INSTRUCTIONS AND INFORMATION

General

AASHTO has issued proposed interim revisions to *The Manual for Bridge Evaluation, Second Edition* (2010). This packet contains the revised pages. They are not designed to replace the corresponding pages in the book but rather to be kept with the book for fast reference.

Affected Articles

Underlined text indicates revisions that were approved in 2011 by the AASHTO Highways Subcommittee on Bridges and Structures. Strikethrough text indicates any deletions that were likewise approved by the Subcommittee. A list of affected articles is included below.

All interim pages are printed on pink paper to make the changes stand out when inserted in the second edition binder. They also have a page header displaying the section number affected and the interim publication year. Please note that these pages may also contain nontechnical (e.g., editorial) changes made by AASHTO publications staff; any changes of this type will not be marked in any way so as not to distract the reader from the technical changes.

Please note that in response to user concerns, page breaks are now being added within sections between noncontiguous articles. This change makes it an option to insert the changes closer to the affected articles.

Table i—2011 Changed Articles

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Add the following new Article:

2.4.3—Element Level Inspection

In 2010 the Subcommittee for Bridges and Structures (SCOBS) approved the AASHTO Guide Manual for Bridge Element Inspection. This Guide Manual is intended as a resource for agencies performing element level bridge inspection. It replaces the AASHTO Guide to Commonly Recognized Structural Elements (1994) and revisions in the future as a reference for standardized element definitions, element quantity calculations, condition state definitions, element feasible actions and inspection conventions.

The AASHTO Guide Manual for Bridge Element Inspection builds on the element level condition assessment methods developed in the AASHTO Guide for Commonly Recognized Structural Elements. Improvements have been made to fully capture the condition of the elements by reconfiguring the element language to utilize multiple distress paths within the defined condition states. The multi-path distress language provides the means to fully incorporate all possible defects within the overall condition assessment of the element. The overall condition of an element can be utilized in this aggregate form or broken down into specific defects present as desired by the agency for Bridge Management System (BMS) use.

The AASHTO Guide Manual for Bridge Element Inspection provides a comprehensive set of bridge elements that is designed to be flexible in nature to satisfy the needs of all agencies. The complete set of elements captures the components necessary for an agency to manage all aspects of the bridge inventory utilizing the full capability of a BMS.

The element set presented includes two element types identified as National Bridge Elements or Bridge Management Elements. The combination of these two element types comprise the full AASHTO element set.

National Bridge Elements

The National Bridge Elements represent the primary structural components of bridges necessary to determine the overall condition and safety of the primary load carrying members. The NBE’s are a refinement of the deck, superstructure and substructures condition ratings defined in the Federal Highway Administration’s Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges. The National Bridge Elements are designed to remain consistent from agency to agency across the country in order to facilitate the capture of bridge element condition in the National Bridge Inventory.

Bridge Management Elements

Bridge Management Elements include components of bridges such as joints, wearing surfaces and protective coating systems that are typically managed by agencies utilizing Bridge Management Systems. The Bridge Management Elements represent a recommended set of elements and corresponding condition assessment language that can be modified to suit the agencies needs.

Agency Developed Elements

Flexibility exists for an agency to establish custom elements in accordance with the defined element framework that can be subsets of National Bridge Elements, Bridge Management Elements or other defined elements without ties to the elements contained in the AASHTO Guide Manual for Bridge Element Inspection.

By defining a comprehensive set of bridge elements necessary for robust bridge management, the AASHTO Guide Manual for Bridge Element Inspection provides a flexible element set that can be tailored to the needs of all agencies in the country.
SECTION 3: BRIDGE MANAGEMENT SYSTEMS

Delete Section 3 entirely and replace it with the following:

SECTION 3: BRIDGE MANAGEMENT SYSTEMS

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3.1—INTRODUCTION

The transportation system in the United States has aged since the transportation investment boom of the post World War II era. Many transportation agencies have shifted away from expanding their infrastructure to a philosophy which preserves and maintains its existing infrastructure. State Departments of Transportation, and other bridge owners, currently face reduced staffing, budget constraints and increased expectations from the public.

Bridges, like other transportation assets, are no exception. They are also challenged to operate within a complex infrastructure, an increased public demand for accountability and a high expectation regarding level of service. In response, some transportation agencies are managing their inventory of bridges like a business. As a direct result, the emphasis on bridge management, and Bridge Management Systems, has been increasing over the last several years.

Bridge Management Systems combine management, engineering and economic inputs to enhance safety, preservation of existing infrastructure, and service to commerce and motorists. Although these systems can assist in making project-level decisions, they are fundamentally concerned with network analysis.

Therefore, an automated Bridge Management System does not make decisions. These systems should only provide objective and credible information which facilitates a dialogue between various stakeholders in order to achieve consensus regarding the decision-making process.

3.2—DEVELOPMENT OF A BRIDGE MANAGEMENT PROCESS

Public sector Bridge Owners have partnered with the private sector transportation industry to develop and implement Asset Management Concepts. In order for the bridge community at-large to properly implement Bridge Asset Management, both strategic and operational plans need to be developed. At a minimum, these plans will incorporate the following:

- Condition monitoring on a cyclical basis;
- Best-practices implementation with regards to construction materials and preservation treatment characteristics utilization;
- Prediction models pertaining to the future condition trends of both individual bridges and the bridge inventory as a whole; and
- Identification/prioritization of possible candidates for replacement, rehabilitation, preservation, and/or maintenance expenditures based on pre-determined goals and objectives.

Bridge management systems have been evolving since the early 1990s. Bridge management systems are helpful to identify current and/or future inventory...
deficiencies, estimate the backlog of investment requirements, project future requirements and develop cost–effective project prioritization candidates. In order for a bridge management system to be effective for an organization, it must attempt to answer these key questions:

- What are the goals, policies, and objectives?
- What should be included in the inventory of bridge assets?
- What is the past, current, and the predicted future condition of the bridge?
- How well does the bridge perform in the environment where it is located?
- What are the needs to preserve, maintain or improve the asset for maximum in-service life and performance of the bridge?
- What are the resources available to keep the bridge in service as long as possible?
- What are the options for investment within a bridge component class? What are the costs and benefits involved?
- What are the optimal options or combination of options available, that will maximize the return on investment?
- What is the consequence to the public and the transportation network if the bridge is not preserved?
- How do Bridge Owners monitor the impact of their decisions and policies?
- What options or combination of options inconvenience motorists the least?

In order for an organization to answer these questions, the following six institutional components must be addressed so that its Bridge Management System can function properly:

1. Definitions
2. Culture
3. Performance measures
4. Data collection
5. Models
6. Outcomes

Each of these institutional components will be explained in Section 3.3.

### 3.3—Essential Institutional Components of a Bridge Management System

It should be noted that the proper management of an organization’s bridge inventory includes other activities beyond just the use of analytical software. An organization should develop the six institutional components in order to define its Bridge Management Process. By properly addressing these components, the effectiveness of its bridge management activities will be
The six essential institutional components of a Bridge Management System are depicted in the following diagram:

```
Definitions

Outcomes

Culture

Models

Performance Measures

Data Collection
```

This diagram also illustrates the cyclical relationship of the six components. By fully utilizing these components appropriately, an organization can improve the performance of its bridge inventory.

### 3.3.1—Definitions

The establishment of definitions is critical in the development of a Bridge Management System. These definitions will not only provide a standardized understanding of the terms used within the context of the Bridge Management System but also the same understanding for both internal and external stakeholders. By having a common understanding of the information presented, discussions regarding bridge inventory prioritization will be more efficient and cost-effective. Definitions examples should include activity parameters such as capital investment, preservation, preventive maintenance, and reactionary maintenance—but each organization should develop its own list based on the goals and objectives of their Bridge Management System.

### 3.3.2—Culture

The operating culture within an organization is an essential component of its decision-making framework. How well the organization communicates, and shares, information both vertically and horizontally will affect the overall success of its Bridge Management System. Essential information must flow within the organization, and from the organization to external customers and stakeholders, in order to provide the necessary education and by-in required to adequately manage the bridge inventory.

Effective vertical communication channels between the various organizational levels will provide the necessary information to educate senior managers on the factors that influence decisions at the operational levels.

C3.3.1

The Subcommittee on Bridges and Structures, Technical Committee 9 – Bridge Preservation, has developed a glossary of terms that define bridge activities. These lists of terms were developed with the Subcommittee on Maintenance, Bridge Maintenance Task Force and Transportation System Preservation Technical Services Program (TSP-2) Bridge Preservation Expert Task Group.

This glossary is intended to be used by the bridge community for standard definitions development of bridge activities.
And, workers at the operational levels will have access to the information required to at least understand the correlation between the organization’s strategic goals and the factors involved with regards to a specific decision.

Effective horizontal communication is also critical to the organization’s decision-making process and management of its bridge inventory. Organizational functions, such as finance, planning and information services, must be also be comfortable with the bridge management decision-making process since they will have to incorporate and coordinate the required elements within their own work units.

3.3.3—Performance Measures

An interactive Bridge Management System requires feedback on the progress and return on investment of the bridge inventory it is intended to manage. Performance measures provide this feedback in a readily understandable format which is categorized and reported in a consistent standardized manner from one reporting period to another.

Examples of currently utilized industry performance measures include: number or percent of bridges rated in good, fair or poor condition, structurally deficient bridges, functionally obsolete bridges, National Bridge Inventory Sufficiency Rating, Bridge Health Index, and indices of multi-objective utility function(s). A Bridge Management System needs to be flexible with regards to both adding and eliminating performance measures depending on the requirements of an organization’s decision-making process and policy requirements.

3.3.4—Data Collection

Data collected for the Bridge Management System must be as accurate as possible. As a direct result, data collection procedures must take the necessary steps to insure adequate internal quality controls exist to ensure an agreed-upon level of accuracy. Collected data should be stored in a computerized database repository. By doing so, retrieval and analysis of the data can be more efficient and consistent.

As a direct result of the introduction of the National Bridge Inspection Standards (NBIS) Program, the United States bridge community has formally gathered National Bridge Inventory (NBI) and bridge safety data since the late 1970s. In the early 1990s, organizations realized a need for more granularity and condition information with regards to their bridge inventory. In response, AASHTO’s Guide Manual for Commonly Recognized Structural Elements (CoRe) was developed and implemented. This guide further defined inspection parameters when collecting bridge condition data.

The AASHTO Guide for Commonly Recognized Structural Elements (CoRe) was replaced in 2011 by the AASHTO Guide Manual for Bridge Element Inspection. In addition to the safety and condition information that was previously collected, bridge infrastructure owners
can now collect performance information on products and design details.

An interactive Bridge Management System also requires additional information derived from element deterioration models, cost data for identified work items, program budgets, recommended work items, performance measure thresholds, and condition improvements expected from predicted work items.

3.3.5—Models

Models located within the Bridge Management System facilitate the infrastructure investment decision-making process by providing the ability to articulate the impact of choosing one alternative over another by utilizing “what-if” scenarios. Three general modeling tools/methods are currently recognized by the bridge industry at-large. They are Engineering Economic Analysis, Forecasting Models, and Group Decision-Making Analysis.

Engineering Economic Analysis

Engineering Economic Analysis provides a broad range of tools which allow competing investment options to be considered and prioritized according to relative economic efficiency levels. These tools may include life-cycle cost analysis, benefit/cost analysis, multi-objective optimization/prioritization, and risk consideration/analysis. These tools attempt to identify the option that will achieve the established performance objectives at the lowest long-term cost or provide the maximum benefit for a given investment/funding level.

Forecasting Models

Credible forecasting models are a critical component of a successful Bridge Management System. These models can relate future investment levels to future condition and performance. For example, if inadequate routine maintenance, or deferred capital preservation, is being considered then these predictive forecasting models can provide information which can be used to assess the potential impact to the bridge inventory. At a minimum, an interactive Bridge Management System should include forecasting models that will provide information pertaining to bridge inventory condition deterioration, cost prediction and functional needs.

Group Decision-Making Analysis

The development of recommended alternatives and investment strategies pertaining to an organization’s bridge inventory can create potential adverse situations between competing objectives. For example, correlating an organization’s performance measure thresholds to proposed funding levels is one of the most common situations that will need to be addressed. But, by utilizing this category of tools correctly, all parties can participate in finding a solution to a given controversial situation.
3.3.6—Outcomes

The information extracted from a Bridge Management System needs to be consolidated and presented in a format that is consistent with the audience’s level of need. For example, decision makers may be looking for information regarding level of service, resource allocation and/or public feedback while a technical analyst may be looking for information pertaining to individual bridge current conditions and projected deterioration models for a specific time period which can then be utilized for project prioritization process development refinement. At a minimum, any Bridge Management System should be able to extract and report the following with regards to its organization’s bridge inventory: current and future conditions, resource needs over a specified time period, and recommended actions to achieve specific goals and objectives.

3.4—BRIDGE MANAGEMENT SYSTEM INFRASTRUCTURE

An effective Bridge Management System should be designed as a strategic planning tool for upper/top management, as well as, an engineering tool for technical decision makers. The system should be able to assist all stakeholders involved to understand and answer policy questions regarding the bridge inventory.

The following diagram depicts a basic Bridge Management System infrastructure:

But, in order for a Bridge Management System to be successful in meeting the information requirements of both upper/top management, and technical decision makers, the following four areas of concern need to be adequately addressed:
1. The relationship between a systematic process and a Bridge Management System.
2. The design of the database.
3. The evaluation and optimization approaches.
4. The reporting of the data and outcomes.

3.4.1—Systematic Process vs. Bridge Management System

Before beginning the task of designing a Bridge Management System, all stakeholders should have a clear understanding of the difference between a Systematic Process and a Bridge Management System. A Bridge Management System is a collection of numerous interacting systematic processes while a Single Systematic Process may be limited to a specific need or activity such as bridge rehabilitation or reactionary maintenance. As a direct result, other critical needs such as bridge replacement or bridge preventive-maintenance would not be included in the decision-making process. Since a Bridge Management System can be designed to optimize a collection of interacting systematic processes, all previously specified bridge inventory activities can be addressed and prioritized collectively.

In order for a systematic process to be credible, it must be developed and approved by all the stakeholders involved in the bridge inventory management process. At a minimum, six key attributes must be addressed by the group when approving a proposed systematic process:

1. Define how the needs are identified.
2. Outline how the needs are prioritized and programmed.
3. Define the outcome or goal, including resources necessary with timeframes to reach the outcome or goal.
4. Demonstrate that the proposed activity is a cost-effective means of extending the service life of the bridge.
5. Dedicate resources necessary to reach the defined outcomes and/or goals.
6. Annually track, evaluate, and report on the progress in reaching outcomes and/or goals and evaluate resource requirements accordingly.

By utilizing at least these six key attributes, an organization can develop and institutionalize credible systematic processes for use by its Bridge Management System.

3.4.2—Database

At the center of any interactive Bridge Management System is a computerized comprehensive database that contains both spatial and relational data. The Bridge Management System software must have the ability to edit and update the database as required.

Spatial data provides unique information pertaining to each bridge inventory location. This information is
used by operational level personnel to consistently locate
and input the specific relational data for each bridge
inventory record into the database.

Relational data requirements are more
comprehensive in nature than spatial data requirements
but they need to be defined so as to support all of the
organization’s internal processes. At a minimum, the
relational data element information that is required to be
collected is defined in the National Bridge Inventory
Program from FHWA and the AASHTO Guide Manual
for Bridge Element Inspection. In addition, the database
needs to be able to store more detailed safety, inventory
and condition data pertaining to the elements of each
structure within the bridge inventory depending on
information required by the individual organization.

The database should be able to extract, and store,
information from other organizational asset management
systems, analysis processes and forecasting models.
Examples of additional database items can include:
detailed supplemental/special inspection information,
deterioration model parameters, cost information, level-
of-service criteria, construction/maintenance project
scheduling/completion information and State
Transportation Improvement Program (STIP)
information.

3.4.3—Alternative Evaluation and Program
Optimization Approaches

Economics, engineering, and sound management
principles all play an essential role with an
organization’s bridge management process. As a direct
result, Bridge Management Systems have evolved over
time in order to assist in the allocation of limited funding
and resources. Since the allocation of limited funding to
competing objectives is basically an economic problem,
economic analysis tools, coupled with program
optimization approaches, will need to be incorporated
into any successful Bridge Management System.

At least three types of evaluation/optimization
systematic processes will need to be utilized by an
organization’s Bridge Management System in order to
meet its desired bridge management goals and
objectives. The three types of evaluation/optimization
systematic processes are (1) Forecasting of Future
Condition, (2) Resource Needs, and (3) Optimization
Approaches.

Forecasting of Future Condition

An organization needs to develop a long-term
philosophy with regards to the economic life of its bridge
inventory so that future costs and benefits of its bridge
policies can be evaluated. Both short-term and long-term
costs need to be properly presented so that the most
cost-effective decision possible can be made. In order to
develop credible cost estimates for both short-term and
long-term estimating, a Bridge Management System
needs to utilize information derived from element level
deterioration models.

C3.4.3

NCHRP Report 590 — Multi-Objective Optimization
for Bridge Management Systems, give guidance and
process to develop utility functions that can be used for
individual and aggregated reporting and performance
measures. These functions can be used for level-of-
service thresholds with influence in project and program
development.

In addition to the utility functions for performance
measures, AASHTO’s Guide Manual for Bridge Element
Inspection has been streamlined to give intuitive
reporting with minimal understanding of the condition
language. All of the elements have been reduced to four
condition states. These condition states have the same
general condition description. The general condition
language describes the four states as good, fair, poor,
and severe.
Element level deterioration models primarily aid in prediction of the future condition of the bridge inventory. Typically, these models predict the future condition of key elements of a specific structure, and the total structure with the effect of intervening and no-intervening actions. Deterioration models can also be used to estimate the service life of new bridges, the remaining life of in-service bridges and the extension in service-life if various maintenance, preservation or rehabilitation actions are proposed.

Historically, deterioration models have been developed using the following two methodologies:

1. Expert Elicitation; and
2. Leveraging Inspection Data Over Time.

**Expert elicitation** is the most commonly used deterioration model methodology. This methodology is implemented when limited in-service bridge inventory data is available. Under this method, the institutional knowledge of an organization’s bridge engineers and inspectors is fully utilized within the deterioration model. Their expert recommendations are incorporated into the model depending on the desired outcome of the assumptions provided for the structure or structures.

**Leveraging Inspection Data Over Time** is the second deterioration model methodology. This methodology leverages inspection information trends and extrapolates future infrastructure element behavior over specified time periods. Since this methodology relies on more than just expert recommendations, the historical data information requirements are significantly more. To maximize the effectiveness of this deterioration model, the following information will be required: many cycles of historical inspection data; knowledge of any historical intervening actions; the age of the infrastructure elements/components; projected traffic activity for the time periods specified; and, any environmental factors that could influence the rate of deterioration. When applied properly, this methodology can provide a more empirical justification for the decisions made with regards to the organization’s bridge inventory rather than just relying on expert recommendations.

**Resource Needs**

For most organizations, the most limited resource available to maintain a bridge inventory is usually monetary in nature. Any successful Bridge Management System will need to be able to incorporate the effect of both agency costs and user costs into its systematic processes.

**Agency costs** normally pertain to any action ranging from the maintenance of individual elements to full replacement of the infrastructure. It should be noted that the initial cost of construction should not be the only cost considered for any bridge inventory asset during its service life. Any type of investment that will extend the long-term operation of the bridge inventory should be
considered. Estimating these types of costs is usually based on historical data along with engineering judgment.

**User costs** quantify accident, travel time and motor vehicle operating costs due to structural and/or functional deficiencies within the bridge inventory. An organization’s Bridge Management System will need to have the capability to estimate user costs applicable to varying levels of load capacity, clear deck width and vertical clearances.

**Optimization Approaches**

A manual or judgmental approach to project selection/scheduling may not be effective, if an organization’s bridge inventory is large in number and/or the economic trade-offs are complicated. If an economic component is not present, decisions tend to become subjective in political arenas which may result in monetary allocations that maximize project-level benefits instead of system-level benefits. Therefore, an organization’s Bridge Management System should have program planning tools that optimize the selection and scheduling of projects along with the ability to allocate funding at the system level. The optimization approaches need to adequately weight economic concerns, minimize both agency and user costs, utilize performance measures and be an important component of the organization’s decision-making process.

In order to accurately estimate the “return-on-investment” for an organization’s bridge inventory, performance measures need to be established based on standardized measurable criteria. By optimizing competing performance measures, an organization can determine the best overall investment strategy applicable to the bridge inventory at the network level and potentially distribute the monetary expenditures over a period of time.

The following is list of generally accepted bridge management performance measure categories that have been historically used in a variety of Bridge Management Systems:

**Bridge Condition and Serviceability**

Within this category of bridge management performance measures, three sub-categories are widely utilized by the bridge community at-large. These three performance measure indicators are Condition Ratings, Sufficiency Ratings, and the Bridge Health Index.

**Condition Ratings** are used to describe the current in-place status of a component of a bridge asset. The existing condition of a bridge component is compared to an as-new condition. Condition Ratings provide an overall classification of the general condition of the entire bridge component being rated not just localized individual conditions. According to National Bridge Inspection Standards (NBIS), three primary components of a bridge are used to classify structural deficiencies. They are the deck, superstructure and substructure.
Culvert-type structures have their set of condition ratings which are unique to this type of infrastructure.

**Sufficiency Ratings** is a method of evaluating bridge data by calculating four separate factors to derive a numerical rating which indicates a bridge’s sufficiency to remain in service. The four factors utilized are a bridge’s structural adequacy and safety, essentiality for public use and its serviceability and functional obsolescence.

**Bridge Health Index** is a normalized weighted average of various element conditions which provides an overall indication of the health of the structure. A numerical ranking is assigned to each element based on its element condition rating then weights are assigned to each element based on economic importance such as element failure consequences or the impact of long-term user or agency costs.

**Remaining Service Life**

The Remaining Service Life performance measure is typically measured in years and refers to the time remaining for the overall bridge asset condition to reach some pre-defined terminal value where a major improvement will be required to extend the bridge asset’s useful remaining service life. A major improvement typically refers to rehabilitation or reconstruction activities of either an element or elements of a bridge asset. The Remaining Service Life performance measure can be applied to both individual bridge assets or to a network of bridge assets. When applied to a network, an Average Remaining Service Life will be derived and utilized.

**Life-Cycle Costing**

**Life-Cycle Costing** has been widely accepted by the bridge community at-large as a performance measure. There may be significant data limitations in most agencies that may preclude the routine use of life-cycle cost analysis. As long term collection of the necessary data improves, life-cycle cost analysis will be a more useful tool in bridge management decision making. Life-Cycle Costing methodology assists in the evaluation of the overall long-term efficiency between competing investment strategy decisions. Basically, this analysis tool provides a standardized procedure for evaluating the economic worth of a project(s), or investment(s), by discounting the future costs (agency and/or user) over the life of the project(s) or investment(s).

Organizations that utilize Life-Cycle Costing should take the necessary steps to develop and standardize its process to address the following key elements of the calculation:

- How agency and/or user costs will be quantified;
- How salvage values and remaining useful life will be estimated;
- How the cost and effectiveness of maintenance
activities will be estimated;
- How bridge deterioration will be quantified; and
- How travel demand and associated costs will be estimated for various periods of time.

**Economic Return**

*Economic return* as a performance measure refers to the level of economic benefit, or economic loss, that could be derived from an estimated level of investment or estimated level of non-investment such as a cost deferment strategy. Within the context of infrastructure management, economic return is typically depicted using benefit-cost ratios, net present values, and/or equivalent uniform annual returns.

**Risk and Vulnerability**

Risk and vulnerability assessment provides a means for bridge owners to systematically review and manage the vulnerability of bridges (i.e., catastrophic failures) along with the criticality or importance of the bridge to the community. Risk assessment can be used when the original design has become inadequate or become vulnerable to various failure modes, and it can be used to prioritize projects when funding becomes limited.

Organizations have flexibility when choosing the best tools and techniques to incorporate into the design of their Bridge Management System. But, in the end, either a top-down or a bottom-up approach to program planning will be implemented.

A top-down approach will begin with an analysis of network-wide goals and constraints which will result in general network-wide optimization policy. Then, this policy is used to allocate funds to competing projects based on either maximizing net benefits or minimizing total costs. This fund allocation then guides project-level decisions applicable to specific bridges.

A bottom-up approach begins with finding optimal actions on individual bridges applicable to different level-of-service standards. Then, the approach combines the bridges to determine the total cost of each standard and compares the totals to the policy constraints. When utilizing this approach, the capability to analyze multiple sets of standards in order to determine the best one possible within available funding limits is critical to its overall effectiveness and success.

Whether a top-down or bottom-up approach is implemented, an organization’s Bridge Management System should have the capability to develop optimization approaches utilizing both unconstrained and constrained funding allocations. Unconstrained funding allocation scenarios provide valuable information pertaining to when selected alternatives should be optimally scheduled in order to maximize the return on investment and/or minimize future costs. When adequate funding is not available to maintain a desired level of service, constrained funding allocation scenarios can determine the economic consequences of providing a
lower level of service in terms of both agency and user costs which can provide objective guidance for setting priorities for the bridge inventory.

In addition, an effective Bridge Management System should have the capability to determine the overall effect, to both the individual bridge and the bridge inventory network, when a scheduled activity on a bridge, or bridges, is delayed.

Information from the Bridge Management System’s deterioration models, economic cost models, traffic growth projections and impacts to the public can be extracted and used to determine an alternate set of actions. By developing period-by-period project deferral scenarios, multi-year programs can be generated.

3.4.4—Reporting of Data and Results

An effective Bridge Management System should have the capability to produce a variety of output reports in both graphic and tabular formats. At a minimum, the system should be able to generate reports pertaining to the input data, intermediate results determined to be important such as results of calculations or formulas pertaining to individual performance measures and the final results of its optimization approaches with regards to bridge inventory program scheduling. These reports can then be used to evaluate and support an organization’s decision-making process to both internal and external stakeholders.

3.5—CONCLUSION

A properly designed and implemented Bridge Management System can provide increased efficiency with regards to developing maintenance/rehabilitation/replacement programs and budgets. It can also provide essential information to organizations in order to increase safety and extend the service life of its bridge inventory. But, ultimately, an effective Bridge Management System will provide an organization the ability to illustrate when, why and how their resources were committed to both internal and external stakeholders.

3.6—REFERENCES


SECTION 4: INSPECTION

4.4.3—Inspection Team Leader

Add the following commentary to this Article:

C4.4.3

As described in this article and the CFR, bridge inspector team leaders can be engineers or nonengineers with appropriate licensure, certification, training and experience. Highway bridge owners have bridges with varying degrees of complexity, and it is recognized that a team approach of engineer and nonengineer bridge inspector team leaders has been effective to plan and perform bridge inspections, and proper training and experience are of principal importance for both engineer and nonengineer bridge inspector team leaders.
SECTION 6: LOAD RATING

6A.6.12.5—Riveted Connections

Delete the text of this Article and replace it with the following:

Riveted connections shall be evaluated as bearing-type connections.

6A.6.12.5.1—Rivets in Shear

The factored resistance of rivets in shear shall be taken as:

\[ R_n = \phi_s F_u R_1 R_2 m A_r \] (6A.6.12.5.1-1)

where:

- \( \phi_s \) = Resistance factor for rivets in shear, taken as 0.80
- \( F_u \) = Rivet ultimate tensile strength (ksi)
- \( R_1 \) = Shear/tension ratio, taken as 0.67
- \( R_2 \) = Joint length factor, taken as \( 1 - (0.25L/50) \) for \( 0 \leq L \leq 50 \) in., \( 0.75 \) for \( L > 50 \) in.
- \( L \) = Connection length between extreme fasteners in each of the spliced parts measured parallel to the line of axial force, for splices, the 50-in. length is to be measured between the extreme bolts on only one side of the connection.
- \( m \) = The number of faying surfaces
- \( A_r \) = Cross-sectional area of the rivet before driving (in.\(^2\))

Where rivets carrying loads pass through undeveloped fillers 0.25 in. or more in thickness in axially loaded connections, their shear resistance shall be further reduced by the Undeveloped Filler Plate Reduction Factor, \( R_3 \) taken as:

\[ R_3 = \frac{1 + \lambda}{1 + 2\lambda} \] (6A.6.12.5.1-2)

Otherwise, \( R_3 \) shall be taken as 1.0.

in which:

\[ \lambda = \frac{A_f}{A_p} \] (6A.6.12.5.1-3)

where:

- \( A_f \) = Sum of the area of the fillers on the top and bottom of the connected plate (in.\(^2\))
\( A_p = \) Smaller of either the connected plate area or the sum of the splice plate areas on the top and bottom of the connected plate (in.\(^2\))

The values in Table 1 may be used for \( \phi F_u R_1 R_2 \) unless more detailed information is known regarding the rivet’s ultimate tensile strength.

**Table 6A.6.12.5.1-1—Factored Shear Strength of Rivets: \( \phi F_u \)**

<table>
<thead>
<tr>
<th>Rivet Type or Year of Construction</th>
<th>( F_u ), ksi</th>
<th>( \phi F_u R_1 )</th>
<th>( \text{if } L \leq 50 \text{ in.}, \phi F_u R_1 R_2 )</th>
<th>( \text{if } L &gt; 50 \text{ in.}, \phi F_u R_1 R_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown rivet type and origin</td>
<td>50</td>
<td>27</td>
<td>Varies</td>
<td>20</td>
</tr>
<tr>
<td>Carbon Steel, ASTM A 141, or</td>
<td>60</td>
<td>32</td>
<td>Varies</td>
<td>24</td>
</tr>
<tr>
<td>ASTM A 502 Grade I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM A 502 Grade II</td>
<td>80</td>
<td>43</td>
<td>Varies</td>
<td>32</td>
</tr>
</tbody>
</table>

C6A.6.12.5

Revise this Article as follows:

Factored resistance values for rivets are based on AASHTO Standard Specifications, Article 10.56.1. Refer to the AASHTO LRFD Specifications Article 6.13.6.1.5—Fillers and commentary for more information regarding filler plates.

If rivets are of unknown origin or if more rigorous testing is necessary to determine the Ultimate Tensile Strength of the rivets, the use of chemical testing of the rivet may be considered to determine the carbon equivalent and corresponding ASTM specification or grade.

**6B.5.3.1—Structural Steel**

Revise paragraph 3 as follows:

The Operating rating for welds, bolts, and rivets should be determined using the maximum strengths from Table 10.56A 6B.5.3.1-1 in the AASHTO Standard Specifications.

Add the following after the last paragraph of this Article as follows:

Where rivets carrying loads pass through undeveloped fillers 0.25 in. or more in thickness in axially loaded connections, Refer to Article 6A.6.12.5.1 and AASHTO LRFD Article 6.13.6.1.5 for a potential capacity reduction factor.

Add the following Table 6B.5.3.1-1 after the last paragraph of this Article as follows:
## Table 6B.5.3.1-1—Design Strength of Connectors

<table>
<thead>
<tr>
<th>Type of Fastener</th>
<th>Strength ($\phi F$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groove Weld$^a$</td>
<td>$1.00 F_y$</td>
</tr>
<tr>
<td>Fillet Weld$^b$</td>
<td>$0.45 F_u$</td>
</tr>
</tbody>
</table>

### Low-Carbon Steel Bolts

- **ASTM A 307**
  - Tension: 30 ksi
  - Shear on Bolt with Threads in Shear Plane$^d$: 18 ksi

### Power-Driven Rivets$^f$

- **ASTM A 502**
  - $\phi F_{vu}$ Shear—Grade 1: 32.0 ksi
  - $\phi F_{vu}$ Shear—Grade 2: 43.0 ksi

- **ASTM A 141 or Carbon Steel**
  - $\phi F_{vu}$ Shear: 32.0 ksi

### Rivets$^f$

- Unknown rivet type and origin $\phi F_{vu}$: 27.0 ksi

### High Strength Bolts

- **AASHTO M 164**
  - (ASTM A 325)
    - Applied Static Tension$^c$: 68 ksi
    - Shear on Bolt with Threads in Shear Plane$^{c,d,e}$: 35 ksi

- **AASHTO M 253**
  - (ASTM A 490)
    - Applied Static Tension: 85 ksi
    - Shear on Bolt with Threads in Shear Plane$^{c,d}$: 43 ksi

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$^a$ $F_y$ = yield point of connected material.

$^b$ $F_u$ = minimum strength of the welding rod metal.

$^c$ The tensile strength of M 164 (A 325) bolts decreases for diameters greater than 1 inch. The design values listed are for bolts up to 1-inch in diameter. The design values shall be multiplied by 0.875 for diameters greater than 1 in.

$^d$ For bolts, the tabulated values shall be reduced by 20 percent in bearing-type connections whose length between extreme fasteners in each of the spliced parts measured parallel to the line of axial force exceeds 50 in. For flange splices, the 50-in. length is to be measured between the extreme bolts on only one side of the connection.

$^e$ If material thickness or joint details preclude threads in the shear plane, multiply values by 1.25.

$^f$ For rivets, tabulated values shall be reduced by a reduction factor for length in bearing-type connections. When the length (L) between extreme fasteners in each of the spliced parts measured parallel to the line of axial force is less than or equal to 50 in., the reduction factor shall be determined from the following variable reduction equation $1-(0.25L/50)$. Tabulated values shall be reduced by 25 percent in bearing-type connections whose length between extreme fasteners in each of the spliced parts measured parallel to the line of axial force exceeds 50 in. For flange and other splices, the 50-in. length is to be measured between the extreme rivets on only one side of the connection.