Federal Highway Administration's Role in Bridge Preservation

Anwar S. Ahmad[1]

Abstract

The purpose of this paper is to provide a brief overview of the bridge preservation efforts in the United States and briefly discuss key steps for implementing a successful bridge preservation program.

Introduction

State departments of transportation and other bridge owners are faced with significant challenges in addressing the Nation's highway bridge preservation and replacement needs.

According to the National Bridge Inventory, more than 30% of the approximately 607,000 highway bridges[2] nationwide have exceeded their 50 year design life[3] and are in need of repairs and or replacement; more than 25% are classified as deficient (structurally deficient or functionally obsolete)[4]. This issue is exacerbated by an increase in travel demands, shortfall in funding, and increasing costs of labor and materials. Due to these circumstances bridge owners are adopting cost effective bridge preservation strategies as part of their overall bridge management efforts.

Typically the term "bridge preservation" is associated with existing bridges. However, bridge preservation actions and strategies should be considered during all phases of a bridge's life, from the initial planning through design, construction, and its service life until the bridge is decommissioned. Considering preservation throughout these stages is essential to maximize the service life and minimize the overall lifetime cost of the bridge.

[1] Anwar Ahmad, Senior Bridge Engineer, US DOT, Federal Highway Administration, Office of Bridges and Structures, 1200 New Jersey Avenue, Washington, DC 20590; Telephone: (202) 366-8501; Email: Anwar.Ahmad@dot.gov

[2] FHWA maintains a national bridge inventory database that is updated on annual basis. Each state is required to inventory and inspect each bridge measuring a 20 feet (6 meters) minimum on regular basis in accordance with the United States Code of Federal Regulations, 23 CFR Part 650, National Bridge Inspection Standards.

[3] The theoretical design life of a bridge has been 50 years, but with the evolution of new design guidelines and construction materials the anticipated life for newly constructed bridges is 75 years or greater.

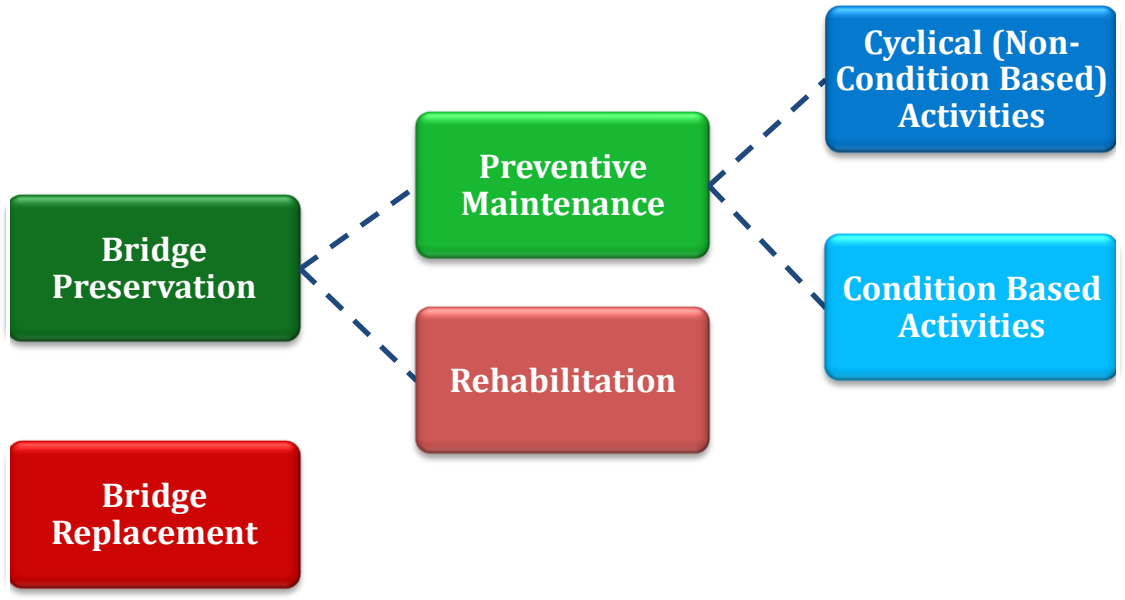
[4] Bridges are considered Structurally Deficient if significant load carrying elements are found to be in poor condition due to deterioration and/or damage, or the adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing overtopping with intolerable traffic interruptions.
Bridges are considered Functionally Obsolete (FO) when the deck geometry, load carrying capacity (comparison of the original design load to the current State legal load), clearance, or approach roadway alignment no longer meet the usual criteria for the system of which it is an integral part. In general, FO means that the bridge was built to standards that are not used today.

What is bridge preservation?

The FHWA defines bridge preservation as: actions or strategies that prevent, delay or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good condition and extend their life. Preservation actions may be preventive or condition-driven. This definition was adopted by the American Association of Highway Transportation Officials (AASHTO) in 2011.

Effective bridge preservation actions are intended to delay the need for costly reconstruction or replacement actions by applying preservation strategies and actions on bridges while they are still in good or fair condition and before the onset of serious deterioration. Bridge preservation encompasses preventive maintenance and rehabilitation activities.

Figure 1: Classification of Bridge Activities



As illustrated in figure 1, bridge preservation encompasses all activities that are essential to keep the bridge serviceable during its service life. In other words, bridge preservation entails performing all necessary activities to keep the bridge functioning as originally designed from the time the bridge is open to traffic until the time it's decommissioned. It is important to note that functional improvements such as major widening or raising the bridge to increase vertical clearance and complete replacement of a bridge fall outside of bridge preservation scope.

Why is it important to preserve bridges?

Studies (e.g., http://www.fhwa.dot.gov/Bridge/management/index.cfm) have shown that a bridge preservation strategy that employs the right treatments at the right times, is the most cost-effective strategy for the management of highway bridges. It costs less to maintain bridges in good condition than to maintain them in a deteriorated condition. Applying the wrong treatments or deferring maintenance altogether, leads to a major rehabilitation or possible

complete replacement. Managers are then hard pressed to find new sources of funding while struggling to keep bridges from being restricted or closed.

For example, a new bridge that is in good condition makes a good candidate for preventive maintenance (PM) activities. PM activities such as, bridge cleaning, lubricating bearing devices, waterproofing bridge deck, cleaning and/or resealing its expansion joints. These are very simple and relatively inexpensive activities that protect the bridge elements, prevent them from deterioration, and thus extending the service life of the bridge at a minim cost. If the same bridge is left without any maintenance, and as it continues to age, it will likely exhibits various deterioration mechanisms that calls for repairs, or major rehabilitation, or a complete replacement of the element or the entire bridge. These activities are much more expensive than preventive maintenance activities. They also require higher efforts in planning, engineering, and construction.

Bridge repairs and rehabilitation improve the condition of the bridge. Each repair adds to the length of time the bridge will remain in service. As the structure ages further, the condition drops and soon another repair or rehabilitation becomes necessary. Eventually, the deterioration becomes extensive and the structure has to be replaced.

More extensive rehabilitation, such as deck or superstructure replacement have a greater effect on the bridge condition, but are done less frequently. The deck may be replaced once during the life of the bridge. A second deck replacement project is not common as too many other elements of the bridge may also require replacement. At that point the service life of the bridge is reached. The bridge becomes a replacement candidate

Table 1: Benefits of Preventative Maintenance and Consequences of Deferred Maintenance

Consequences	Benefits
Worsening condition	Cost effective
Limited alternatives	Minimum traffic disruption
Higher cost	Lower user costs
	Public safety
	Reduce need to replace

Who is responsible for bridges and how is bridge preservation funded?

Bridge owners are responsible for inspecting, maintaining, and operating their bridges. Table 2 shows the number of bridges owned by the various entities. As shown in table 2, the Federal government owns only 1% of the bridges in the US, whereas the states and other local agencies within the states own the vast majority of the bridges. Each state is responsible for maintaining an inventory of all bridges within their states except for federally owned bridges, update this inventory and submit data electronically to FHWA annually.

Table 2: Number of bridges in the United States

	Number of Bridges by Owner						
	State	**County**	**City**	**Town**	**Other**[5]	**Federal**	**Total**
	283,995	227,221	44,377	29,886	13,314	8,958	**607,751**
Percent of total	47%	37%	7%	5%	2%	1%	

The FHWA monitors the conditions of the more than 607,000 bridges across the Nation. FHWA's National Bridge Inspection Program (NBIP) was established to assure the safety of the Nation's highway bridges and National Bridge Inspection Standards (NBIS) are an integral part of the program. The NBIS sets the national standards for the proper safety inspection and condition evaluation of all highway bridges by the States. The inspection data are used in preparing the biennial report to Congress on the "*Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance.*"

Between 2002 and 2011, bridge conditions improved overall, as the percentage of deck area on all bridges that were classified as "Structurally Deficient" fell from 10.3 percent (2003) to 7.7 percent (2013). Despite these improvements, significant challenges remain in addressing bridge deficiencies.

Table 3: Comparison of Count and area of bridges[6]

	2013	**2003**	**2013**	**2003**
	All Systems		**National Highway System**	
Number of Bridges	**607,751**	**592,337**	**140,238**	**114,677**
Structurally Deficient (SD)	63,522	82,283	6,348	6,733
Percent of total	10.50%	13.90%	4.50%	5.90%
Deck Area (million square meters)	**362.4**	**322.1**	**205.1**	**159.1**
Structurally Deficient (SD)	27.9	33.3	14	14
Percent of total	7.70%	10.30%	6.80%	8.80%

Federal-aid funds are made available to the States to help them in their preservation and other bridge management efforts aimed at maintaining a state of good repair of their bridges. The Moving Ahead for Progress in the 21st Century (MAP-21) legislation consolidated federal-aid funding programs and addresses bridge funding through eligibility in two core programs: the National Highway Performance Program (NHPP) and the Surface Transportation Program. The NHPP provides funding for the National Highway System (NHS) and makes bridges on that system eligible for funding. It also requires that the State meets minimum standards for bridge

[5] These include other entities such as State and Local Parks, Local Agencies, Toll Facilities, etc.
[6] Data obtained from the FHWA National Bridge Inventory

condition on the NHS such that no more than 10 percent of deck area may be structurally deficient. If the State does not meet that standard, it must spend a greater amount of money on bridges. The Surface Transportation Program provides flexible funding for bridges on any public road.

MAP-21 institutionalizes the need for performance outcomes and requires states to identify targets for each of the measures established by FHWA, including reports on progress in meeting those targets. If targets are not met over multiple years, the state must document actions they will take to achieve them. States are also required to develop asset management plans to maintain the highway assets in a state of good repair. If a state does not meet that standard, it must spend a greater amount of money on bridges.

In addition to federal-aid, the States use other state funding sources to address bridge needs including bridge preservation in an effort to maintain a state of good repair.

What are the key strategies for implementing a successful bridge preservation program?

Historically, most transportation agencies focused mainly on expanding the highway transportation system through new design and construction and with very little emphasis on maintaining and preserving the existing system. Most agencies budgets were historically based with little regard to key factors such as the size of the inventory, assets conditions, and other special needs. Most agencies are now transitioning to a more performance-based program where they are trying to strike a balance between new construction and preserving the existing system.

Implementing an effective bridge preservation program calls for appropriate tools and resources. And optimum results are achieved by applying the appropriate treatments/strategies at the appropriate time.

The FHWA Bridge Preservation Guide [7] contains some key steps that can assist bridge owners in developing and implementing a bridge preservation program. Following is a brief discussion on these steps.

Figure 2: Key program implementation steps

[7] FHWA Publication Number: FHWA-HIF-11042 "Bridge Preservation Guide - Maintaining State of Good Repair Using Cost Effective Investment Strategies"

Establishing Goals & Measures – As with any effective management program, a bridge preservation program should have goals and objectives. This is a key step in the development of a successful program as it serves as a compass for the journey ahead and a mirror that reflects on past performance. Some of the items that are generally considered during this step include:

- Current Condition of the Bridge Inventory
- Historical Condition and Funding Trends
- Available Resources
- Customers & Stakeholders Input

Identifying Preservation Activities – This involves the selection of proven and cost effective treatments and activities. Generally, preventive maintenance activities can be classified under two categories: 1) Condition based activities, such as sealing or replacing leaking deck expansion joint material, painting structural steel elements, installation of scour countermeasures, performing electro chemical extractions on heavily chloride contaminated concrete deck, etc.; and 2) Cyclical activities, such as bridge cleaning, lubricating bearing devices, sealing and waterproofing bridge decks, etc.

Some of the items that are generally considered during this step include:

- Activities that will facilitate achievement of goals
- Establishing condition threshold for bridge elements, components, or entire bridge. For example, bridges in overall fair to good condition
- Bridge material types
- Cyclical and Condition Based Activities
- Classifying these activities under two or three categories, i.e. preventive maintenance, rehabilitation, and replacement

Table 4: Condition thresholds and corresponding common work categories

Bridge Overall Condition	Feasible Work Category Candidate	Preservation?
Good	Systematic Preventive Maintenance (SPM)	Yes
Fair	SPM and or Rehabilitation	Yes
Poor	Rehabilitation or Replacement	Yes, if rehabilitation No, if Replacement

Determining Investment Levels – This involves estimating the cost of the work needed to achieve the established program goals. Some of the items that are generally considered during this step include:

- Data currency for bridge condition and unit costs
- Adequacy and sustainability of funding levels to achieve desired goal(s)
- Balancing investment levels for preservation and replacement needs

Selecting & Prioritizing Work Efforts – This involves selecting and prioritizing qualified projects based on the established program's parameters. Factors such as traffic volumes, detour lengths, risks, safety, etc. can be considered when developing a prioritization scheme.

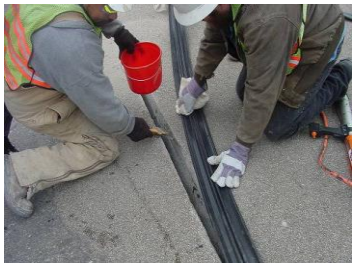
Developing & Executing Work Plans – This involves the development and execution of short and long term plans based on established goals and objectives. Key factors that are typically considered during this stage include:

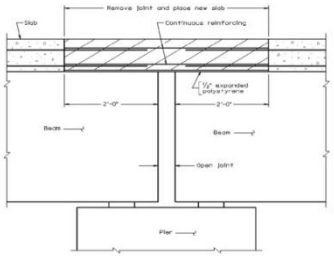
- Availability of funding
- Resources (in house vs. outsourcing)
- Environmental restrictions
- Work Zone Traffic restrictions
- Past Plan Delivery Performance

What are some of the commonly used bridge preservation treatments in the US?

There are various key preservation activities that are employed by bridge owners ranging from ordinary maintenance activities such bridge washing and cleaning to a more complex rehabilitation activities such as superstructure strengthening and deck replacements. The more popular activities involve preventive and protective types such as waterproofing bridge decks, replacing or sealing expansion joins devices, and structural steel coatings. Following are examples of preservation treatments that may be considered cost effective when applied to appropriate bridges at the appropriate time using quality material and workmanship:

1. **Seal or replace leaking joints or eliminate deck joints** - minimizes the deterioration of superstructure and substructure elements beneath the joints.



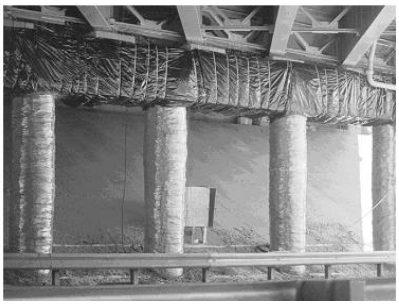
2. **Deck overlays** - significantly increase the life of the deck by sealing the deck surface from aggressive solutions and reducing the impact of aging and weathering. Overlay systems include waterproofing membrane with asphaltic concrete overlay, low permeability or high performance concrete overlays, and methyl methacrylate and polymer-system overlays.



3. **Cathodic Protection (CP) systems** - proven technology for stopping the corrosion of reinforcing steel.



4. **Electrochemical Chloride Extraction (ECE) treatment** - removes the chloride ions from the vicinity of the reinforcing steel and thus eliminates the source of corrosion.


5. **Painting/coating of structural steel** - protects against corrosion. Reduces the deterioration of the structural steel.

6. **Installation of scour countermeasures** - protects the substructure elements from undermining and failure due to scour.

7. **Removing large debris from channels** - prevents channel bed material from scouring.

8. **Installation of jackets with CP systems around concrete piles**– protects against corrosion and deterioration.

9. **Bridge cleaning and/or washing services** – cleaning of decks, joints, drains, superstructure, and substructure horizontal elements. Slows the deterioration of concrete and steel elements since debris, bird droppings, and contaminants in conjunction with water will accelerate the deterioration of concrete and steel elements. Histoplasmosis from bird droppings is a known health hazard to inspectors and maintenance personnel.



10. **Application of concrete sealants, coatings, and membranes for surface protection of the concrete** - protect the reinforcing steel from corrosion by stopping or minimizing the intrusion of water and chloride through the concrete.


Conclusion

Building an effective bridge management program entails a proactive and balanced approach. The program must include effective strategies and strikes a balance for the main work categories of preventative maintenance, rehabilitation and replacement.

Implementing an effective bridge preservation program calls for appropriate tools and resources. And achieving optimum results is accomplished by applying the appropriate treatments/strategies at the right time

Bridge Preservation Resources

AASHTO's TSP.2 – AASHTO has created the Transportation System Preservation Technical Services Program that provides services on pavement and bridge related preservation topics. The TSP.2 website contains large amount of technical information related to bridge and pavement preservation. **http://www.tsp2.org**

AASHTO Bridge Element Inspection Manual - Contains guidance on collecting element level inspection data. This manual is available for purchase at the following web site: https://bookstore.transportation.org/collection_detail.aspx?ID=97

FHWA Resource Center – The Structures Technical Services Team provides technical assistance, technology deployment and training. Information on the FHWA RC can be found at the following Web site:
http://www.fhwa.dot.gov/resourcecenter/teams/structures/index.cfm

FHWA Turner–Fairbank Highway Research Center - The FHWA Infrastructure Research and Development (R&D) program provides technologies and solutions to advance practices in highway infrastructure engineering. Information on the FHWA TFHRC can be found at the following Web site:
http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/index.cfm

FHWA Office of Bridge Technology - Offers assistance in the areas of bridge design, construction, inspection and preservation. Information on the FHWA Office of Bridge technology can be found at the following Web site: **http://www.fhwa.dot.gov/bridge/**

FHWA Office of Asset Management - Offers assistance in the areas of system preservation techniques, pavement and bridge management systems, and materials usage and economic analysis tools. Information on the FHWA Office of Asset Management can be found at the fol**lowing Web site : http://www.fhwa.dot.gov/infrastructure/asstmgmt/index.cfm**