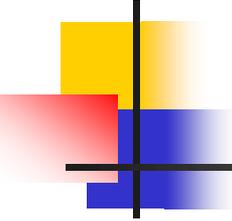


# AASHTO Roadmap (2008)

## ■ Substructures research:

ROADMAP ID	TITLE	COST (\$1000)	TYPE CODE*	RANK
Substructures 01	Preservation of Concrete Highway Bridge Substructure Units by Preventing or Delaying the Initiation of Active Corrosion of the Steel Reinforcement	\$400	TRTMT	8
Substructures 02	Preservation of Concrete Highway Bridge Substructure Units by Controlling the Corrosion Rate of the Steel Reinforcement once Corrosion has Initiated	\$300	TRTMT	6
Substructures 03	Development of a High Performance Galvanic Anode	\$600	TRTMT	22
Substructures 04	Substructure Preservation Decision Matrix to Address Corrosion Issues of the Steel Reinforcement of Concrete Bridge Substructure Elements	\$450	TRTMT	10
Substructures 05	Preservation of Steel Bridge Piles	\$500	TRTMT	25

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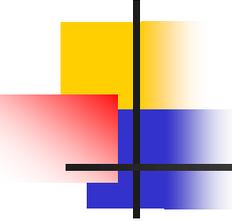


# AASHTO Roadmap (2008)

## ■ Superstructures research:

ROADMAP ID	TITLE	COST (\$1000)	TYPE CODE*	RANK
Superstructures 01	Development of a Test for Assessment of Performance of Weathering Steel	\$350	TRTMT	21
Superstructures 02	Development of Procedures for Preservation of Weathering Steel Bridges	\$300	TRTMT	24
Superstructures 03	Performance Assessment of Existing Concrete Structure Corrosion Prevention/Mitigation Technologies	\$1,000	TRTMT	9
Superstructures 04	Improved Inspection Techniques for Steel Prestressing Strand, Cables, and Ropes	\$2,000	INSP	1
Superstructures 05	High-Durability Coatings and Sealer Materials for Structural Concrete	\$350	TRTMT	17

\* INSP -- Inspection; TRTMT -- Specific treatment(s) or repair actions; MGMT -- Asset management or decision support.



# AASHTO Roadmap (2008)

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- **Decks and Joints research:**

ROADMAP ID	TITLE	COST (\$1000)	TYPE CODE*	RANK
Decks&Joints 01	Best Practices for Preserving Bridge decks	\$300	TRTMT	2
Decks&Joints 02	Determine the Recommended Practice and the Life-Cycle Cost Savings for Using Thin Overlays to Preserve Concrete Bridge Decks	\$900	TRTMT	14
Decks&Joints 03	Determine the Recommended Practice and the Life-Cycle Cost Savings for Using Sealers to Preserve Concrete Bridge Decks	\$500	TRTMT	15
Decks&Joints 04	Determine the Recommended Practice and the Life-Cycle Cost Savings for Preserving Superstructure and Substructure Elements Through the Use and Maintenance of Watertight Joints	\$500	TRTMT	12

\* INSP -- Inspection; TRTMT -- Specific treatment(s) or repair actions; MGMT -- Asset management or decision support.



# AASHTO Roadmap (2008)

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- **Research on Selection/Performance of preservation actions:**

ROADMAP ID	TITLE	COST (\$1000)	TYPE CODE*	RANK
Performance 01	Quantify the Information Necessary to Guide Bridge Preservation Decisions	\$1,125	MGMT	3
Performance 02	Develop Deterioration Models that Account for the Performance of Preservation Actions in Bridge Management Systems	\$300	MGMT	7
Selection 01	Implementation of Preservation Practices on Highway Bridges by State DOTs	\$500	MGMT	4
Selection 02	Develop Bridge Design Guidelines to Enhance Constructability and Maintainability	\$300	MGMT	5

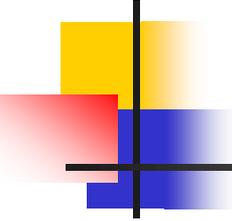
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# **AASHTO Roadmap (2008)**

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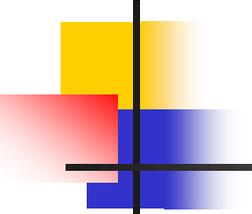
- **Observations from the AASHTO Roadmap (2008) list of 25 research need statements:**
  - **Only one Inspection type of preservation research but favored best by DOTs and with highest cost (\$2 million).**
  - **13 Treatment/Repair types of preservation efforts listed and cost an average of \$496,000.**
  - **11 Management type of efforts listed and cost an average of \$450,000.**



# Ongoing research

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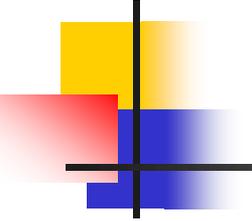
- Review based primarily on TRB's Research in Progress (RiP) website.
- May be a very limited source of information.
- 18 projects identified.
  - 4 are Inspection types of research.
  - 5 are Treatment/Repair types of research.
  - 9 are Management types of research.



# Ongoing research projects

## TRB Website Search -- Research In Progress (18 projects) (Keywords: "bridge" and "preservation")

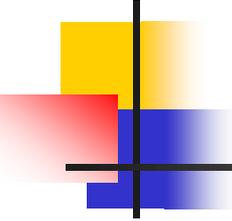
	Research Title	Funding	Start date	End date	Sponsor
1	The Rideability of a Deflected Bridge Approach Slab (LTRC Project 02-2GT Continuation: Phase II)	\$295,789	4/1/2011	3/31/2013	Louisiana Transportation Research Center
2	Guide for In-Place Preservative Treatment of Covered Bridges		2009	2010	National Center for Wood Transportation Structures
3	Synthesis of Wood Treatment Alternatives for Timber Railroad Structures	\$25,000	12/13/2010	12/31/2012	New Hampshire Department of Transportation
4	Development and Validation of a Predictive Settlement Model for Pile Driving in Silts		2010/12/31		University of Rhode Island, Kingston
5	Development and Validation of Deterioration Models for Concrete Bridge Decks	\$299,747	10/20/2009	8/15/2011	Michigan Department of Transportation
6	Bridge Replacement Program	\$135,000	7/1/2010	6/30/2012	Kentucky Transportation Cabinet
7	Comprehensive Bridge Deck Deterioration Mapping of Nine Bridges by Ground Penetrating Radar and Impact Echo	\$182,106	2009/7/29	12/31/2009	Iowa Department of Transportation
8	Developing Pontis Deterioration Models for Nebraska Bridges	\$32,917			Nebraska Department of Roads
9	Development of a Cost-Effective Bridge Preservation and Rehabilitation Program	\$196,300	9/1/2009	12/31/2011	Indiana Department of Transportation
10	Timber Abutment Piling and Back Wall Rehabilitation and Repair		3/1/2010	2/28/2012	Iowa Department of Transportation



# Ongoing research projects

## TRB Website Search -- Research In Progress (18 projects) (Keywords: "bridge" and "preservation") Cont'd.

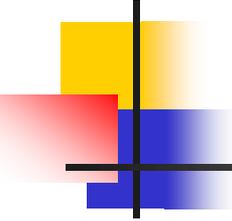
	Research Title	Funding	Start date	End date	Sponsor
11	Sealants, Treatments and Deicing Salt Practices to Limit Bridge Deck Corrosion	\$155,000	7/1/2009	6/30/2011	Kentucky Transportation Cabinet
12	Measuring Performance Among State DOTs, Sharing Best Practices' Preservation: Comparative Analysis of Bridge Conditions	\$75,000	9/3/2009	6/2/2010	National Cooperative Highway Research Program
13	Deterioration and Cost Information for Bridge Management		12/4/2008	10/12/2011	Colorado Department of Transportation
14	Validation of Rehabilitation Strategies to Extend the Service Life of Concrete Bridge Decks	\$398,537	10/1/2008	6/30/2011	California Department of Transportation
15	FHWA Long-Term Bridge Performance Program	\$25,000,000	1/4/2008	1/4/2013	Federal Highway Administration
16	Consequences of Delayed Maintenance	\$599,997	6/7/2010	6/6/2013	National Cooperative Highway Research Program
17	Resource Allocation Framework to Meet Highway Asset Preservation Needs	\$349,786	4/19/2010		National Cooperative Highway Research Program
18	Validation of Rehab Strategies to Extend the Service Life of Concrete Bridge Decks	\$569,339	7/1/2008	6/30/2011	California Department of Transportation



# **Suggested future research**

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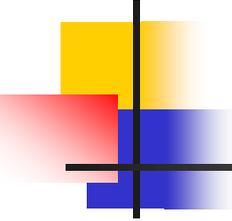
- **Need an integration of the three categories in bridge preservation.**
- **Management's models may make quantitative use of the results of evaluations done for specific repair or treatment techniques.**
- **Estimate the potential extension on service lives directly from studies done primarily on evaluation of the applied preservation treatments.**
- **Need studies to document savings due to early interventions in bridge preservation.**



# **Suggested future research**

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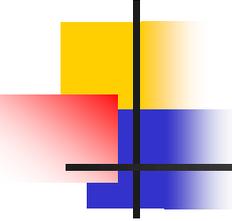
- **Need to incorporate more mechanistic aspects of bridge deterioration into the statistical models.**
- **Advanced inspection and monitoring or testing techniques collect detailed (mechanistic) data on strain, crack, etc..**
- **Existing statistical models (deterministic or stochastic) are based on indices or observed condition state distributions.**
- **Louinis and Madanat (2002) proposed a method of integration useable for bridge management.**



# Conclusions

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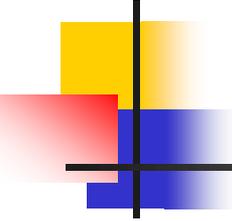
- Bridge preservation efforts can be classified as one or a combination of three types: Inspection; Treatment/Repair, or Management types.
- AASHTO Roadmap (2008) shows 25 research need statements but only one Inspection type of research.
- Ongoing research on bridge preservation is available through the TRB website, but may not be conclusive.



# Conclusions

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- **Suggested future research on bridge preservation includes:**
  - **Integrating inspection, treatment/repair, and management types of studies, i.e., share results.**
  - **Need for studies to document savings due to early interventions in bridge preservation.**
  - **incorporating more mechanistic aspects of bridge deterioration into the statistical models.**



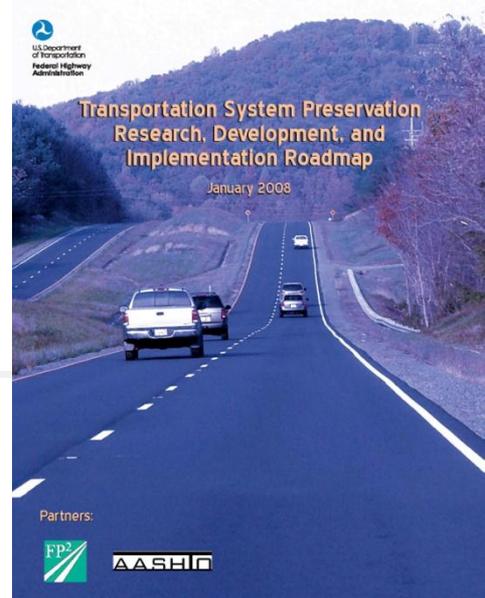
**THANK YOU!**

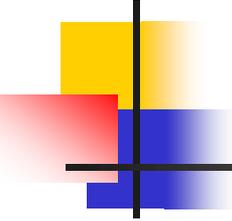
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**ANY QUESTIONS?**

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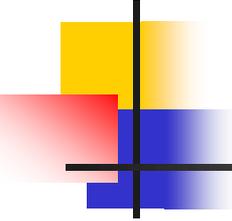


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