DEPARTMENT OF THE ARMY
Corps of Engineers
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CECW-EC

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Engineering and Design
INSPECTION AND EVALUATION OF USACE BRIDGES

1. Purpose. This manual provides guidance for inspecting and evaluating bridges owned by the U.S. Army Corps of Engineers (USACE). Bridges on military installations are covered under the Unified Facilities Criteria 3-310-08.

2. Applicability. This manual applies to all Headquarters, U.S. Army Corps of Engineers (HQUSACE) commands having civil works responsibilities. The user of this Engineer Manual (EM) is responsible for seeking opportunities to incorporate the Environmental Operating Principles (EOPs) wherever possible. A listing of the EOPs is available at: https://www.usace.army.mil/Missions/Environmental/Environmental-Operating-Principles/

3. Distribution Statement. Approved for public release; distribution is unlimited.

4. References. Appendix A lists required and related publications.

5. Records Management (Recordkeeping) Requirements. Records Management (Record Keeping) requirements. Records management requirements for all record numbers, associated forms, and reports required by this regulation are included in the Army's Records Retention Schedule – Army (RRS-A). Detailed information for all record numbers, forms, and reports associated with this regulation are located in the RRS-A at https://www.arims.army.mil.

6. Discussion.

a. This manual covers requirements for implementing inspection and evaluation of bridges as defined by, and according to, Engineer Regulation (ER) 1110-2-111, USACE Bridge Safety Program. These procedures are in compliance with 23 Code of Federal Regulations (CFR) 650, the National Bridge Inspection Standards (NBIS), and 49 CFR 237, Bridge Safety Standards, and are essential for managing risk and ensuring the safety of the public and USACE personnel.

b. Industry and regulatory requirements from the American Association of State Highway Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), the Federal Railroad Administration, and American Railway Engineering and Maintenance-of-Way Association (AREMA) have been adopted as applicable.

FOR THE COMMANDER:

2 Appendixes
(See Table of Contents)

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Contents

Contents--Continued

Contents--Continued

Contents--Continued

Table List

Figure List

Chapter 1
Introduction

1.1. Background.

1.1.1. The primary purpose of the USACE Bridge Safety Program is to ensure the USACE bridge inventory is safe for the intended purpose. A secondary purpose is to identify maintenance and repair items. A team of individuals representing Engineering, Operations, and Management functions of USACE Districts, Divisions, and HQUSACE is responsible for implementing this program.

1.1.2. The National Bridge Inspection Standards

a. Under the NBIS, "Federal agencies must inspect, or cause to be inspected, all highway bridges located on public roads that are fully or partially located within the respective agency responsibility or jurisdiction." USACE has entered into agreement with the FHWA to ensure compliance with the NBIS. The purpose of this agreement is to help ensure safety of bridges on public roads under the jurisdiction of the U.S. Government. Under this agreement, USACE is responsible for meeting the staffing, inspection, and reporting requirements prescribed in the NBIS and related documents.

b. USACE will identify all bridges subject to the NBIS for which USACE is responsible, provide an error-free Inventory Data as determined by the FHWA Edit/Update Program, document the NBIS processes and the Quality Assurance/Quality Control (QA/QC) procedures used to monitor the bridge inventory and inspection processes, and submit the Inventory Data annually to the FHWA. Under this agreement, FHWA will ensure compliance with the NBIS and will provide other assistance as agreed upon between USACE and the FHWA.

1.1.3. Districts with railroad bridges in their inventory must establish a bridge safety management program according to 49 CFR 237. Elements of the program include a record of the safe load capacity of each bridge, a provision to obtain and maintain the design documents of each bridge, documentation of all repairs or modifications, and development of a bridge inspection program. This manual provides the guidelines on how USACE complies with 49 CFR 237. See ER 1110-2-111 for qualification, inspection, and load rating requirements.

1.1.4. Bridge Safety Program inspection and evaluation personnel include the HQUSACE Bridge Safety Program Manager (BSPM), Major Subordinate Command (MSC) BSPM, District Chiefs of Engineering Functions, District BSPM, inspection team members, Responsible Engineers, and all support personnel. These individuals, along with Business Line Managers, operations personnel, and program personnel, comprise the USACE Bridge Safety Program Team. Each member of the team must be qualified for the tasks that the individual performs within the team. Qualifications and responsibilities are defined in ER 1110-2-111, and additional specific requirements are provided within this manual.

1.2. General Requirements.

1.2.1. USACE requirements for ensuring compliance with the NBIS and FHWA guidelines are contained within ER 1110-2-111 and this manual. The agreement with FHWA is for public roadway bridges, defined as "A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passage way for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 ft. between under copings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening."

1.2.2. ER 1110-2-111 also contains USACE requirements for all other bridge types including railroad, nonpublic access, and pedestrian bridges. Each district is required to maintain their bridge inventory in compliance with ER 1110-2-111 and the NBIS as applicable.

1.2.3. This manual will be used in conjunction with ER 1110-2-111 and provides more detailed procedures and guidance than the ER. This manual establishes a program for regular and comprehensive inventory, inspection, evaluation, recording, and reporting of all USACE bridges. This document will be updated to incorporate periodic revisions based on the practices outlined by FHWA and USACE.

1.3. Scope. This manual provides specific requirements, detailed procedures, and best practices for conducting inspections and evaluations of USACE bridges. Much of this guidance is based on FHWA, AASHTO, and other referenced industry standards. This manual is not intended to duplicate the information in its entirety. Therefore, the associated references should be read and followed in conjunction with this manual. Where there is conflict between this manual and referenced standards, this manual will take precedence.

1.4. Computer Programs.

1.4.1. The USACE Bridge Safety Program utilizes the Corps of Engineers Bridge Inventory System (CEBIS) at https://cebis.usace.army.mil. CEBIS is a web-based program used to maintain all inventory data; design, construction, and repair documents; annual Program Management Plans (PgMPs); inspection, safety, and critical findings plans; CEBIS generated inspection reports, load ratings, scour evaluations, and other evaluations; and listings of current recommendations, including budgetary cost estimate and information on relative risk.

1.4.2. CEBIS must be used as the database for storing all required information for USACE bridges meeting the definitions provided in ER 1110-2-111.

1.4.3. The Facilities and Equipment Maintenance (FEM) system should be used to schedule and track all inspection, maintenance and repair activities for USACE bridges. Bridge Safety Program personnel will coordinate with appropriate Operations personnel to ensure current and correct information is entered.

1.5. Mandatory Requirements. The terms “must,” “must not,” “will,” and “will not” and imperative mood are used to convey mandatory requirements throughout this manual. The term “should” is used to convey a strong recommendation for following a procedure or best practice.

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Chapter 2
Inspection Types and Intervals

2.1. Background. There are seven types of bridge inspections defined in the AASHTO Manual for Bridge Evaluation (MBE): Initial, Routine, In-Depth, Fracture-Critical Member, Underwater, Special, and Damage Inspections. USACE adds an additional type: Complex Bridge and Special Feature Inspections. Each inspection type is described in the paragraphs that follow. See ER 1110-2-111 for inspection interval requirements.

2.2. Initial Inspection.

2.2.1. Scope.

a. The Initial Inspection is a detailed inspection conducted after construction of a new bridge or after major rehabilitation of an existing bridge. Use the documented condition of the bridge from the Initial Inspection to compare the condition of the bridge in all future inspections.

b. Collect and document the following data during the Initial Inspection:

(1) Structure Inventory and Appraisal data required by federal and USACE regulations.

(2) Baseline structural conditions and quantities.

(3) Existing or potential problems and identification of associated locations.

(4) Relevant information required to construct an accurate bridge file (see Chapter 6: Bridge Management System).

(5) Load Rating Report (see Chapter 7: Load Rating Procedures).

(6) Location and condition of fracture critical members, fatigue sensitive details, or fracture susceptible details (see Chapter 8: Fatigue and Fracture).

(7) Scour Evaluation Report (see Chapter 9: Scour Evaluations and Plans of Action).

(8) Seismic Vulnerability Evaluation Report (see Chapter 11: Seismic).

(9) Future inspection types and schedules.

2.2.2. Precision. Conduct the Initial Inspection within arm’s length of all members. Document the size and location of all deficiencies including construction errors, misalignments, and damage. Review all available construction or repair documentation prior to the inspection to aid in the recording of data and identifying critical areas. Identify critical findings according to Chapter 4: Critical Findings.

2.3. Routine Inspection.

2.3.1. Scope. Routine Inspections are regularly scheduled inspections to determine the physical and functional condition of the structure and to identify any changes from the Initial Inspection or from previously recorded Routine Inspection conditions.

2.3.2. Precision.

a. Routine Inspections should be conducted from the bridge deck, ground, water level, or from permanent work platforms and walkways, if present. Conduct close-up inspection of critical load-carrying members, failure-prone details or elements, and any element of the bridge that appears to be distressed. Periodically provide close-up inspection of all elements regardless of condition or importance. Obtain measurements to adequately quantify distressed areas.

b. For bridges crossing waterways, conduct inspection of underwater portions of the substructure during low-flow periods without exceeding the required inspection interval. Use visual and probing methods when safe and feasible. Probing is conducted using a rod or sounding pole to identify magnitude and extent of scour and undermining. Visually inspect areas above and directly below the waterline where visibility permits. Do not wade in unsafe conditions such as deep water, poor water visibility, excessively soft or irregular streambed conditions, or swift currents that make movement difficult or dangerous. See Section 2.6.1 for guidance and procedures related to wading or diving inspections.

c. Fully document all inspection results on a standard inspection report form. Record cross-sections upstream and downstream of the bridge during routine inspections and compare to past cross-sections to monitor changes in the channel. Note conditions that have changed since the previous inspection. Notify the District BSPM when a change in condition reduces the load capacity of a member and a new load rating may be required. Update all appraisal items when necessary.

d. Inspect the site for user safety. The following are examples of conditions that may warrant documentation and notification of those responsible for the bridge's maintenance:

(1) Trip hazards, severe approach settlement, or large spalls on sidewalks;

(2) Rebar protruding from decks, walks, or parapets;

(3) Loose, missing, or damaged railings or parapets;

(4) Missing or damaged guardrail;

(5) Loose concrete that could fall onto a traveled way below the bridge (road, walk, bike path, waterway, or rail line);

(6) Load posting and road safety signage;

(7) Roadway lighting; and

(8) Any other condition that the inspector perceives as a threat to public safety.

e. Other inspection types may be scheduled in conjunction with routine inspections.

2.4. In-Depth Inspection.

2.4.1. Scope.

a. An In-Depth Inspection is a hands-on inspection of one or more bridge elements above or below the water level to identify any deficiencies not readily detectible using Routine Inspection procedures. Hands-on means a visual or manual inspection made at a distance no greater than arm's length from the member surface. An In-Depth Inspection is also used to identify developing problems or changes from the previous inspection. It is also used to obtain detailed information to facilitate the preparation of structure rehabilitation plans.

b. Provide traffic control and special equipment (e.g., under-bridge inspection equipment, staging, and workboats) as necessary to obtain access. Personnel with special skills such as divers and riggers may be required where specialized access is needed.

c. The Team Leader or District BSPM will use risk-informed judgment to determine whether a condition warrants an In-Depth Inspection considering factors including safety, reliability, and consequence of failure. Examples of conditions that prompt an unscheduled In-Depth Inspection include:

(1) Apparent cracks in steel members;

(2) Apparent cracks, de-bonding, or loss of tendon section in a prestressed or post-tensioned member;

(3) Suspected frozen bearings or failed hold-down devices;

(4) Significant section loss in steel members;

(5) Buckled or bent steel girders or beams;

(6) Disconnected or loose members;

(7) Visual fretting rust on the pin of a pin and hanger connection;

(8) Undermining of foundations; and

(9) Structural cracks or significant spalls in reinforced concrete members.

d. Perform advanced inspection methods when visual and physical methods cannot detect the extent of a deficiency.

e. An In-Depth Inspection may be conducted independently of a Routine Inspection or it may be a follow-up for a Damage or other type of inspection. Thoroughly document the activities, procedures, and findings of In-Depth Inspections with appropriate photographs, test results, measurements, and a written report. Update the bridge file to incorporate changed conditions identified under this inspection.

2.4.2. Precision. An In-Depth Inspection is a hands-on, close-up inspection. Inspect each element within arm's length of the inspector. Perform nondestructive field tests or material tests where needed to more fully define the impact of deterioration. For pin and hanger assemblies, where fretting rust or seizing is identified, conduct nondestructive evaluation. Include a recommendation for new load rating or nondestructive load testing where conditions may result in reduced load capacity.

2.5. Fracture Critical Member Inspection.

2.5.1. Scope. A Fracture Critical Inspection is a type of regularly scheduled In-Depth Inspection to examine the FCM or member components of a bridge. See Chapter 8: Fracture and Fatigue for the definition of FCM. FCMs require more thorough and detailed inspections than members that are not fracture critical. Identify FCMs during the inspection planning stage and provide proper access and inspection equipment. An FCM Inspection may be conducted in conjunction with or independently of a Routine Inspection.

2.5.2. Precision.

a. A Fracture Critical Inspection is a hands-on inspection. All surfaces of the members and member components must be examined. Provide the proper access equipment, such as an under-bridge inspection vehicle or rope access, to position the inspector within arm's length of critical members. Use permanent work platforms and walkways where available and ensure they are inspected prior to use.

b. Where cracks are identified, mark the crack tip, and record the date with inspector's initials on the member with a permanent marker. Follow up with Nondestructive Testing (NDT) to further define the crack extents if needed. Document the location and extents of all cracks on the field inspection forms and sketches. Record FCMs not identified in the planning stage on inspection forms or sketches and update the inspection plan accordingly.

2.6. Underwater Inspection.

2.6.1. Scope.

a. An underwater inspection is an inspection of the underwater portion of a bridge substructure and the surrounding channel which cannot be inspected visually at low water by wading or probing or where conditions prevent wading or probing. Low water is defined as 3 feet of depth or less from the water surface to channel bed. An underwater inspection generally requires diving or other appropriate techniques such as surveying or remotely operated imaging. The preferred underwater inspection method is diving so that a close-up, hands-on visual or tactile inspection is achieved.

b. Inspections can be supplemented with surveying, to document changes in channel elevations, and underwater imaging cameras (e.g., sonar, near-infrared light, and clear water box) in turbid water where clear visual images are not possible. These methods may be used in lieu of diving where diving is unsafe, unreliable, or impractical. Perform a wading inspection only under the following conditions:

(1) Water depths of 3 feet or less with little or no flow (greater flow rates that may be safely tolerated with lesser water depths; however, even in slow-moving water of less than 3 feet in depth, it may be deemed unsafe for an inspector in waders to inspect a bridge element below water).

(2) A minimum two-person team possessing the appropriate technical qualifications.

(3) No severe underwater hazards such as sudden drop-offs, heavy surf above 3 ft (1 m), dangerous aquatic life, or unstable channel bottom.

c. The type and extent of underwater inspection will be determined by the District BSPM. Factors to consider for the type and extent of an underwater inspection include: structure type, materials of construction, foundation type, footing location relative to channel bottom, known or suspected problems, waterway characteristics, superstructure and substructure redundancy, and scour susceptibility. The basis of determination will include a review of previous bridge inspections, scour evaluations, waterway soundings and cross-sections and other pertinent information in the bridge file. See ER 1110-2-111 for guidance on bridges crossing dams and spillways.

2.6.2. Underwater Surveys.

a. Scope.

(1) Surveying includes hydrographic surveys or any sounding method that provides channel elevations or contours. The District BSPM will determine the need and scope of Underwater Surveys based on factors related to the vulnerability of the bridge substructure, potential consequences, depth of the water and flow in the channel. Conduct surveys in conjunction with Routine or Underwater Inspections and after significant hydraulic events. The District BSPM should consult with Hydraulic Engineers to develop the schedule and identify events that trigger interim surveys.

(2) Generally, Underwater Surveys will be taken in deeper, continuously flowing channels to monitor changes in the channel bed and impacts from those changes on the bridge substructure. Individuals conducting surveys must be trained and experienced in the use of the surveying equipment and should be directed by a qualified Team Leader. Recommended channel cross-section locations are:

(a) Upstream and downstream fascia of each substructure unit in the water.

(b) At 50- and 100-foot distances upstream and downstream of corresponding fascia to a point where the bridge location has minimal impact on the channel hydraulics and scour. A hydrographic survey of sufficient detail may be substituted for the cross-sectional surveys as long as it meets the frequency requirements prescribed below.

(c) At all locations of abrupt change in channel geometry in the vicinity of the bridge.

(3) Also, survey areas around the perimeter of each substructure unit as a supplement to the underwater diving inspection. Light detection and ranging equipment is a highly accurate method of obtaining both above and below water survey data. Reference or monument the termini of upstream and downstream profiles to ensure that subsequent profiles are taken at the same locations. Global Positioning System (GPS) coordinates are an acceptable reference or monument. The District BSPM will monitor all surveys, quantify changes, and identify impacts to the bridge substructure.

b. Precision.

(1) Hydrographic survey data is used to evaluate trends in channel bottom movement and to compare channel bottom elevations to footing elevations. Record water depth measurements to the nearest tenth of a foot. However, interpretations may be based on changes in elevations greater than 0.5 foot since most channel bottoms are irregular surfaces with random cobbles, debris, and sand ripples.

(2) It is generally an acceptable practice for bridge inspectors to measure the water depth relative to the water surface, in waterways without steep profiles or obvious hydraulic drops, assuming the waterline elevation in most waterways is constant over the surveyed area adjacent to the bridge. In actuality, since water always flows toward a lower topographic elevation, it is common for there to be at least a minor decrease in water surface elevation over the length surveyed. For waterways with steep profiles or obvious hydraulic changes in the water surface elevation (e.g., tidal areas), all water surface elevations must be recorded if direct water depth measurements are taken.

(3) Rather than documenting several water surface elevations, the inspector may choose to record the channel bottom elevation to a constant elevation using a surveyor's level or total station equipment. During all underwater surveys, the water surface elevation should always be

referenced to a known elevation on or near the bridge so that the reasonably accurate mudline elevation can be determined and correlated with data collected during previous inspections.

2.6.3. Diving Inspections.

a. Scope. When bridge elements are continuously submerged, underwater inspections are used to establish the condition of the submerged bridge elements so that failures can be avoided. As such, underwater bridge elements must be inspected to determine their structural condition with certainty. Underwater inspections must also include an evaluation of the streambed conditions in the vicinity of the bridge. A qualified underwater bridge inspection diver should be used to conduct diving inspections. The Underwater Bridge Inspection Diver has a wide range of diving inspection equipment and techniques available.

b. Precision.

(1) Due to the potential for limited underwater visibility, the inherent access restrictions of the underwater environment, and the presence of marine growth, the required underwater diving inspection precision depends on the level of effort. Three underwater diving inspection intensity levels, described below, are defined by the FHWA. The expected underwater diving inspection precision is based on the individual coverage percentage of these three levels of effort.

(a) Level I Effort. A Level I effort is an inspection involving a visual examination or a tactile examination using large sweeping motions of the hands where visibility is limited. Although the Level I effort is often referred to as a “Swim by” inspection, it must be detailed enough to detect obvious major damage or deterioration due to overstress or other severe deterioration. It should confirm the as-built structural plans, ensure the full-length continuity of all members and detect undermining or exposure of normally buried elements. A Level I effort may also include limited probing of the substructure and adjacent channel bottom to identify areas of potential scour or undercutting.

(b) Level II Effort. A Level II effort is a detailed inspection that requires marine growth to be removed from portions of the structure. Cleaning is time-consuming; hence, there is a need to limit the detailed inspection to a representative sampling of components. For piles, a 12-inch high band should be cleaned at designated locations, generally near the waterline, at the mudline, and midway between the waterline and the mudline. On an H-pile, marine growth should be removed from both flanges and the web. On a rectangular pile, the marine growth removal should include at least three sides; on an octagonal pile, at least six sides; on a round pile, at least three-fourths of the perimeter.

(c) On large diameter piles, three feet or greater, one-foot squares should be cleaned at four locations approximately equally spaced around the perimeter, at each elevation. On large solid faced elements such as pier shafts, one-foot squares should be cleaned at four random locations, at each elevation. The Level II effort should also focus on typical areas of weakness such as attachment points and welds. The Level II effort is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling or built-up corrosion. The thoroughness of cleaning should be governed by what is necessary to discern the condition of the underlying material. Removal of all biofouling staining is generally not required.

(d) Level III Effort. A Level III effort is a highly detailed inspection of a critical structure or structural element, or a member where extensive repair or possible replacement is contemplated. The purpose of this type of inspection is to detect hidden or interior damage, or loss of cross-sectional area, and to evaluate material homogeneity. This level of inspection includes extensive cleaning, detailed measurements, and selected NDT and partially destructive testing techniques such as ultrasonics, sample coring or boring, physical material sampling, and in-situ hardness testing. Level III testing is generally limited to key structural areas, areas which are suspect, or areas which may be representative of the underwater structure.

(2) Additionally, areas around the perimeter of each substructure unit may be surveyed for the effects of local scour. These areas of potential local scour should be inspected by the Underwater Bridge Inspection Diver. In addition to bottom elevation data, the Underwater Bridge Inspection Diver should identify potential areas of re-sedimentation by probing the mudline. In these areas both the mudline elevation and the sediment thickness should be recorded.

c. Frequency. An underwater diving bridge inspection should include at least a Level I effort on 100 percent of all underwater elements, a Level II effort on 10 percent of all underwater elements. Additional Level II efforts or Level III efforts should be performed as determined by the District BSPM or Team Leader for the bridge being inspected.

d. Methods of Underwater Inspection.

(1) After identifying that a structure requires an underwater diving inspection, it must be decided which underwater diving inspection method should be used. Underwater diving inspection methods are categorized as manned or unmanned. Regardless of method used, a Team Leader must be present at all times during the underwater inspection. The following factors influence the determination of which method of underwater diving inspection is best suited for a structure:

(a) Water depth;

(b) Water visibility;

(c) Water velocity;

(d) Streambed conditions (if soft or irregular, should be performed by diving);

(e) Presence of debris or other obstructions/obstacles;

(f) Substructure configuration; and

(g) Presence of potential differential head pressures (e.g., if inspection is located at a dam).

(2) The qualified manned method consists of an inspection-diver using Surface Supplied Air (SSA) equipment or commercial Self-Contained Underwater Breathing Apparatus (SCUBA) equipment. For qualified manned methods, the Underwater Bridge Inspection Diver and Team Leader must meet the qualifications defined in ER 1110-2-111. Dive team training, configurations, and equipment must meet the requirements of EM 385-1-1, Section 30.

(3) Where possible, underwater photography or videography should be used to document the underwater condition of the bridge. Real-time audio and video should be relayed to a qualified Team Leader, who remains on site at the time of the inspection, to ensure the Underwater Bridge Inspection Diver adequately inspects and documents the underwater elements.

(4) The unmanned methods typically use a real-time submersible videography or electronic imaging devices to transmit observation data to a qualified Team Leader. Submersible videography may be used on telescopic poles, or in Remote Operated Vehicles (ROVs). While these unmanned methods are acceptable if they are conducted in a way that ensures a sufficient level of certainty, they should be considered only as a secondary alternative if the more preferable qualified manned method is not feasible. The manned method is required for diving inspections on public vehicular bridges unless conditions make it impossible or unsafe to do so according to EM 385-1-1 (e.g., high flows, unexploded ordnance, partial bridge failure).

(5) Justification for use of unmanned diving inspections on public vehicular bridges must be documented and submitted to the MSC for approval. Consult the National Underwater Bridge Inspection Project Manager for any questions concerning the applicability or use of unmanned underwater inspection methods. For unmanned methods, document the following in the inspection plan and inspection report:

(a) Why a traditional underwater inspection with divers or a wading inspection cannot be performed.

(b) That only a 100% Level 1 underwater inspection was performed. (Level 2 cannot really be performed by an ROV.)

(c) That the marine growth or visibility did not prevent a complete 100% Level 1 inspection.

(d) The National Bridge Inventory (NBI) Condition Rating is Satisfactory (6) or better for underwater components. If a poorer condition is observed, divers will be deployed to inspect the extent of observed defects.

(6) Underwater diving inspection is typically conducted by a dive team using SSA or tethered SCUBA equipment. Both of these methodologies provide audio communications between the Underwater Bridge Inspection Diver and topside support personnel. The Underwater Bridge Inspection Diver(s) will make a visual and tactile evaluation of the substructure units by swimming around the individual units.

(7) An underwater diving inspection should primarily be conducted by a dive team using an SSA system. The equipment consists of a standard exposure suit, a full-face mask/helmet, and umbilicals connecting the diver to the surface. The Underwater Bridge Inspection Diver(s) will make a visual and tactile evaluation of the substructure units by swimming around the individual units. This method of inspection is well-suited for adverse diving conditions, such as swift velocities, polluted water, and long diving durations. Limitations of the SSA method is that the equipment restricts free movement; it requires a more extensive equipment footprint and specialized training and equipment for the inspectors.

(8) SCUBA (tethered or untethered) may also be used and consists of using a standard exposure suit and a portable air tank. Untethered SCUBA operations must be performed as a buddy team (two divers in the water) and allows the inspector greater freedom of movement, the ability to visually inspect the substructure units both above and below the waterline, and to reach all areas even in deep water. The SCUBA method is limited in duration and depth, requires specialized equipment and training, and may require tethering.

(9) The underwater Bridge Inspection Divers will require a larger than normal amount of equipment to complete the various tasks associated with the structure investigation regardless of the method used. These items are a mix of common tools and specialized equipment that will provide a breathing medium, means of movement, and aid the inspector in collecting data at the structure. Additional information related diving methodology and equipment is provided in the Federal Highway Administration "Underwater Bridge Inspection Reference Manual (Publication No. FHWA-NHI-10-027)" dated June 2010. See the Bridge Reference Library (BRL) in CEBIS.

2.7. Special Inspections.

2.7.1. Scope. A Special Inspection is used to monitor a known or suspected deficiency. A bridge requiring Special Inspections would typically have a known defect or condition severe enough to warrant extra scrutiny. Examples include load posted bridges, bridges with foundation settlement or scour, or bridges with members that have advanced deterioration.

2.7.2. Precision.

a. Quantify the severity and extent of all deficiencies and the change in condition between inspection intervals. Document deficiencies with photos and sketches showing exact locations and extent of deficiencies so that accurate evaluations can be performed. Define the locations and measurements of deficiencies within reasonable accuracy so that accurate analyses can be accomplished. Use advanced inspection methods when visual and physical inspection methods are not sufficient in defining the extent of the deficiencies.

b. Special Inspections need not be performed by certified bridge inspectors. Periodic monitoring can be conducted by an Inspection Team Member or local site personnel under the direction of a Team Leader. Monitoring tasks include measuring a crack, photographing a weld, measuring section loss on specific members, or measuring differential movement. The Team Leader will determine the need for advanced inspection methods when monitoring indicates deterioration has advanced to the point where safety of the bridge may be impacted.

2.7.3. Special Inspection Frequency. Perform a Special or Interim Inspection when a structure requires more frequent inspection than is given by the Routine Inspection cycle. Special Inspections are conducted in addition to or as part of Routine Inspections. Use the following general guidelines for scheduling Special Inspections:

a. Inspection interval of 12 months is recommended for posted bridges.

b. Inspection interval of 12 months is recommended for National Bridge Inventory (NBI) Condition Rating of 4 or less for the deck, superstructure substructure, or culvert.

c. Inspection intervals must be determined by the District BSPM for bridges having known load carrying deficiencies, advanced deterioration or unusual movement, or nonstructural deficiencies that impact safety of the users.

2.8. Damage Inspection.

2.8.1. Scope. A Damage Inspection is an unscheduled inspection to assess structural damage resulting from environmental events or human actions.

a. Flood damage, fire damage, barge impact, earthquakes, and vehicle impact are common examples of events that may call for a Damage Inspection. The scope of a Damage Inspection should be sufficient to determine whether there is a need for emergency load restrictions or closure of part or all of the structure to traffic and to collect sufficient data to evaluate the damage. Expedited calculations to establish emergency load restrictions may be necessary.

b. The amount of effort expended on this type of inspection may vary significantly and depends on the extent of the damage. The District BSPM will schedule the inspection as soon as possible given the extent and severity of the damage.

2.8.2. Precision. Document the severity and extent of all deficiencies using photos, sketches, and notes. Complete an inspection report and enter into the bridge file. If necessary, supplement this inspection with an In-Depth Inspection.

a. A refined analysis may be required to establish or adjust interim load restrictions or determine urgency of repairs. All documentation must be legible and thorough due to the potential for litigation. See Chapter 4: Critical Findings if damage is sufficient to warrant the Critical Findings procedures.

b. See Visual Inspection & Capacity Assessment of Earthquake Damaged Reinforced Concrete Bridge Elements, Caltrans Report No. CA08-0284, November 2008, Oregon Department of Transportation, Bridge Inspection Manual, and Washington State Bridge Inspection Manual for guidelines on inspections after an earthquake.

2.9. Complex Bridge and Special Feature Inspections. Complex bridges and special feature inspections are conducted in conjunction with other inspections (Routine, FCM, or In-Depth). See Chapter 3: Inspection Procedures for guidelines on inspection procedures.

2.10. Variations to Bridge Inspection Intervals. The District BSPM is responsible for identifying those bridges requiring variations from the prescribed intervals defined in ER 1110-2-111. Longer inspection intervals are subject to review and approval by the MSC BSPM. Considerations for variations are provided in the paragraphs that follow.

2.10.1. Routine and Fracture Critical Member Inspections Intervals Less than 24 Months.

a. Routine Inspection intervals should be decreased for any condition rating (Inventory Data Items 58 through 62) lower than 4 or where the rate of deterioration is such that public safety may be impacted beyond that interval.

b. Fracture Critical Member Inspection intervals should be decreased to 12 months or less where cracks are discovered in critical members and the District BSPM has determined the function of these members will not be impacted over the inspection interval. More frequent Special Inspections may be required to monitor crack growth and verify stable crack growth behavior. The interval may be increased to up to 24 months if a fatigue analysis shows a safe life for the interval proposed.

c. The following cases should also be considered for reducing inspection intervals:

(1) Bridges requiring repair work.

(2) Bridges having inadequate maintenance history.

(3) Bridges subjected to frequent overloads.

(4) Bridges with unique or unusual details, unique structure types, or those with unknown performance history.

(5) Nonredundant structures.

(6) Large structures that carry a significant amount of traffic.

(7) Bridges with temporary supports.

(8) Bridges subjected to significant substructure movement or settlement.

(9) Concrete bridges with unknown reinforcing details.

(10) Structures with potential foundation or scour problems.

d. See Chapter 4: Critical Findings for monitoring requirements for bridges with Critical Findings.

2.10.2. Underwater Inspection Intervals Less than 60 Months.

a. Underwater Inspection intervals should be decreased for any condition rating (Inventory Data Items 60 through 62) lower than 4 or where the rate of deterioration is such that public safety may be impacted beyond that interval.

b. Other considerations include those listed in Section 2.10.1 and the following: substructure configuration; bridges downstream from a dam; waterway pollution; damage potential due to waterborne traffic, debris, or ice; and susceptibility of channel bed materials to scour. See Chapter 4: Critical Findings for monitoring requirements for bridges with Critical Findings. See Chapter 9: Scour Evaluations and Plans of Actions for monitoring requirements for scour critical bridges and bridges with unknown foundations.

2.10.3. Routine Inspections Intervals Greater than 24 Months.

a. For a USACE public access bridge to be eligible for a 48-month routine inspection interval, all of the following must be met:

(1) Must have a condition rating (Inventory Data Items 58 through 62) greater than 6.

(2) Must have an inventory rating that meets or exceeds the state legal loads, Specialized Hauling Vehicle (SHV) loads, and Emergency Vehicle (EV) loads.

(3) Must have maximum span length (measured from center to center of bearing points) less than or equal to 100 feet.

(4) Steel bridges must have load path redundancy or meet other acceptable load path redundancy criteria adopted by AASHTO/FHWA.

(5) Must have vertical over or under clearances greater than 14'-0."

(6) Must not be susceptible to vehicle damage, such as a through or pony truss with less than 4'-0" shoulders.

(7) Must be a noncomplex bridge or bridge that is normal in design, construction, and operations. However, evaluation of individual structures is required. This rule applies to structures of all material types.

(8) A new or newly rehabilitated structure must have had an initial inspection plus at least one cycle (24-month interval) routine inspection.

(9) Must have Inventory Data Item 113 coded as 5, 7, 8, 9, or N.

b. Requests for intervals between 24 and 48 months are not allowed. The District BSPM must submit a request for review and approval to the MSC and HQ BSPMs. This request must show that an evaluation has been made that addresses the requirements in these policy items and contains the following information:

(1) Structure type and description,

(2) Structure age,

(3) ADT,

(4) ADTT,

(5) Major maintenance or structural repairs performed within the last 2 years,

(6) Potential or known frequency and degree of overload,

(7) Failure history, maintenance history, and latest inspection findings, and

(8) Recommendations for inspection cycle.

c. For Short Span, Non-Public Access, and Public, Non-Public, and All Other Pedestrian bridges, the interval may be increased to 60 months and will be based on criteria developed by the District BSPM. The increased interval for Routine Inspections does not preclude the need for or circumvent the requirement for other inspections, such as Underwater Inspections, Damage Inspections, or Inventory Inspections after reconstruction or repairs. Thoroughly document the justification for increased intervals and maintain in the bridge file.

2.10.4. Underwater Inspection Intervals Greater than 60 Months.

a. Underwater Inspection intervals may be increased to up to 72 months for all bridge types if all of the following criteria are met:

(1) Condition Ratings for Inventory Data Items 60 or 62 is 6 or better;

(2) The Condition Rating for Inventory Data Item 61 is 7 or better;

(3) NBI Item 113 has a rating of 5, 8, or 9;

(4) Condition or Scour Ratings have not changed over the previous inspection cycle;

(5) Pier protection is present and in good condition where a bridge crosses a navigable waterway; and

(6) Must not have substructure elements that are unprotected steel or unwrapped wood and are in an aggressive environment such as salt water or fast currents.

b. The District BSPM must submit a request for review and approval to the MSC and HQUSACE BSPMs. The justification for increased intervals must be thoroughly documented in the PgMP, approved by FHWA and maintained in the bridge file. Substructure elements constructed of unprotected steel or timber that reside in an aggressive environment, waterways with stream stability or scour issues, and bridges with unknown foundations should not be considered for an increased inspection interval.

2.10.5. Fracture Critical Member Inspections Intervals Greater than 24 months.

a. Fracture Critical Member Inspections Intervals Greater than 24 months are allowed on other than Reportable bridges and may be extended up to 60 months. The District BSPM must submit a request for review and approval to the MSC.

b. Inspection intervals for FCM inspections must be determined based on number and magnitude of load cycles, condition of bridge, internal redundancy, and potential for fracture. For vehicle bridges, include length of remaining life determined from a fatigue analysis. The justification for increased intervals must be thoroughly documented in the PgMP and maintained in the bridge file.

2.10.6. Inspections Not Meeting Specified Intervals.

a. Inspections must be completed at specified intervals, expressed in months. Inspections should not deviate from that schedule throughout the life of the bridge. Should a planned inspection date not align with the specified interval or should a new baseline inspection date need to be established, the following actions are required:

(1) For deviations of 1 calendar month or greater, the District BSPM will include an explanation in the bridge inspection report that provides justification for either increasing or decreasing the interval. Lack of funding or availability of inspectors are not valid justifications.

(2) For deviations of Reportable bridges greater than 1 calendar month, pre-approval must be requested at least 60 days in advance of the original inspection date. Approvals requests go through the MSC BSPM and the HQUSACE BSPM to FHWA for final approval. Lack of pre-approval will likely result in a non-compliance assessment during FHWA review of compliance with the NBIS. Deviations between 2 and 4 calendar months should be limited to extremely unusual circumstances. Deviations greater than 4 calendar months are not allowed unless major repairs or replacement are on-going.

(3) For deviations of non-Reportable bridges greater than 1 calendar month, pre-approval must be requested at least 60 days in advance of the original inspection date. Approval will be made by the MSC BSPM. Deviations between 2 and 4 calendar months should be limited to extremely unusual circumstances. Deviations greater than 4 calendar months are not allowed unless major repairs or replacement are on-going.

b. If a change of inspection date request is disapproved and the District BSPM is unable to meet the original inspection date, the District BSPM will immediately schedule a call with the MSC BSPM and HQUSACE BSPM to determine appropriate action.

Chapter 3
Inspection Procedures

3.1. Background.

3.1.1. USACE inspection procedure requirements for all bridges are described in ER 1110-2-111. Inspection procedures consist of the onsite inspection and also includes the pre-inspection and post-inspection phases. Pre-inspection includes all planning and preparation. Post-inspection includes all recording, reporting, recommendations, archiving, and follow-up to critical findings. All individuals performing these tasks must meet qualification requirements and understand the duties they are expected to perform.

3.1.2. All inspection documents for each bridge must be maintained in CEBIS. See the FHWA Bridge Inspector's Reference Manual (BIRM) for a description of inspector responsibilities. These guidelines are applicable to all bridge types.

3.2. Duties of the Inspection Team.

a. The bridge inspection Team Leader duties include the following:

(1) Planning the inspection and developing the plan;

(2) Preparing for the inspection;

(3) Performing the inspection;

(4) Preparing the inspection report;

(5) Recommending repairs or maintenance;

(6) Recommending re-rating, load posting, or structure closure; and

(7) Ensuring Quality Control according to the Quality Control Plan (QCP) throughout the inspection process.

b. The Team Leader may designate various inspection team members to perform tasks to fulfill these duties. There must be at least one Team Leader at the bridge site at all times during each field inspection.

3.3. Inspection Planning and Preparation.

a. Planning and preparation are important to provide an efficient and systematic process for each bridge inspection. All inspections must have written inspection plans. Section 4 of the MBE provides additional planning considerations.

b. Certain bridge or member types require greater attention to planning and specific plans are required. Specific plans include:

(1) FCM Inspection Plans,

(2) Underwater Inspection Plans,

(3) Complex Bridge Inspection Plans, and

(4) Scour Critical Bridge Monitoring Plans of Actions.

c. Standard Inspection Plan templates are provided in the BRL.

3.3.1. Field Inspection Folder. An inspection folder containing the following should be brought to each inspection:

a. Inspection Plans.

b. Standard Inspection Forms.

c. Scour Critical Plan of Action if applicable (See Chapter 9: Scour Evaluation and Plans of Action).

d. Level 1 Scour Analysis Form (See Chapter 9: Scour Evaluation and Plans of Action).

e. Copies of construction or repair plans.

f. Sketches of the bridge and bridge elements to document field notes.

g. List of equipment needs.

h. Identification of NDT locations.

i. Inspection sequence.

j. QC checklist.

k. Traffic control plan.

l. Safety plan.

m. Permits.

3.3.2. Bridge File Review. Review the Bridge File see Section 6.2 Bridge File. Identify the type and construction material of the bridge, critical details (fatigue sensitive, fracture susceptible, failure critical members, and fracture critical members), type and location of previously identified deficiencies, repairs completed since the last inspection, results of previous testing and monitoring, accident and damage history, and any other pertinent information.

3.3.3. Inspection Plan. Develop an inspection plan for each inspection type that ensures effective, efficient, and safe inspection of all bridge elements. Identify the responsibilities and duties of all inspection team members and ensure they are fully understood by each team member. Conduct a pre-inspection visit to the site if necessary or practical to develop or finalize the inspection plan. Use the inspection plan template in the BRL to develop the plan.

a. FCM Inspection Plan. Identify the location and type of FCM and describe the FCM inspection frequency and procedures in the plan. See Chapter 2: Inspection Types and Intervals for Fracture Critical Member inspection guidelines. See Chapter 8: Fatigue and Fracture for descriptions of fatigue sensitive details, fracture susceptible details, and FCM Inspection Plan requirements. Use the FCM Inspection Plan template in the BRL to develop an FCM Inspection Plan.

b. Underwater Inspection Plan. Identify the location of underwater elements and include a description of the underwater elements, the inspection frequency and the procedures for each bridge requiring underwater inspection. Prepare an Underwater Inspection Plan identifying and describing procedures including type of underwater inspection, precision of inspection, equipment, tools, and methods of recording findings. See Chapter 2: Inspection Types and Intervals for inspection guidelines. Use the Underwater Inspection Plan template in the BRL to develop an Underwater Inspection Plan.

c. Complex Bridge and Special Feature Inspection Plan. Identify specialized inspection procedures, and additional inspector training and experience required to inspect complex bridges and special features. See Chapter 2: Inspection Types and Intervals for complex bridge and special feature inspection guidelines. Use the Complex Bridge Inspection Plan template in the BRL to develop a Complex Bridge Inspection Plan. See the MBE for guidelines on the inspection of Complex Bridges. See the AASHTO Movable Bridge Inspection, Evaluation, and Maintenance Manual for additional guidelines on inspecting movable bridges.

d. Scour Critical Bridge Plan of Action. See Chapter 9: Scour Evaluations and Plans of Actions for Scour Critical Plan of Action (POA) details. Use the Scour Critical Bridge Plan of Action template in the CEBIS BRL to develop a Scour Critical Bridge Plan of Action.

3.3.4. Traffic Control. Inspection operations that obstruct traveled ways can create unexpected and unusual situations for motorists. Effective traffic control eliminates surprises and routes traffic safely around any hazards, inspection personnel, or equipment.

a. Traffic Control Plan. Develop traffic control plans for any inspection work that will adversely affect the smooth flow of traffic through the work zone. Follow the traffic control guidelines for the state in which the bridge is located. Use the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) (http://mutcd.fhwa.dot.gov/) if there are no state guidelines.

b. The Team Leader, District BSPM or a qualified employee of a traffic control subcontractor will design a traffic control plan, including any changes or updates. A traffic control plan should include a plan view drawing of the proposed work zone that shows where traffic control devices will be placed, what devices will be used, and how they will be oriented. In some instances of high traffic zones, positive protection (e.g., barriers, shadow trucks) that meets crashworthiness evaluation criteria outlined in the AASHTO Manual for Assessing Safety

Hardware (MASH) should be considered. All parties that will be operating in the work zone must review and be familiar with the traffic control plan.

c. Fundamentals of Traffic Control. Design the traffic control plan and implement the plan to accomplish the following goals:

(1) Inform the Motorist. Proper use of signs can keep the motorist informed of unexpected conditions. Use the following types of signs:

(a) Regulatory Signs: Speed limit, do not pass, etc.

(b) Warning Signs: This lane ends, work zone ahead, etc.

(c) Guide Signs: These show motorists the direction they are supposed to travel and tell them how to reach their destination. Use these signs for detours.

(2) Control the Motorist. Safety principles used to design roadways apply to the design of traffic control. The geometry, signs, and lights used for traffic control will guide traffic to allow unobstructed roadway conditions as closely as possible. This minimizes the confusion for the driver. Use warning signs to warn drivers of hazards ahead in the roadway or just off the roadway. Use channelizing devices such as traffic cones, barrels, barricades, and wands to guide drivers safely through a work zone. Monitor channelization devices to ensure that they are in place and functional. Use speed limit signs to slow traffic in the work zone and increase work zone safety.

(3) Provide a Clearly Marked Path. Use warning signs to inform the motorist of unusual or changing conditions. Use channelization devices to define a clear, definite path for drivers to follow. Channelization devices will also provide drivers with a smooth, gradual transition from one lane to another, onto a bypass or a detour or through the narrowing of a traveled lane or shoulder. Avoid abrupt changes in traffic direction and abrupt constriction of the traveled way. Once no longer needed, promptly remove all traffic control devices.

3.3.5. Safety Plan. A Safety Plan with an Activity Hazard Analysis (AHA) must be developed during the bridge inspection planning and preparation phase and must be followed while performing the inspection. Use the Safety Plan and AHA template in the BRL to develop a Safety Plan. See the FHWA BIRM for safety fundamentals for bridge inspectors.

a. Inspection Team Safety.

(1) To minimize the chance of an inspector becoming injured, all inspectors in the field should adopt the following work habits:

(a) Follow the safety plan.

(b) Follow proper procedures for traffic control.

(c) Work in groups of two or more when performing any inspection fieldwork.

(d) Be well-rested, alert, in good health and at a level of good physical conditioning.

(e) Be familiar with and use the proper tools.

(f) Keep work areas neat and uncluttered.

(g) Carry a mobile phone or a radio for use in case of an emergency.

(h) Be familiar with USACE safety standards and requirements.

(i) Wear proper personal protective clothing when needed (vests, safety glasses, ear protection, gloves, face protection, hardhats, and appropriate footwear).

(j) Keep all equipment, safety devices, and machinery in good operating condition. Discard worn or damaged equipment.

(k) Operate equipment and vehicles according to the operating manuals provided by the manufacturer and the safety plan.

(l) Inspect and maintain equipment and vehicles according to the manufacturer's recommendations.

(m) Use lanyards, safety harnesses, life jackets, and other personal safety equipment consistent with applicable standards.

(n) Keep safety equipment clean and away from potentially harmful chemicals such as gasoline, dye penetrant, and/or oil.

(o) Ensure all inspectors are trained and certified in hazardous activities including confined space, fall protection, and operation of access equipment.

(p) Follow proper safety precautions and confined space entry procedures when entering confined spaces.

(2) Each structure site is unique. If unusual working conditions exist, specialized safety precautions may be required.

b. Public Safety. To minimize the chance of the public becoming injured, plan for the following:

(1) Appropriate traffic control for vehicles and pedestrians when required.

(2) Methods to secure tools and equipment so they do not fall onto people or traffic below. A tool pouch, belt, or bucket is a good way to secure tools and items. Hardhat chinstraps are also recommended to prevent hardhats from falling.

(3) Prevent debris (e.g., loose concrete, paint chips, pack rust) from falling onto people or traffic below.

(4) Plan for traffic (vehicular and pedestrian) in traveled ways.

(5) Plan for a ground inspector to observe vehicle and pedestrian traffic and relay pertinent information, such as stray vehicles or pedestrians in the work zone, to the aerial inspector. Plan for the aerial and ground inspectors to have radios to communicate.

(6) Prepare a plan to keep inspection vehicles such as under-bridge access units, trucks, and vans away from live traffic. Do not extend manlifts, etc. over live lanes of traffic. Manlifts will not be operated directly adjacent to live traffic (i.e., on a narrow shoulder) without providing appropriate traffic control. Close lanes if access to structure members over live traffic lanes is necessary.

3.3.6. Required Permits and Safety Training. Obtain permits (e.g., railroad rights-of-way, waterways, environmental) prior to the inspection. Formal safety training (e.g., confined space, fall protection, access equipment operation) may be required prior to the inspection.

3.3.7. Site Coordination. Coordinate the inspection with the site project manager prior to the inspection. Coordination activities may include security access requirements, cleaning of bridge member surfaces, paint removal, traffic control, navigation traffic, accommodation of access equipment, or control of machinery operations.

3.3.8. NDT. Identify NDT needs during the planning process. NDT includes methods used to detect embedded and surface defects, material strengths, and measure strains and deflections. Consider the procurement methods and allow sufficient time for procurement (e.g., contracting). Establish qualification requirements for each testing method use and verify operators meet those qualification. Include minimum requirements for equipment such as calibration intervals and periodic maintenance to help ensure the equipment works as designed.

3.3.9. Use of Remote Imaging Tools

a. A Remotely Operated Vehicle (ROV) and Unmanned Aircraft System (UAS) may be used as a supplemental inspection tool for routine visual, tactile, and non-destructive testing according to NBI standards. The intent for their use is to improve the quality of the bridge inspection by obtaining information and detail that may not be readily obtained with a routine inspection or for interim monitoring of deficiencies. The ROV and UAS performance and capabilities need to meet the intended use and expected results.

b. Measurements can be estimated from images, but tactile functions such as cleaning, sounding, measuring, and testing equivalent to a hands-on inspection cannot be replicated using ROV's or UAS's. If a significant deficiency is known, or found, that requires follow up action, a hands on inspection needs to be performed in the areas of concern. Once quantified, UAS or ROV may be used for interim special inspections to monitor defects between designated hands-on inspection intervals until repairs can be made.

c. If a ground-based inspection is not otherwise prohibited by the MBE or USACE policy, the district BSPM has the discretion to supplement the inspection using a UAS. The use of a UAS has to be documented in the PgMP and inspection report. All ROV operators and UAS pilots must have their qualifications and technical specifications of equipment documented in CEBIS.

3.3.10. Remotely Operated Vehicle (ROV)

a. ROV underwater inspection submarines may be used as a supplemental inspection tool when underwater dive access cannot be made due to emergency circumstances, unsafe water conditions, or for interim monitoring of a previously defined defect. ROV may also be used for bridges founded on dam structures, if deemed appropriate by the district Dam Safety Program Manager and concurred with by the district BSPM.

b. A qualified bridge inspector needs to be present during any bridge inspection when using an ROV. ROV performance and capabilities need to be aligned with the intended use and expected results. All ROV's must meet Army requirements. The proposed use of ROV must be documented in the PgMP and approved by the division BSPM.

3.3.11. Infrared Thermography Best Practices

a. Requiring the use of "cooled" cameras which have relatively low time constants i.e., < 2 msec, which produce clearer infrared datasets (less blur) as compared to microbolometer cameras with time constants on the order of 7-12 msec. Additionally the infrared camera should have a minimum frame rate of 50Hz and minimum resolution of 640x512.

b. Requiring accompanying high-resolution (4k) visual imagery in order to distinguish thermal anomalies produced by surface features (e.g., staining, debris, moisture) from those related to subsurface defects.

c. Requiring infrared and visual imagery to have integrated geospatial data via high-resolution GPS or a distance encoder.

d. Requiring the ability to assemble infrared and accompanying visual datasets into composite imagery for accurate mapping of defects.

e. Requiring All infrared thermography of bridge decks to meet the requirements in ASTM D4788 - 03(2013), Standard Test Method for Detecting Delaminations in Bridge Decks Using Infrared Thermography.

f. Requiring consultants to have a minimum of 10 years' experience utilizing infrared thermography on concrete structures.

g. Requiring Project Managers to have a minimum of 5 years' experience utilizing infrared thermography on concrete structures.

h. Requiring Field Staff and Analysts to have a minimum of 5 years' experience utilizing infrared thermography on concrete structures.

3.3.12. Unmanned Aircraft System (UAS)

a. UAS can provide important pre-inspection information for planning and obtaining information such as clearances, rope access anchor points and general conditions. A UAS cannot be used when a hands-on inspection is required.

b. The Team Leader needs to be present during any routine bridge inspection that requires the use of an UAS. UAS cannot be used for special inspections except where the special inspection is an interim monitoring type inspection of a previously defined defect. An example would involve a routine inspection where section loss in a member was identified and a hands on cleaning and measurements were taken to determine the extent of deterioration. In this case, a

UAS special inspection can be done to determine if progression of corrosion warrants action prior to the next inspection.

c. All UAS bridge inspections require an Activity Hazard Analysis per EM 385-1-1 requirements. The bridge inspection safety plan and PgMP must address UAS requirements and how they will be used.

d. UAS performance requirements needs to consider weight, controllability and built-in fail safeguards. Field conditions need to take into account weather, bridge types, bridge locations and bridge configurations. Depending on the use and inspection type, a UAS may need the following:

(1) A secondary display for the bridge inspector

(2) A zoom camera.

(3) Ability to direct cameras upward

(4) Ability to fly without a GPS signal

(5) Camera detail equivalent to a close-up photo

(6) Collision-tolerant design if in use in tight spaces

e. The MSC has approval authority for use of UAS's. The proposal for use of UAS's for bridge inspections will be documented in the PgMP.

f. All UAS's must meet Army and FAA requirements and be registered with the FAA. All pilots must meet Army requirements, have a Remote Pilot Certification from the FAA and have the applicable level of experience needed based on the bridge type, size, location and environmental conditions.

3.4. Performing the Inspection.

a. Uniform inspection techniques and documentation are required for efficiency and completeness. Time spent on each element should be in direct proportion to the importance of the element.

b. Review the Inspection Folder onsite prior to the inspection and perform the inspection according to the inspection plan. Deviation from the plan is acceptable when field conditions differ from those assumed when creating the plan. The Team Leader directs the inspection team, ensures the inspection plan is followed, uses a check off procedure to ensure the sequence is followed, and ensures all members are inspected. Identify any repairs to or rehabilitation of the structure that might have influenced the behavior or performance of other parts of the structure.

c. Record all observations that may impact bridge safety and operability. Team Leaders have the authority to close a structure that poses an immediate danger to the public or shows signs of imminent failure and will follow the Critical Findings Plan for the bridge, see Chapter 4: Critical Findings.

3.4.1. Traffic Control. The Team Leader is responsible for implementing the Traffic Control Plan. Coordinate traffic control requirements with those setting up the traffic control, if they are not part of the Inspection Team. Maintain the traffic control (watch for tipped or moved cones, signs, etc. and replace/realign them as needed).

3.4.2. Safety Plan.

a. The Team Leader is responsible for implementing the Safety Plan for each bridge inspection. Access equipment, safety features, procedures and training requirements are identified in the inspection plan. Follow the safety plan and AHA plan or similar document. Conduct a safety briefing with all team members on site prior to the inspection. Periodic briefings may be required depending on the complexity of the inspection or where a deviation from the inspection plan is required.

b. Note in the inspection forms where the safety plan cannot be met and what actions need to be taken to ensure safety of the inspection team and public. Correct any violations of or deviations needed from the safety plan immediately.

c. Inspect all personal safety equipment for condition and suitability of use. Such equipment may include, but is not limited to, high visibility clothing, body harnesses, hardhats, safety shoes, eye protection, ear protection, respiratory protection, and protection from hazardous paint or other materials.

d. The Team Leader ensures proper access is always provided and the proper access equipment is used, inspection personnel are properly trained, and it is operated by qualified operators. The Team Leader is also responsible for safe use of all access equipment. Note in the inspection forms where access cannot be achieved and identify any impacts to the inspection where access does not meet the inspection needs.

e. Should an inspector discover any defect in a bridge that would make imminent failure of the structure likely or pose a danger to the public, the inspector has the authority to close the bridge. When light poles, sound walls, retaining walls or highway sign bridges are found to be in dangerous conditions, the inspector will assess the danger level and respond appropriately to prevent any injury or property damage. Contact site personnel or local law enforcement for assistance in road closures or cordoning off dangerous areas. See Chapter 4: Critical Findings for details on bridge closures and notifications.

3.4.3. Field Inspection Documentation.

a. The inspectors will produce field inspection documentation which consists of all completed forms, notes, sketches, photos, and any other documentation of the inspection in the field. Record the findings and results of bridge inspections on standard inspection forms. Identify all defects and record the severity and extent on standard inspection forms. Use the standard inspection form in the BRL or develop and use a similar standard inspection form. Complete report forms in their entirety at the bridge site. Handwritten notes must be legible. Cross out, initial, and date any mistakes. Use overall photos to capture general conditions.

b. Consult the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (Coding Guide) NBI condition code descriptions and the USACE Bridge Inspection Pocket Manual during the inspection provide better consistency in defining the condition states.

c. Document the Element Level inspection on the standard inspection form by assigning condition states that correlate to the severity of the defects and recording the quantities of the defects in each element. Refer to the USACE Bridge Inspection Pocket Manual for the list of elements, units of measurement, condition state descriptions for each element defect, and other guidance for documenting the Element Level inspection findings.

d. Immediately report deficiencies that require emergency repairs or action by using the procedures defined in Chapter 4: Critical Findings. Include all field documentation in the bridge file. These documents become part of the permanent record of the bridge. For simple bridges, the inspection report may contain sufficient information to also serve as the field book.

3.4.4. Update Inspection Plan.

a. Document any deviations from the Inspection plan during the inspection. Update the inspection plan with the necessary changes.

b. Follow the inspection sequence plan and maintain a proper structure orientation and member identification system. Use the same identification and numbering system if the structure elements are already identified and numbered on a set of structure plans, repair plans, or in a previous report.

c. If a numbering system has not been established for the bridge, number substructure units from lowest to highest following the cardinal direction. Number pier columns and longitudinal superstructure elements such as girders or stringers from left to right on a bridge cross section when looking north or east. The cardinal directions are south to north and west to east, where directions are defined by the route direction and not the direction of the bridge. Fully document the numbering scheme used to ensure the same scheme is used during future inspections.

3.5. Inspection Reports.

a. The purpose of the inspection report is to record the inspection findings, provide a narrative description of conditions at the bridge site, note any changes in the Inventory Data, and present the recommendations the Team Leader or District Bridge Program Manager considers necessary to maintain safety and serviceability of the bridge. The inspection report is reviewed by those in decision making roles so that they can make informed decisions about maintenance, repairs, and replacement.

b. The inspection team will prepare an inspection report for each inspection that will provide sufficient information to convey bridge conditions and support findings and recommendations. Identify safety issues and structure elements in need of repair or maintenance. Include in the CEBIS bridge file any field notes and sketches that support inspection findings and recommendations. Insert relevant photographs in the CEBIS inspection report and provide photo references in the narrative of the report. For condition codes less than 6, sufficient narrative documentation will be included in the report to support the findings. Use the CEBIS inspection report format and update the NBI data.

c. Include or update the Element Level inspection documentation in CEBIS. Include all elements present in the bridge. Label, date, and place in the project folder all photographs not used in the report. Report items requiring immediate attention to the District BSPM following procedures defined in Chapter 4: Critical Findings.

d. The inspector must verify if an updated load rating is required as a result of a change in condition and document that information in the bridge inspection report. Include in the inspection report any recommendation for a re-rating, load posting, or closure of a structure. Consult a qualified Responsible Engineer, as defined in Chapter 7: Load Rating Procedures, to determine requirements for load posting or revisions to existing load ratings.

3.6. Quality Control (QC) and Quality Assurance (QA) Documentation. Perform QC/QA consistent with the Quality Management Plan, QC Plan, and QA Plan. Record QC/QA comments using standard forms and checklists. See Chapter 5: Quality Measures for guidance on QC/QA.

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Chapter 4
Critical Findings

4.1. Introduction.

a. A Critical Finding is a structural or safety related deficiency that requires immediate follow-up inspection or action. This chapter describes a uniform method for timely notification of a critical finding and a process for tracking and documenting the deficiency from the initial finding to a final resolution. A notification hierarchy is provided that defines the process when a Critical Finding is encountered.

b. Districts and local units of government may have additional guidelines discussing alternate route information, public relations, and information dissemination procedures. Coordinate all procedures with the District Safety and Security Officers, project site managers, Public Affairs Office, and local agencies as applicable.

c. The urgency of the response is a function of the severity of the deficiency, impacts of the deficiency on the behavior of the bridge, and consequences of inaction. Actions may vary depending on the deficiency found and urgency of response. Actions include bridge closure, lane closure(s), speed or load restrictions, temporary supports or repairs, and permanent repairs.

d. Deficiencies affecting primary members in bridges lacking load path redundancy will generally require greater urgency than those with load path redundancy; deficiencies affecting primary members will generally require greater urgency than deficiencies affecting secondary members; deficiencies affecting nonstructural members will require a varying degree of urgency depending upon the potential impact to bridge users.

4.2. Critical Findings Plan.

a. Each District must develop a Critical Findings Plan. Elements of the plan include:

(1) Team Members,

(2) Notification Procedures,

(3) Closure Procedures, and

(4) Documentation Procedures.

b. A plan can be developed for a single bridge, a project, or all bridges within the District. Incorporate guidelines of this chapter into the District Plan. Reference specific sections of this manual in the plan as needed. Develop a notification hierarchy that includes alternate contacts for each person in the list. Use the Critical Findings Plan template to develop the Critical Findings Plan. See the BRL.

c. Identify one person and at least one alternate for each position in the hierarchy list. Notify each person of their participation responsibilities and secure their agreement to participate. The Critical Findings Plan must be kept as part of the bridge file and updated annually.

4.3. The Critical Findings Team. Identify all team members in the critical findings plan. Team members will typically include the District BSPM, MSC BSPM, HQUSACE BSPM, Safety and Security Officers, Operations personnel, local agencies (where local roads and traffic are affected), local law enforcement agencies, the Dam Safety Program Manager, and the Public Affairs Officer.

4.4. Response Guidelines. The response levels are Emergency Bridge Closure and Prompt Interim Action (PIA). Responses can vary from minor repairs to bridge closure. The decision to close or limit the use of a bridge should be made by or in consultation with a qualified engineer possessing sufficient knowledge and experience who can judge which conditions warrant bridge closure or restrictions. The actions taken on a critical finding requires a team of individuals whose tasks include identifying critical defects, decisions on actions taken including closures, traffic control, repairs, reinspection, and public relations.

4.4.1. Emergency Bridge Closure.

a. If conditions exist that present unacceptable safety risk, the bridge must be closed or alternative protective measures must be implemented.

b. Bridge closure requires some combination of barrier, signage, and flagging or other means of controlling bridge access. Follow local state guidelines where available. For public use bridges, local law enforcement may install and maintain a temporary closure in an emergency until formal traffic control can be implemented. For nonpublic use bridges, this responsibility may lie on project site personnel.

c. The Team Leader or project site personnel should remain at the site until relieved by other personnel, if necessary. Detour information will be the responsibility of the local affected agency, where applicable; otherwise, it will be the responsibility of the District's Operations Office.

d. Notify the District BSPM as soon as possible once a bridge is closed. The District BSPM will verify the criticality of the finding and once verified will initiate the notification procedures and implement additional closure procedures defined in the District Critical Findings Plan.

e. Reopen a bridge only after repairs or remedial actions are completed or the bridge is determined to be safe for the allowed loads by a Responsible Engineer.

4.4.2. Prompt Interim Action Response. A Prompt Interim Action (PIA) is any action, including repairs, load limits, or partial or full bridge closures that are enacted to alleviate a significant safety problem on the bridge. Prompt means as soon as possible or practical given the conditions and consequences of inaction. Interim means that the action may be temporary but is to the extent necessary to ensure safe use of the bridge. Initiate a PIA when a condition exists that if left unattended beyond the next inspection would likely become unsafe. The following examples provide general guidance on when a PIA is required. See the FHWA BIRM for additional examples.

a. Substructure Examples.

(1) Scour that has caused other than minor undermining of an abutment or pier without piles and not founded on rock, and the danger of failure is imminent or there is a potential for failure with the next flood.

(2) Movement, deterioration, or distress in piers or abutments that is excessive and there is a possibility that piers or abutments may fail to support the superstructure.

(3) Significant structural cracks in a substructure with active signs of growth.

b. Superstructure Examples.

(1) Distortion in a critical member (e.g., the visible buckling of a compression chord member in a truss).

(2) Any crack in a fracture critical member or major impact damage in a primary member. A minor crack in the tension area of a primary redundant steel member or cracks in compression areas may not require Prompt Interim Action. A minor crack in a primary redundant steel member may not be critical, if in the judgment of the Team Leader, it will not propagate. However, extreme caution should be taken when determining crack propagation since brittle fractures can occur. It is recommended that steel coupons and other investigations be conducted prior to concluding that a crack will not propagate. See Chapter 8: Fatigue and Fracture for additional guidance.

(3) Significant section loss not previously evaluated in the flanges of steel member in an area of maximum bending stress. Significant section loss not previously evaluated in a girder web near a support or point of maximum shear.

(4) Bearings overextended or rotated to the point that portions of the superstructure may drop in elevation.

(5) A hole in the deck along with deterioration of the surrounding deck extensive enough to threaten a structural failure of the deck.

c. Safety Related Deficiencies. Safety related deficiencies may be encountered when there is a nonstructural deficiency that is a danger to vehicular or pedestrian traffic.

(1) Concrete falling onto under-feature traffic or onto an area where pedestrians can be present.

(2) Exposed curb reinforcing bars or portions of structure railing protruding into a bike path or roadway.

(3) Damaged utilities leaking combustible gases.

(4) Deteriorated inspection catwalks and ladders.

(5) A significant sized hole in a structure deck, but there is no threat of structural failure.

(6) Missing, illegible, or improperly posted vertical clearance sign, where required. Vertical clearance signs which are improperly posted, but are more restrictive, are not Safety Related Deficiencies.

(7) Exposed electrical wiring on the structure where pedestrian traffic could be present.

(8) Missing or nonfunctional sections of bridge or approach rail. If a railing is simply nonconforming to present standards, it should not be listed as a safety issue since these are nonconforming issues.

(9) A hole in the sidewalk of a structure creating a tripping hazard.

(10) Missing or incorrect load posting sign.

4.5. Critical Findings Report.

4.5.1. As soon as practical, the Team Leader will prepare a Critical Findings Report and submit it to the District BSPM. The District BSPM will submit the report to the MSC BSPM within 24 hours when a bridge closure is required and within 5 days otherwise. The MSC BSPM will notify the USACE BSPM upon receipt of the report.

4.5.2. The report will include a description of the finding, actions taken, all individuals notified and when they were notified, future actions required, and a schedule for those actions. The District BSPM will brief the District's Chief of the engineering function on the report and receive concurrence on the Critical Findings responses. Use the Critical Findings Report template to develop the Critical Findings Report. See the BRL for a Critical Findings Report template.

4.6. Critical Findings Follow-up.

a. After a Critical Finding is reported, the District BSPM should review the previous inspection report to ascertain whether conditions that could have led to the event were previously reported. If the District BSPM determines that the previous report should have indicated the Critical Finding but did not, the District BSPM will discuss these findings with the previous Team Leader. The MSC BSPM will review all Critical Finding Reports and related inspection reports to evaluate the effectiveness of the inspection program. Findings will be reported to the USACE BSPM.

b. The District BSPM must update the Critical Findings Report with schedule changes, photos of the completed work, and dates of completed actions. Monitor and track all active Critical Findings during future inspections until the Critical Finding can be closed. Schedule In-Depth or Special Inspections as needed to monitor a Critical Finding more frequently than Routine Inspections. A Critical Finding will be considered active until final and permanent repairs or other activities are completed at which point it will be closed. These activities are considered complete when the District BSPM verifies all work has been completed.

c. All Critical Finding Reports and resolutions will be maintained in the Bridge File using all standard forms available in the CEBIS program. Where the Critical Findings plan has changed significantly from the original version, the District's Chief of the engineering function must be re-briefed and concur on the changes to the Critical Findings responses.

d. The District BSPMs will maintain a current list of structures with active Critical Findings status and a historic record of those structures previously having a Critical Findings. The District BSPM will notify the MSC BSPM when a Critical Finding has been closed.

e. The MSC BSPM will maintain a list of all District Critical Findings, track the progress of each, and report periodically to the USACE BSPM on their status. The MSC BSPM will notify the USACE BSPM when a Critical Finding has been closed. The USACE BSPM will report all public vehicular bridge Critical Findings to the FHWA in a timely manner.

4.7. Load Rating. If the critical finding is based on a loss of capacity, update the existing load rating or conduct a new load rating. See Chapter 7: Load Rating Procedures.

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Chapter 5
Quality Measures

5.1. Quality Management.

a. Quality Management (QM) is the coordination of activities used to direct and control an organization to ensure products are completed in a timely and cost-effective manner while meeting all technical requirements. QM includes oversight of development and implementation of quality policies and procedures. Quality Management Systems (QMS) are required for all USACE activities. QMS is the resident system where processes are stored. This document provides guidance on the development and implementation of procedures that ensure quality is attained for all bridge inspections and evaluations and associated documentation.

b. The elements necessary in developing quality products include the following:

(1) Understanding USACE policies.

(2) Establishing qualified Project Delivery Teams (PDTs) and Agency Technical Review (ATR) teams.

(3) Ensuring proper resources are available to complete the product.

(4) Defining measurable objectives.

(5) Maintaining quality control processes.

c. Technical quality is achieved through development and implementation of work plans, quality control and quality assurance plans and reviews, compliance with technical guidance, coordination between the team members, and proper oversight by senior technical experts and supervisory review. Technical quality is enhanced by effective application of After Action Reviews (AAR) and Lessons Learned (LL).

d. Quality Management for District Bridge Safety Programs is the responsibility of every District BSPM.

e. Every bridge inspection and evaluation requires the following:

(1) Project or Program Management Plan (PgMP).

(2) Quality Management Plan (QMP).

(a) Quality Control Plan (QCP).

(b) Quality Assurance Plan (QAP).

f. Typically, a single PgMP and QMP is developed for a district program. A single QCP or QAP can be used for multiple similar bridge types.

5.2. Quality Management Plans.

5.2.1. Project or Program Management Plan (PgMP). A PgMP is required for all work, it needs to identify the scope, schedule, and resources needed to accomplish the work. The roles and responsibilities for each member of the District Bridge Safety Program Team must be defined in the PgMP. The qualifications of each member must be documented. The PgMP template must be used to develop the District bridge program PgMP. See the BRL for the PgMP template.

5.2.2. Quality Management Plan (QMP). The QMP is the quality component of the PgMP. Its purpose is to document the project-specific quality control and quality assurance procedures that includes the QCP and QAP for each product. The District BSPM is responsible for determining the procedures necessary to achieve the level of quality required by the project and will work with the other members of the PDT to develop the QMP. The QMP template must be used to develop the District bridge program QMP. See the BRL for the QMP template.

5.3. Quality Management Organization.

a. Each product developed under the Bridge Safety Program is subject to District Quality Control (DQC). Conduct periodic checks and controls throughout the inspection process. The technical review for the inspection report should be conducted by an independent, qualified inspector outside the home District. An ATR must be conducted on all evaluation reports. In some cases, an external expert should be consulted to ensure an adequate review or provide a second opinion. Refer to USACE Civil Works Review Policy for complete guidance on Civil Works review policy.

b. See ER 1110-2-111 for roles and responsibilities and qualification requirements of each Bridge Safety Program team member.

5.4. Quality Control. Quality Control is that part of Quality Management that ensures quality requirements are met and includes the QCP, quality checks and reviews, DQC, ATR, and quality control certification.

5.4.1. Quality Control Plan (QCP). The QCP is the quality control component of the QMP and defines how quality control will be executed for inspections and evaluations. The QCP is prepared by or under the direct supervision of the District BSPM in conjunction with the PDT. The QCP is developed during the planning phase and is implemented during the execution phase. A minimal treatment or generic QCP may be used for small scope or repetitive products. The District BSPM is responsible for updating the QCP as required for changing conditions. The QCP template must be used to develop the District bridge program QCP. See the BRL for the QCP template.

5.4.2. Quality Checks and Reviews.

a. Quality checks and reviews are required during the planning and execution phases. The bridge inspection Team Leader is responsible for quality checks during the inspection planning and during the bridge inspection. The Team Leader is responsible to ensure that the bridge inspection is conducted according to the requirements of ER 1110-2-111 and this manual.

b. The District BSPM is responsible for ensuring inspection reports have received adequate quality checks and reviews prior to an independent technical review. The District BSPM is responsible for ensuring qualified individuals conduct quality checks on all evaluations. The District BSPM will maintain all quality control records for each bridge in the bridge file.

c. The Compliance Metrics and Programmatic Reports in CEBIS (located under Inventory Reports) produces a checklist summary of all inspection reports. Use this summary to assess current compliance with the USACE requirements. For Reportable Bridges, this checklist can also be used to assess current compliance with the FHWA Metrics for the Oversight of the National Bridge Inspection Program. For any metric not satisfied develop a Plan of Corrective Action (PCA) to address deficiencies. See ER 1110-2-111 for descriptions of the FHWA Metrics.

5.4.3. Independent Reviews.

a. Independent reviews are conducted by a qualified person or team not directly involved in the bridge inspection or evaluation and for the purpose of confirming the proper application of criteria, regulations, laws, codes, principles, and professional practices. All products are subjected to an independent review. There are two types of independent reviews:

(1) DQC- managed by the home District and should be performed outside the home District for the final technical review of the inspection report.

(2) ATR-managed outside the home Division and must be performed on evaluation reports and should be performed on inspection reports for bridges with high risk.

b. Consider using an ATR for inspection reports for the following bridge inspection reports:

(1) Bridges considered Complex or that contain Special Features (see ER 1110-2-111 for definitions).

(2) Bridges with FCM.

(3) Bridges with high traffic volumes or significant truck traffic, significant being in terms of number and weight or type of payload.

(4) Bridges with low Bridge Safety Action Classification (BSAC), BSAC I or II.

(5) Bridges with poor conditions (NBI condition code of 4 or less or bridge elements with a Condition State of 4).

(6) Bridges that are Scour Critical.

c. Technical reviewers must meet the qualification requirements of ER 1110-2-111 for the product reviewed. Follow the QC checklist for conducting technical reviews. See the BRL for the QC checklist.

d. Review team members will be identified in the QCP, and any personnel changes are to be coordinated with the District BSPM and reflected by updating the QMP. The review team must ensure independence from the PDT but be available to act as advisors to the PDT.

e. The review process is a continual process (seamless) with formal reviews coordinated with the PDT at critical points. Review team members should be involved in the planning and execution phases of work. The District BSPM is responsible to ensure appropriate dialogue occurs between the review team and the PDT. The formal technical review will generally be conducted after the product is completed.

f. For complex bridges, or bridges with unusual conditions or significant problems, the reviewer may need to conduct a site visit to review inspection procedures or conditions that significantly impact the evaluation. Informal comments and discussions are encouraged at these intermediate points to identify and resolve issues that may impact the final product.

5.5. Quality Assurance. Quality Assurance (QA) is defined as that part of quality management that ensures project quality requirements defined in the PgMP are met. QA includes those processes employed to ensure that QC activities are being accomplished according to planned activities and that those QC activities are effective in producing a product that meets the desired end quality.

5.5.1. Quality Assurance Plan (QAP).

a. The QAP is a component of the QMP and PgMP and is prepared by the District BSPM during the project planning phase. It is a written plan that defines how quality assurance will be executed on products that are completed within a District, government agency, or A-E resources. The QAP is implemented during the project execution phase. The QAP defines an approach to ensure that the quality control program is being undertaken properly.

b. At a minimum the QAP will describe how quality assurance will be performed. Team members responsible for QA review, the risks inherent to the project, and any special considerations that must be addressed should be included. The technical supervisors and the review team members will review the QAP before it is finalized. See the BRL for the QA template.

5.5.2. District and MSC QA Coordination.

a. The MSC BSPM conducts QA reviews, using the standard QA checklist in CEBIS, on all inspection reports and ensures the reports meet ER 1110-2-111 requirements. The Team Leader will provide a concurrence or nonconcurrence to the MSC BSPM review and will provide any reason for nonconcurrence in the QA checklist. In addition, the MSC BSPM will occasionally conduct QA site visits and will determine if a bridge report meets the FHWA 23 metric requirements and assigns a level of compliance or verifies that a PCA has been developed for any noncompliant findings. See the CEBIS BRL for the PCA template.

b. The MSC BSPM should communicate with the District BSPM and Team Leader on noncompliance issues that may result in disapproval of the report and resolve these issues through the review process.

c. During the development of the QAP, the District BSPM will coordinate with the MSC BSPM to identify qualified QA reviewers.

5.5.3. QA Reviews for Work Performed Outside the District. If an inspection or evaluation is conducted by others outside of the home District, government agency, or AE contract, the assigning District will conduct a QA review of the inspection or evaluation reports using qualified QA reviewers.

5.6. Quality Assurance Audits.

5.6.1. The USACE BSPM is responsible for conducting QA audits on the District Bridge Safety Programs in compliance with the NBIS. The HQUSACE BSPM will review QM documentation, including personnel qualifications, QCPs, and QC reviews and selected representative samples of bridge inspections and evaluations. The bridge files will be reviewed, and site visits will be conducted as necessary.

5.6.2. Bridges selected for review will be based in part on changes to condition and appraisal ratings, critical features and details, load ratings, traffic volumes, and bridge importance. Audits will be performed on select Districts annually. QA audit will be conducted according to HQUSACE Bridge Safety Program Audit Procedures. See the BRL.

5.7. Review and Approval Documentation Procedures.

5.7.1. Review and Approval of Evaluation Reports. Provide a signature sheet for each evaluation report. The signature sheet signifies the report has received the required review and the reviewers have certified or approved the report. See USACE Civil Works Review Policy for sample review signature sheets.

5.7.2. Review and Approval of Inspection Reports. Review and approve inspection reports using CEBIS. The review and approval apply to all supplemental inspection reports conducted within the inspection interval. Each supplemental inspection report will contain a separate signature sheet certifying the inspection procedures and report meet ER 1110-2-111 requirements. There are four required levels of review requirements.

a. The Bridge Inspection Team Leader certifies that the inspection procedures and report meet ER 1110-2-111 requirements. The first level of review is part of the DQC review and conducted by the bridge inspection Team Leader directly involved in the inspection planning, execution, and reporting. When the inspection is completed by an AE contractor or outside agency, a Team Leader or District BSPM enters the inspection data into CEBIS and signs the report. This signature certifies that QA of the report has been conducted.

b. The Team Leader signature also signifies the Team Leader has reviewed all supplemental reports, conducted QA on the supplemental reports, and incorporated all relevant findings and recommendations from the supplemental inspection reports into the inspection report. Only users with Inspector level of access in CEBIS can access the electronic signature for this level of review.

c. The Technical Reviewer certifies that an independent DQC or ATR has been conducted for this inspection report (including any supplemental inspection reports), is consistent with the QCP, and meet ER 1110-2-111 requirements. This signature also signifies that the Technical Reviewer concurs with all findings and recommendations and that all substantive issues arising during the review have been resolved. This level represents an independent technical review conducted by a qualified reviewer. The Technical Reviewer will review the bridge reports using the standard QC checklist for comments.

d. The Chief of Engineering function of the District certifies that the report and the technical review (independent DQC or ATR) meet ER 1110-2-111 requirements. This signature also signifies the Chief of Engineering function concurs with all recommendations in the report. Only users with District Approval level of access in CEBIS can access the electronic signature for this level of review.

e. The MSC approves the inspection report. The MSC approval is completed after the MSC BSPM has completed the QA review and the report has been signed by the MSC Commander or designee.

Chapter 6
Bridge Management System

6.1. Introduction.

a. A Bridge Management System (BMS) is a tool used to collect, organize, analyze, report, and archive bridge inspection and evaluation information. The USACE BMS is the CEBIS program. All Bridge Safety Program related information must be stored in CEBIS. CEBIS contains several different sections for storage of data including:

(1) Bridge Files,

(2) Structure and Inventory Data,

(3) Bridge Inspection Reports,

(4) QC/QA Documentation, and

(5) Asset Management Methods.

b. Inspection personnel must record bridge inspection data on standard forms according to ER 1110-2-111 and this manual. The data input format of CEBIS satisfies this requirement. Bridge Safety Program requirements, regulations, guidelines, and related information can be accessed through the CEBIS program.

6.2. Bridge File.

a. Each District must maintain a complete, accurate, and current record of each bridge in the District's inventory in CEBIS. A bridge file contains the cumulative information about an individual bridge. It should provide a full history of the structure, including details of any damage and all strengthening repairs made to the bridge. The bridge record contains data on the capacity of the structure and includes the computations substantiating any weight restrictions.

b. The Bridge File provides information that may be important for cases involving repair, rehabilitation, or replacement. Information contained in a Bridge File is described in the MBE and Appendix 6-B. Files relating to Load Rating Documentation will meet the requirements as defined in Chapter 7: Load Rating Procedures. Enter all bridge data into the Bridge File with an electronic format (Adobe Acrobat) according to the instructions provided in CEBIS.

c. Complete a PCA when a noncompliance is identified and place in the Bridge File. Follow the PCA template located in the BRL.

6.3. Structure and Inventory Data.

6.3.1. Collect and record Structure and Inventory data items for each bridge. Figures 6.1 through 6.4 of this section provide a list of data required for different bridge types. The data items for vehicle bridges are described in the FHWA document Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (Coding Guide). Input all data correctly.

6.3.2. Errors are generated within CEBIS when incorrect data is input. There are four types of errors: Item Edits, Item Crosscheck Edits, Item Reasonableness Edits, and Item Reasonableness Crosscheck Edits. Correct all Item Edit and Item Crosscheck Edit errors before submitting the data as required in ER 1110-2-111. Review Item Reasonableness and Item Reasonableness Crosscheck Edits. Incorrect data should be corrected.

6.4. Inspection Reports. Input all inspection reports into CEBIS using the provided format. A standard report is generated from the data recorded. Enter inspection notes in the element inspection format. Each report must include photos showing general conditions and significant defects. Include photos for any defect resulting in an element rating of 3 or 4 or an NBI condition rating of 5 or less.

6.5. QC/QA Documentation. See Chapter 5: Quality Measures for QC/QA requirements. Record quality reviews on the forms provided in CEBIS.

6.6. Asset Management.

a. CEBIS includes a process for Operational Condition Assessment and Operational Risk Assessment (OCA/ORA). This process provides a Relative Risk score and associated Bridge Safety Action Classification (BSAC) for all maintenance and repair recommendations.

b. Each year, the District BSPM will develop a list of maintenance and repair items based on the Relative Risk scores. This information should be shared and discussed with Operations Business Line Managers for their use in development of the annual budget. USACE budget development guidance requires relative risk information to be documented and used as a primary consideration for prioritizing available funding.

c. Use of the process requires input of the type of system/subsystem the bridge serves, the business line for the bridge, the project P2 number, and the potential consequences to life safety, mission, and regional commerce if the bridge were to "fail." The consequence information is the basis of the determination for an appropriate Consequence Category of I through V. All the components and subcomponents defined for a bridge must also be input. The components and subcomponents include the AASHTO defined elements and agency defined elements.

d. At the conclusion of each inspection, the Team Leader will assign a Condition Classification of A through F to each subcomponent. A Condition Classification determination includes consideration of the current physical condition and the impact that the condition may have on the overall safety or capacity of the bridge within a certain timeframe.

e. CEBIS compares the Condition Classification value of each subcomponent with the bridge Consequence Category to determine the Relative Risk and BSAC values for each. When recommendations are made for the bridge, they are linked to the associated subcomponents and thereby get assigned the same values. The Condition Classification will be reviewed by the

District BSPM. The full description of the Bridge OCA/ORA process, ES 08150, and a training document are located at the BRL.

202	COE Number	XXXXXXXX-XXXXXX
Geographical and Route Data		
1	State	3 digits
2	District	2 digits
3	County	3 digits
4	Place	5 digits
6	Feature Under	25 digits
7	Facility On	18 digits
9	Location	25 digits
16	Latitude	8 digits XXdegXXminXX.XXsec
17	Longitude	9 digits XXXdegXXminXX.XXsec
98	Border Bridge	5 digits
99	Border Bridge Str No	15 digits
103	Temporary Str	1 digit
On and Under Record Data		
5	Inventory Route	9 digits
10	Min Vert Clr	4 digits XX.XX ft
11	Kilometer Point	7 digits XXXX.XXX
19	Detour Length	3 digits XXX
20	Toll	1 digit
26	Func Class	2 digits
28	Lanes on/under	4 digits
29	ADT	6 digits
30	Year ADT	4 digits
47	Total Horz Clearance	3 digits XX.X
100	Defense Hwy	1 digit
101	Parallel Str	1 digit
102	Direction of Traffic	1 digit
104	Hwy System	1 digit
109	Truck Traffic	2 digits XX%
110	Natl Truck Network	1 digit
General Data		
12	Base Hwy Network	1 digit
13	LRS Inventory Rt, Subrt.	12 digits
21	Maintenance Responsibility	2 digits
22	Owner	2 digits
27	Year Built	4 digits
31	Design Load	1 digit
33	Bridge Median	1 digit
34	Skew	2 digits XX deg.
35	Str Flared	1 digit
37	Hist Significance	1 digit
38	Navigation Control	1 digit
42	Type of Service	2 digits
43	Structure Type Main	3 digits
44	Structure Type Approach	3 digits
45	No of Span Main	3 digits
46	No of Approach Spans	4 digits
105	Federal Land Highways	1 digit
106	Year Reconstructed	4 digits
107	Deck Str Type	1 digit
108	Wear Surf/Protv Sys	3 digits
111	Nav Pier/ Abut Protection	1 digit
Inspection data		
90	Inspection Date (MoYr)	4 digits
91	Inspection Frequency	2 digits
92	Critical Inspection Feature	9 digits
	Frac Crit Insp:	Y/N mo
	Underwater Insp:	Y/N mo
	Other Spec Insp:	Y/N mo
93	Critical Inspection Feature	12 digits
	Frac Crit Insp:	moyr of last insp
	Underwater Insp:	moyr of last insp
	Other Spec Insp:	moyr of last insp

8	NBI Structure Number:	15 digits
Dimensional Data		
32	Approach Rdwy Width	4 digits XXX.X ft
39	Navigation Vert Clearance	4 digits XXX.X ft
40	Navigation Horiz Clearance	5 digits XXXX.X ft
48	Max Span Length	5 digits XXXX.X ft
49	Str Length	6 digits XXXXX.X ft
50	Curb/Sidewalk Width, Left	6 digits XX.X ft, XX.X ft
51	Brg Roadway Width, curb-curb	4 digits XXX.X ft
52	Deck width out-out	4 digits XXX.X ft
53	Min Vert Clr Over	4 digits XX.XX ft
54	Min Vert Clr under	5 digits X code, XX.XX ft
55	Min Lat Underclr R	4 digits X code, XX.X ft
56	Min Lat Underclr L	3 digits XX.X ft
112	NBIS Bridge Length	1 digit
116	Navigation Min Vert Clr	4 digits XXX.X ft
Proposed Improvements		
75	Type of Work	3 digits
76	Improvement Length	6 digits XXXXX.X ft
94	Bridge Improv Cost	6 digits
95	Rdwy Improv Cost	6 digits
96	Total Proj Cost	6 digits
97	Year of Cost Est	4 digits
114	Future ADT	6 digits
115	Year of Future ADT	4 digits
Condition Rating		
58	Deck	1 digit
59	Superstructure	1 digit
60	Substructure	1 digit
61	Channel & Channel Protect	1 digit
62	Culverts	1 digit
Apparaisal Rating		
36	Traffic Safety Features	4 digits
67	Structure Evaluation	1 digit
68	Deck Geometry	1 digit
69	Underclrn Vert & Horz	1 digit
71	Waterway Adequacy	1 digit
72	Approach Rdwy Alignment	1 digit
113	Scour Critical Bridges	1 digit
Load Rate and Post		
41	Str Open/Post/Close	1 digit
63	Method to Detrmn Op. Rtg	1 digit
64	Operating Rating	3 digits XX.X tons
65	Method to Detrmn Inv. Rtg	1 digit
66	Inventory Rating	3 digits XX.X tons
70	Bridge Posting	1 digit
Over 200 Items		
200	COE MSC	5 digits
201	COE District	5 digits
203	Inspection Officer	5 digits
204	Inspector	25 digits
205	Inspection Cost	6 digits
209	Recommended Speed Limit	2 digits
210	Posted Speed Limit	2 digits
216	Seismic Category	1 digit
217	Acceleration Coefficient	XX.XX
218	Soil Site Coefficient	X.X
230	Bridge Name	50 digits
231	Life Safety	
232	USACE Mission	
233	Business Line	
234	Regional Commerce	
235	Subsystem	
236	Project (P2) number	

Figure 6.1. Public Highway/Roadway Bridge

202	COE Number	XXXXXX-XXXXXX

Geographical and Route Data		
1	State	3 digits
2	District	2 digits
3	County	3 digits
4	Place	5 digits
6	Feature Under	25 digits
7	Facility On	18 digits
9	Location	25 digits
16	Latitude	8 digits XXdegXXminXX.XXsec
17	Longitude	9 digits XXXdegXXminXX.XXsec
103	Temporary Str	1 digit

On and Under Record Data		
5	Inventory Route	9 digits
10	Min Vert Clr	4 digits XX.XX m
28	Lanes on/under	4 digits
29	ADT	6 digits
30	Year ADT	4 digits
47	Total Horz Clearance	3 digits XX.X

General Data		
21	Maintenance Responsibility	2 digits
22	Owner	2 digits
27	Year Built	4 digits
34	Skew	2 digits XX deg.
37	Hist Significance	1 digit
38	Navigation Control	1 digit
42	Type of Service	2 digits
43	Structure Type Main	3 digits
44	Structure Type Approach	3 digits
45	No of Span Main	3 digits
46	No of Approach Spans	4 digits
106	Year Reconstructed	4 digits
107	Deck Str Type	1 digit
108	Wear Surf/Protv Sys	3 digits
111	Nav Pier/ Abut Protection	1 digit

Condition Rating		
58	Deck	1 digit
59	Superstructure	1 digit
60	Substructure	1 digit
61	Channel & Channel Protect	1 digit
62	Culverts	1 digit

Inspection data		
90	Inspection Date (MoYr)	4 digits
91	Inspection Frequency	2 digits
92	Critical Inspection Feature	9 digits
	Frac Crit Insp:	Y/N mo
	Underwater Insp:	Y/N mo
	Other Spec Insp:	Y/N mo
93	Critical Inspection Feature	12 digits
	Frac Crit Insp:	moyr of last insp
	Underwater Insp:	moyr of last insp
	Other Spec Insp:	moyr of last insp

8	NBI Structure Number:	15 digits

Dimensional Data		
32	Approach Rdwy Width	4 digits XXX.X ft
48	Max Span Length	5 digits XXXX.X ft
49	Str Length	6 digits XXXXX.X ft
53	Min Vert Clr Over	4 digits XX.XX ft
54	Min Vert Clr under	5 digits X code, XX.XX ft
55	Min Lat Underclr R	4 digits X code, XX.X ft
56	Min Lat Underclr L	3 digits XX.X ft

Proposed Improvements		
75	Type of Work	3 digits
76	Improvement Length	6 digits XXXXX.X ft
94	Bridge Improv Cost	6 digits
95	Rdwy Improv Cost	6 digits
96	Total Proj Cost	6 digits
97	Year of Cost Est	4 digits
114	Future ADT	6 digits
115	Year of Future ADT	4 digits

Apparaisal Rating		
36	Traffic Safety Features	4 digits
67	Structure Evaluation	1 digit
68	Deck Geometry	1 digit
69	Underclrn Vert & Horz	1 digit
71	Waterway Adequacy	1 digit
72	Approach Rdwy Alignment	1 digit
113	Scour Critical Bridges	1 digit

Load Rate and Post		
41	Str Open/Post/Close	1 digit
63	Method to Detrmn Op. Rtg	1 digit
64	Operating Rating	3 digits XX.X tons
65	Method to Detrmn Inv. Rtg	1 digit
66	Inventory Rating	3 digits XX.X tons
70	Bridge Posting	1 digit

Over 200 Items		
200	COE MSC	5 digits
201	COE District	5 digits
203	Inspection Officer	5 digits
204	Inspector	25 digits
205	Inspection Cost	6 digits
209	Recommended Speed Limit	2 digits
210	Posted Speed Limit	2 digits
216	Seismic Category	1 digit
217	Acceleration Coefficient	XX.XX
218	Soil Site Coefficient	X.X
230	Bridge Name	50 digits
231	Life Safety	
232	USACE Mission	
233	Business Line	
234	Regional Commerce	
235	Subsystem	
236	Project (P2) number	

Figure 6.2. Nonpublic Access Bridge

202	COE Number	XXXXXXXX-XXXXXX
	Geographical and Route Data	
1	State	3 digits
2	District	2 digits
3	County	3 digits
4	Place	5 digits
6	Feature Under	25 digits
7	Facility On	18 digits
9	Location	25 digits
16	Latitude	8 digits XXdegXXminXX.XXsec
17	Longitude	9 digits XXXdegXXminXX.XXsec
	General Data	
21	Maintenance Responsibility	2 digits
22	Owner	2 digits
27	Year Built	4 digits
34	Skew	2 digits XX deg.
35	Str Flared	1 digit
42	Type of Service	2 digits
43	Structure Type Main	3 digits
44	Structure Type Approach	3 digits
45	No of Span Main	3 digits
46	No of Approach Spans	4 digits
106	Year Reconstructed	4 digits
107	Deck Str Type	1 digit
108	Wear Surf/Protv Sys	3 digits
	Over 200 Items	
200	COE MSC	5 digits
201	COE District	5 digits
203	Inspection Officer	5 digits
204	Inspector	25 digits
205	Inspection Cost	6 digits
209	Recommended Speed Limit	2 digits
210	Posted Speed Limit	2 digits
216	Seismic Category	1 digit
217	Acceleration Coefficient	XX.XX
218	Soil Site Coefficient	X.X
230	Bridge Name	50 digits
231	Life Safety	
232	USACE Mission	
233	Business Line	
234	Regional Commerce	
235	Subsystem	
236	Project (P2) number	

8	NBI Structure Number:	15 digits
	Dimensional Data	
48	Max Span Length	5 digits XXXX.X ft
49	Str Length	6 digits XXXXX.X ft
51	Brg Roadway Width, curb-curb	4 digits XXX.X ft
52	Deck width out-out	4 digits XXX.X ft
	Proposed Improvements	
75	Type of Work	3 digits
94	Bridge Improv Cost	6 digits
95	Rdwy Improv Cost	6 digits
96	Total Proj Cost	6 digits
97	Year of Cost Est	4 digits
	Condition Rating	
58	Deck	1 digit
59	Superstructure	1 digit
60	Substructure	1 digit
61	Channel & Channel Protect	1 digit
	Apparaisal Rating	
36	Traffic Safety Features	4 digits
71	Waterway Adequacy	1 digit
72	Approach Rdwy Alignment	1 digit
113	Scour Critical Bridges	1 digit
	Load Rate and Post	
41	Str Open/Post/Close	1 digit
220	Pedestrian (psf)	
221	Vehicle (Tons)	
	Inspection data	
90	Inspection Date (MoYr)	4 digits
91	Inspection Frequency	2 digits
92	Critical Inspection Feature	9 digits
	Frac Crit Insp:	Y/N mo
	Underwater Insp:	Y/N mo
	Other Spec Insp:	Y/N mo
93	Critical Inspection Feature	12 digits
	Frac Crit Insp:	moyr of last insp
	Underwater Insp:	moyr of last insp
	Other Spec Insp:	moyr of last insp

Figure 6.3. Pedestrian Bridge

202	COE Number	XXXXXX-XXXXXX
	Geographical and Route Data	
1	State	3 digits
2	District	2 digits
3	County	3 digits
6	Feature Under	25 digits
7	Facility On	18 digits
9	Location	25 digits
16	Latitude	8 digits XXdegXXminXX.XXsec
17	Longitude	9 digits XXXdegXXminXX.XXsec
98	Border Bridge	5 digits
99	Border Bridge Str No	15 digits
	On and Under Record Data	
5	Inventory Route	9 digits
10	Min Vert Clr	4 digits XX.XX ft
11	Mile Point	7 digits XXXX.XXX
28	Lanes on/under	4 digits
29	ADT	6 digits
30	Year ADT	4 digits
47	Total Horz Clearance	3 digits XX.X
	General Data	
21	Maintenance Responsibility	2 digits
22	Owner	2 digits
27	Year Built	4 digits
34	Skew	2 digits XX deg.
35	Str Flared	1 digit
37	Hist Significance	1 digit
38	Navigation Control	1 digit
42	Type of Service	2 digits
43	Structure Type Main	3 digits
44	Structure Type Approach	3 digits
45	No of Span Main	3 digits
46	No of Approach Spans	4 digits
106	Year Reconstructed	4 digits
111	Nav Pier/ Abut Protection	1 digit
	Inspection data	
90	Inspection Date (MoYr)	4 digits
91	Inspection Frequency	2 digits
92	Critical Inspection Feature	9 digits
	Frac Crit Insp:	Y/N mo
	Underwater Insp:	Y/N mo
	Other Spec Insp:	Y/N mo
93	Critical Inspection Feature	12 digits
	Frac Crit Insp:	moyr of last insp
	Underwater Insp:	moyr of last insp
	Other Spec Insp:	moyr of last insp
	Load Rate and Post	
41	Str Open/Post/Close	1 digit

8	NBI Structure Number:	15 digits
	Dimensional Data	
39	Navigation Vert Clearance	4 digits XXX.X ft
40	Navigation Horiz Clearance	5 digits XXXX.X ft
48	Max Span Length	5 digits XXXX.X ft
49	Str Length	6 digits XXXXX.X ft
50	Curb/Sidewalk Width, Left	6 digits XX.X m, XX.X ft
51	Brg Roadway Width, curb-curb	4 digits XXX.X ft
52	Deck width out-out	4 digits XXX.X ft
53	Min Vert Clr Over	4 digits XX.XX ft
54	Min Vert Clr under	5 digits X code, XX.XX ft
55	Min Lat Underclr R	4 digits X code, XX.X ft
56	Min Lat Underclr L	3 digits XX.X ft
116	Navigation Min Vert Clr	4 digits XXX.X ft
	Proposed Improvements	
75	Type of Work	3 digits
76	Improvement Length	6 digits XXXXX.X ft
94	Bridge Improv Cost	6 digits
95	Rdwy Improv Cost	6 digits
96	Total Proj Cost	6 digits
97	Year of Cost Est	4 digits
114	Future ADT	6 digits
115	Year of Future ADT	4 digits
	Condition Rating	
58	Deck	1 digit
59	Superstructure	1 digit
60	Substructure	1 digit
61	Channel & Channel Protect	1 digit
62	Culverts	1 digit
	Apparaisal Rating	
36	Traffic Safety Features	4 digits
71	Waterway Adequacy	1 digit
72	Approach Rdwy Alignment	1 digit
113	Scour Critical Bridges	1 digit
	Over 200 Items	
200	COE MSC	5 digits
201	COE District	5 digits
203	Inspection Officer	5 digits
204	Inspector	25 digits
205	Inspection Cost	6 digits
209	Recommended Speed Limit	2 digits
210	Posted Speed Limit	2 digits
216	Seismic Category	1 digit
217	Acceleration Coefficient	XX.XX
218	Soil Site Coefficient	X.X
230	Bridge Name	50 digits
231	Life Safety	
232	USACE Mission	
233	Business Line	
234	Regional Commerce	
235	Subsystem	
236	Project (P2) number	

Figure 6.4. Railway Bridge

6.7. Bridge File Data. This section provides the list of CEBIS folders and associated data requirements to be included in the Bridge File. The items in the list below denoted with an asterisk must be provided in the Bridge File to comply with FHWA requirements. Complete a Plan of Corrective Action (PCA) where this information is not currently available. The PCA should identify a date or timeline for which the data will be entered or the deficiency will be corrected. See Sample PCA for guidelines on completing a PCA (see the BRL for the PCA template).

a. District Documents. District documents include all documentation that is common to the District Bridge Safety Program to include:

(1) * The District Critical Findings Plan (see Chapter 4 – Critical Findings for documentation requirements),

(2) * The inspection Safety and Traffic Control Plans where these plans are common to multiple bridges. See Chapter 3 – Inspection Procedures for a sample Safety Plan.

(3) * The District PgMP/QMP/QCP where these documents are common to multiple bridges (see Chapter 5 - Quality Measures for documentation requirements),

(4) * Qualifications of Bridge Program Managers, inspection team members, divers, and engineers (see Chapter 5 - Quality Measures for documentation requirements),

b. Bridge Design & Construction.

(1) Bridge Design. Include all design documentation associated with the bridge design.

(2) Construction Photographs. Include all pertinent construction photos.

(3) Location. Include any documents that identify bridge location including vicinity and location maps, aerial photos, etc.

(4) Plans and Specs/As-Builts. Include the final as-built drawings, shop drawings, and specifications.

(5) Rehabilitation. Include all design, evaluation, contract, and as-built documentation for all rehabilitation work.

c. Critical Findings Report. Include all Critical Findings reports for each Critical Finding (see Chapter 4 - Critical Findings for guidance on Critical Finding Reports).

d. Evaluations.

(1) Fatigue and Fracture. Include all documentation for any fatigue and fracture evaluation conducted for the bridge including documentation of all reviews.

(2) * Load Ratings / Capacity. Include all documentation for any load ratings and load capacity evaluations conducted for the bridge including documentation of all reviews (see Chapter 7 - Load Rating Procedures for documentation to include in the Bridge File).

(3) * Scour. Include all documentation for any scour evaluations conducted for the bridge including documentation of all reviews.

(4) Seismic. Include all documentation for any seismic evaluations conducted for the bridge including documentation of all reviews.

e. Inspection Data and Bridge History.

(1) Correspondence. Include any correspondence pertinent to the history of the bridge to include internal communications, coordination with local agencies, and approvals for late inspections. Include correspondence date in file name to identify correspondence in chronological order.

(2) Flood Data. Include all pertinent hydrologic data, flood records, scour data (not related to Scour Evaluations and Survey Data), and high water elevation.

(3) * In Depth, Damage and Special Inspection Reports. Include all Damage and Special Inspection reports.

(4) Inspection History. Include a chronological record of all inspections and evaluations conducted and identify the inspection date and type.

(5) Inspection Documentation and Field Book. Include the Field Book, including field notes and sketches, and any reports not otherwise generated in CEBIS. All CEBIS generated reports can be accessed from this folder.

(6) Materials and Tests. Include all material certifications and material test reports.

(7) Photographs – general. Include all pertinent photos not contained elsewhere.

(8) QA Checklists. This folder contains links to all QA Checklists generated in CEBIS.

(9) *Survey Data. Include all channel and scour survey data.

(10) Traffic Data. Include all pertinent traffic data including traffic counts, WIM studies, etc.

(11) *Underwater Inspection Reports. Include all underwater inspection reports, excluding any data contained in Survey Data.

f. Inspection Requirements

(1) *Complex Bridge Inspection Plan. Include all Complex Bridge Inspection Plans.

(2) *FCM Inspection Plan. Include all FCM Inspection Plans.

(3) *Inspection Plan. Include all Routine Inspection Plans.

(4) *Scour Critical Plan of Action. Include all Scour Critical Plans of Action.

(5) *Underwater Inspection Plan. Include all Underwater Inspection Plans.

g. Maintenance and Repair History

(1) Accident Records. Include documentation of all accidents that impact the bridge to include date of accident, a description of the damage of the bridge, a description of repairs completed, and any associated reports.

(2) Coating History. Include documentation for each coating project (excluding spot and other minor maintenance painting) that contains paint specifications and contract documentations, painting records, and associated QC/QA reports.

(3) Repair Records. Include documentation of all repairs and maintenance activities that contain plans and specifications, reports, and photographs showing before and after depictions of the areas affected.

*Data files are required for this item, unless not applicable (NA), and must be entered into the Bridge File or a PCA must be completed and filed. Include a brief statement for NA items stating why it is NA.

Chapter 7
Load Rating Procedures

7.1. Introduction. A load rating must be completed for each bridge according to ER 1110-2-111. A bridge load rating is an evaluation procedure that provides a load capacity rating, or the measure of a bridge's load carrying capacity at the time of the evaluation. The rating is based on the individual components of the bridge structure and considers the existing structural conditions, material properties, loads, and traffic conditions at the bridge site. This chapter addresses the requirements and general concepts to use in preparing bridge load rating evaluations based on the following AASHTO manuals: MBE and the Load and Resistance Factor Design Bridge Design Specifications (LRFD Manual).

7.2. Purpose.

7.2.1. The purpose of this chapter is to provide guidance and requirements for load capacity ratings for all bridges, except railway bridges, using analytical methods or the use of nondestructive load testing. See Chapter 10: Railway Bridges for load rating requirements relating to railway bridges. It also provides information on data collection and material strength testing procedures that are necessary to determine unknown material properties.

7.2.2. This chapter will provide a framework for consistent, reproducible load capacity ratings with systematic quality control and quality assurance procedures, which will help to ensure that each USACE bridge is rated for its safe load-carrying capacity. The process for load rating evaluation is depicted in the flowchart in Appendix B.

7.3. Load Rating Requirements.

7.3.1. New or Reconstructed Bridges.

a. Load ratings by the Load and Resistance Factor Rating (LRFR) method are required for all new and replacement bridges, and for all rehabilitation and repair designs involving a structural alteration that could change load, capacity or load distribution. Required live load models are defined in this document. Perform the LRFR load rating calculations as part of the design process. Update the load rating to be consistent with the as-built or as-rehabilitated condition of the bridge. File the Load Rating, including spreadsheets or any software electronic input and output files in the Bridge File for use in future re-analyses.

b. The bridge will be rated for all construction and traffic loads during construction. The contractor will adhere to any restrictions and, if required, the bridge will be posted for public vehicular traffic.

7.3.2. Existing Bridges.

a. The bridge inspection Team Leader must review the load rating and the current inspection findings after each inspection to see if a new or updated load rating analysis is required. Include a recommendation and update the Evaluation Summary in the bridge inspection report if a new or updated load rating evaluation is required. If a new or updated load rating is not required, a statement to that effect must be included in the Evaluation Summary in the inspection report. A re-rating or additional analysis would usually be necessary if any of the following are true:

(1) Change in condition that impacts the structural capacity. See Section 7.6: Bridge Load Rating Procedure paragraph in this chapter for components to be included in the load rating analysis.

(2) Change in dead load due to resurfacing or other nonstructural alterations such as modification of utilities.

(3) Change in section properties due to deterioration, rehabilitation, re-decking, or other alterations.

(4) Damage due to vessel or vehicular collision or other damaging events.

(5) Structural or fatigue cracking present in primary members.

(6) Losses of strength at critical connections.

(7) Significant changes in traffic loadings or traffic volume.

(8) Special FHWA guidance (e.g., gusset plate analysis).

(9) Soil and substructure settlement and slope instability.

(10) Existing load rating does not include gusset plate analysis or critical truss connection components.

(11) Existing load rating documentation does not include appropriate quality control review documentation (see Section 7.5: Quality Control and Quality Assurance).

b. The District BSPM is responsible to ensure that all existing bridge load ratings are conducted according to this chapter and the current AASHTO Manual for Bridge Evaluation. Load rate all existing bridges that have not been load rated previously or do not have adequate analysis. This should be completed as part of the next inspection using LRFR according to the requirements of this document and the MBE.

c. If complete quality control documentation of an existing load rating is not available, a qualified engineer must perform a QC review to determine if the existing analysis is adequate. If the existing analysis is adequate, file the QC documentation with the analysis. If the existing analysis is not adequate, perform additional analysis in order to address the deficiencies or perform a new load rating. It is the responsibility of the bridge inspection Team Leader to ensure that current load rating status and values are included in the inspection report regardless if a new load rating is required or not.

d. Instances where an existing Allowable Stress Rating (ASR) or Load Factor Rating (LFR) bridge load rating exist and adequate QC documentation exists, the load rating must be updated based on the current load rating criteria. However, it is preferred to re-rate using LRFR since ASR and LFR are outdated criteria and the AASHTO Standard Specifications are no longer supported.

e. General load rating requirements are outlined in Table 7.1.

Table 7.1
Load Rating Requirements

Load Rating Status	Action Required
Any bridge with a load rating and a change in condition or usage	Update or perform a new load rating according to LRFR criteria and perform QC and QA reviews
Load rating performed in LRFR per current criteria and QC performed by qualified individuals and documented	National Load Rating Engineer (LRE) perform QA review
Load rating performed in LRFR per current criteria and QC either not performed by qualified individuals or not adequately documented	Perform QC, then National LRE perform QA review
Load rating for an existing bridge performed in ASD or LFR per outdated criteria and QC performed by qualified individuals and documented	Update load rating to current ASD or LFR criteria. Perform QC review. Then, National LRE performs QA review
Load rating for an existing bridge performed in ASD or LFR per current criteria and QC performed by qualified individuals and documented	National LRE perform QA review of existing load rating
Load rating for an existing bridge performed in ASD or LFR per current criteria and QC either not performed by qualified individuals or not adequately documented	Perform QC review. If calculations appear to be adequate, document QC review and then National LRE performs QA review. If QC finds calculations appear to be insufficient, re-rate in LRFR and perform required subsequent QC review. Then, National LRE performs QA review
No load rating exists or calculations are inadequate	Perform load rating according to LRFR criteria and perform QC and National LRE QA reviews

7.3.3. Bridges with Crane-Only Loads. For bridges that carry only crane loads on rails and are not subjected to vehicular loads, a load rating will be performed when the condition rating of the superstructure falls below 6 or the design crane and/or design pick load has changed. Crane-only bridges are unique bridges with unique loads and no load rating guidance specific to these types of bridges exists. The load rating should be performed by an engineer with extensive experience in load rating bridges using the AASHTO MBE and a knowledge of crane loads based on ASCE 7 and the Crane Manufacturers Association of America (CMAA) Specification No. 70.

7.4. Qualifications and Responsibilities.

a. Bridge load rating requires engineering judgment in performing the necessary calculations to determine the safe load carrying capacity of a bridge and arriving at posting and permitting decisions. Given the importance of this process, the load rating evaluation must be performed under the direction of a Responsible Engineer as defined in ER 1110-2-111.

b. Qualifications for Responsible Engineers must be documented in the District Program Management Plan and as outlined in ER 1110-2-111 and Chapter 5: Quality Measures. Where a qualified Responsible Engineer does not reside in the district, the following options exist:

(1) Select a qualified Responsible Engineer outside of the home district.

(2) Coordinate with the MSC BSPM to find a qualified Responsible Engineer.

(3) Contact the National LRE.

c. The National Highway Institute, the American Society of Civil Engineers (ASCE), and the USACE provide training opportunities for the Load Rating of Highway Bridges Course.

7.5. Quality Control and Quality Assurance. See Chapter 5: Quality Measures for Quality Control and Quality Assurance requirements and USACE Civil Works Review Policy in addition to those listed below.

7.5.1. Quality Control.

a. Quality control review of the bridge load rating includes a DQC by a qualified engineer and an ATR by a qualified engineer. Include the required levels of reviews in the QMP.

b. The Responsible Engineer will ensure that the load rating has followed the requirements of this chapter and Quality Control review requirements in Chapter 5: Quality Measures prior to advancing to the ATR. Document QC review comments and include those comments in the load rating documentation. In addition to the other technical checks, all computer input and output data will be verified during the QC reviews.

c. The District BSPM ensures the ATR is performed by a qualified engineer who resides outside of the home district for which the analysis was performed. An ATR team lead is not required since the ATR review consists of one individual. It is recommended that the ATR be completed by a qualified engineer designated by the National LRE or from the list of qualified individuals listed in the BRL.

d. The ATR review will be performed per the checklist and certification. See the BRL. Document review comments and district responses in a word document or in the pdf of the load rating report. Consult the National LRE when comment resolution is not readily achievable.

e. QC review is complete when all associated comments have been resolved. The home district is responsible for attaching the ATR checklist and certification to the end of the final load rating documentation. Include the QC documentation in the bridge file.

7.5.2. Quality Assurance. The National LRE is responsible for performing the QA review and will be listed in the District QMP as the responsible party for load rating QA review. See Chapter 5: Quality Measures for QMP requirements. The QA review is complete when the signed Load Rating Validation memorandum from the National LRE is filed in the CEBIS load rating file.

7.5.3. Load Ratings and Reviews Performed by Outside Agency. If a consultant or other agency performs the load ratings and reviews, they are to have the similar quality control and quality assurance procedures in place to ensure the accuracy and completeness of the load ratings.

7.6. Bridge Load Rating Procedure.

a. See the flowchart in Appendix B for steps in the load rating process. A load rating will be consistent with the MBE and will include analysis of the following items:

(1) All elements identified as "primary member" as defined in the FHWA BIRM. In general, all superstructure elements except diaphragms, cross bracing, and lateral bracing are primary members. However, for curved girders, these excepted elements could be considered primary members.

(2) Capacity of gusset plates and connection elements for nonredundant steel truss bridges, see FHWA February 15, 2008 Memorandum.

(3) Secondary members if their condition influences the behavior of the primary member.

(4) Possibly some deck and/or substructure elements if conditions exist as described in the MBE.

b. In general, include the following steps for each bridge being rated:

(1) Collect data.

(2) Determine material properties.

(3) Determine the Dead Loads and other Permanent Loads and their effect on the bridge component being rated.

(4) Determine the Live Loads and their effect on the bridge component being rated.

(5) Determine the Capacity of the bridge component considering the existing condition.

(6) Use the Dead Loads, other Permanent Loads, Live Loads, and Capacity to calculate the Design Load Rating Factor using the Load Rating Factor equations.

(7) For those vehicular bridges with a Design Load Rating Factor < 1.0, evaluate legal load ratings. Calculate the legal load rating factor using the AASHTO legal loads or local state legal loads (see Section 7.9).

(8) The AASHTO SHV must be evaluated for those vehicular bridges with the LRFR legal load rating factor for any of the AASHTO Routine Commercial Vehicles less than 1.3 or the ASR or LFR Operating Rating for the AASHTO Routine Commercial Vehicle (Type 3, Type 3S2, or Type 3-3) less than 33 tons (English), 47 tons or 52 tons, respectively. SHVs should be evaluated for all new bridge legal load ratings. Load Rating for SHV is not required for bridges in states that do not allow SHV use or where the state legal loads exceed the SHV loading models.

(9) Evaluate vehicular bridges for Emergency Vehicles (EV) as defined by the FAST Act if the bridge is on the interstate, within reasonable access to the interstate or if the state statute allows overweight EV to cross without restrictions. Type EV2 and EV3 must be evaluated. Reasonable access is within one road-mile from access to and from the National Network of highways unless otherwise dictated by state policies.

(10) Calculate vehicular bridge posting values in tons for any legal load, SHV, or EV Rating Factor <1.0 according to AASHTO MBE.

(11) For bridges with gantry crane or other type of permanent crane and vehicular loads, the members carrying the vehicular loads only will have a design load rating and where necessary a legal load rating performed. The members that carry the gantry crane loads should

be load rated by an engineer with extensive experience in load rating bridges using the AASHTO MBE and a knowledge of crane loads based on ASCE7 and the CMAA Specification No. 70.

(12) For those pedestrian bridges with a Design Load Rating < 60 psf, evaluate and determine a safe posting that limits the number of pedestrians on the bridge at one time.

(13) For those pedestrian bridges where vehicular access is not prevented and with a Design Load Rating < 1.0 for the design vehicle or known vehicular loading, evaluate and determine a safe posting for the allowed vehicular load.

7.7. Data Collection.

a. Use as-built drawings to identify member types and all dimensions used in the load rating calculations. As-built information should be verified through field observations and measurements. Where as-built drawings do not exist or are outdated due to repairs, rehabilitation, or other changes, conduct a field survey to obtain the information. Determine changes in dead load (such as changes in type of decking, additional overlay, or new utilities) since the prior load rating was completed. Confirm all such changes shown by retrofit as-built drawings. Store all information obtained from field surveys in the Bridge File.

b. Review Section 4 of the MBE for field data to be collected or verified before load rating a bridge.

7.8. Material Properties. Use as-built drawings, contract specifications, design documents, or other construction documents to identify material properties. Conduct destructive testing or NDT to determine material properties and member condition when this information is unknown or is suspect. Use only qualified individuals when conducting this testing. Store all information obtained from testing in the Bridge File.

7.8.1. Steel and Concrete Components. Section 6 Part A of the MBE for LRFR and Section 6 Part B for ASR and LFR provides estimated steel, concrete, and reinforcing steel (including prestressing steel) strengths based on the year of bridge fabrication. Year of fabrication is based on existing drawings or should be assumed if drawings do not exist. Assumptions should be based on historical or known information of the site or similar structures nearby.

a. Estimation of prestressing steel strengths when using LFR should be based on the AASHTO Standard Specifications.

b. Where assumptions on material properties lead to unacceptably low load ratings, it is prudent to conduct material testing to determine actual properties which may be more favorable than assumed. See Section 7.14: Material Strength Testing. This may lead to acceptable results and avoid posting or other limitations.

7.8.2. Concrete Bridges with Unknown Reinforcing. A concrete bridge with unknown reinforcing details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period and shows no distress. The bridge must be inspected regularly to verify satisfactory performance. Refer to ER 1110-2-111 for inspection frequency requirements. Testing should be conducted where a change in condition or loading occurs. See Section 7.14: Material Strength Testing.

7.8.3. Timber Components. Use timber strengths identified in the design or as-built drawings or base strengths on the species listed. See AASHTO LRFD Section 8.4 for timber material strengths listed by species. Estimate timber properties where strengths or species are unknown by comparing the bridge with plans from similar bridges built in the same era and same area. Consult the U.S. Forest Products Laboratory or a wood pathologist where no information exists or where uncertainty exists.

7.9. Load Effects—Vehicular Bridges.

a. See Section 6 of the MBE for defined dead loads. Dead load values of standard beams, parapets, and railings may be listed in the bridge design standard details of the governing state.

b. See Section 6 and associated appendices of the MBE for defined design, rating, and posting live loads. Consult individual State Department of Transportation websites or personnel for state legal load rating requirements. Include state-specific legal loads in the legal load rating for public bridges. The AASHTO SHV should be included in all new legal load ratings, but is required to be included for all legal load ratings if the LRFR legal load rating factor for any of the AASHTO Routine Commercial Vehicles is less than 1.3 or the ASR or LFR Operating Rating for the AASHTO Routine Commercial Vehicle (Type 3, Type 3S2, or Type 3-3) is less than 33 tons (English), 47 tons or 52 tons, respectively.

c. Load rating for SHVs is not required for bridges in states that do not allow SHV use or where the state legal loads exceed the SHV loading models. Complete the required SHV load ratings for the aforementioned bridges immediately and for all bridges prior to December 31, 2022 according to FHWA November 15, 2013 memorandum. Load rating for EV2 and EV3 is required by the FAST Act for select bridges near or on the National Highway System (NHS), see FHWA February 24, 2016 and November 3, 2016 memorandums.

d. Use analysis by an appropriate method (statics) or consult published references (e.g., AISC beam tables) when determining moment and shear effects. Several sources provide moment and shear tables for various trucks and simple span lengths. Considering AASHTO loads, live load moments of longitudinal stringers or girders for simple spans are included in Appendix E6A of the MBE and most state highway bridge design manuals provide moment and shear tables for the associated state legal truck loading. AISC tables provide generic moment and shear values for continuous spans that can be used to develop specific values based on defined loads and geometry.

e. For more complex structures (such as a truss, tied arch, and cable-stay), several methods of analysis may be required. In many cases, stringers and floor beams can be analyzed using statics, beam diagrams, or a basic computer model, and the more complex support structure would require more advance analyses. These may include computer based three-dimensional modeling and consideration of nonlinear effects.

7.10. Load Effects—Pedestrian Bridges. See Section 6 of the MBE for defined dead loads. See Section 3 of the LRFD Guide Specifications for the Design of Pedestrian Bridges for the defined live loads. Where vehicular access is not prevented, the bridge will be evaluated with the design vehicle and limit state specified in the LRFD Guide Specifications for the Design of Pedestrian Bridges. If vehicular access is prevented, a design vehicle does not need to be considered.

7.11. Component Capacity. Determine capacity for each component being rated according to the function of the component serves and the limit state evaluated. Typically, shear, axial, and flexural capacities of components are evaluated. In general, the capacity of a component is the product of the nominal resistance, the applicable section property, and the resistance factors. The AASHTO LRFD Manual and State Manuals provide guidance to determine nominal resistance and applicable resistance factors.

7.12. Load Rating.

7.12.1. LRFR. Follow requirements of Section 6 Part A of the MBE for the rating levels and method for LRFR. The Design Load rating for vehicular bridges will be evaluated for the Inventory and Operating levels using the applicable live load factor. Legal loads will be evaluated, using the applicable load factors, when the Inventory rating factor is < 1.0. Specific load rating procedures for pedestrian bridges are not available. The Design Load rating for pedestrian bridges will be evaluated for the Inventory level, as defined in the MBE, using the applicable live load factor.

a. See Section 6 Part A of the MBE for load factors associated with each limit state, condition and system factors. Apply the load factors to appropriate live loads and dead loads, and apply the condition, system, and resistance factors to the component capacities.

b. Permit Load Rating. A Permit Load Rating is required when the passage of vehicles with weight greater than the legally established weight limitations is requested or when special loads such as mobile cranes are placed on the bridge. A Permit Load Rating is required only if the bridge has a legal load rating factor greater than 1.0. Load rate permit vehicles by using load-rating procedures provided in Section 6 Part A of the MBE with load factors selected based upon the permit type, frequency, and loading condition.

c. Fatigue and Fracture Evaluation. Section 6 Part A of the MBE provides guidance to conduct Fatigue and Fracture evaluations to determine ratings based on fatigue. See Chapter 8: Fatigue and Fracture.

7.12.2. ASR and LFR. Follow requirements of Section 6 Part B of the MBE for the rating levels and methods for ASR and LFR.

7.13. Load Posting. The District BSPM will ensure posting and restrictions are carried out as necessary and should coordinate with Operations personnel to determine the appropriate posting and notification of load restrictions on all bridges. For public bridges, local and state requirements should be considered.

7.13.1. Vehicular Bridges.

a. Follow load posting procedures outlined in the MBE to determine posting values and associated rating values. Include project-specific loads when those loads exceed the effects of the legal loads previously described.

b. Load Posting requirements and determination for the LRFR method is described in Section 6 Part A of the MBE. Use the legal load rating factor to calculate a safe load capacity when rating by the LRFR method. The rating in tons of the bridge is the lowest safe load capacity of the bridge components.

c. Bridges with legal load rating factors > 1.0 do not need to be load posted. The District may close a bridge at any posting threshold; however, a bridge with a legal load rating factor < 0.3 must be closed. When load posting is required, the posting must follow the requirements of Section 6 Part A.8 of the MBE and the MUTCD and any local requirements.

d. Load Posting requirements and determination for ASR and LFR methods are as described in Section 6 Part B.7 of the MBE.

7.13.2. Pedestrian Bridges. All pedestrian bridges must be posted when the safe load capacity is less than 60 psf of uniform pedestrian load. The posting must limit the number of pedestrians on the bridge at one time. Bridges with a safe load capacity less than 40 psf of uniform pedestrian load must be closed. Where vehicular access is not prevented, the bridge must be posted for the allowable vehicular load when the safe load capacity is less than the design vehicle load. If the bridge safe load capacity is less than 3 tons for vehicular loading, vehicular access to the bridge must be prevented.

7.14. Material Strength Testing.

a. Conduct sufficient research to find any construction documents, plans or as-built drawings, history of the structure, or material specifications prior to conducting any testing. Typically, bridge plans will list the material strengths used in design and verified during construction. If these values are not available, the plans should show a date of construction or design. This date can then be used to find presumptive material strengths in published resources (see previous discussion).

b. Adequate research can eliminate the need to incorporate destructive procedures for acquiring test specimens. For certain cases that are assumed from published resources, testing may be prudent to determine actual material strength when rating values are insufficient given the assumed strength.

c. Carry out the following procedures where testing is necessary.

(1) Timber: Samples of the timber are examined by a lab to determine the timber species. The LRFD manual can then be referenced to find the nominal shear and moment resistance.

(2) Steel: Material samples can be cut from low stressed areas to produce coupons for Charpy V-notch and tensile testing and chemical analysis. The testing and analysis will determine ductility, yield strength, and weldability.

(3) Concrete: Cores from the structure can be bored out from selected locations and then tested for concrete compressive strength and for causes of deterioration (e.g., Petrographic analysis). Cores for compressive strength testing must be void of reinforcing. Samples of steel reinforcement can be taken from selected areas in the concrete and tested to determine the associated material strength. Areas of concrete removal can be used to determine reinforcement size and spacing, but sufficient area must be exposed to ensure any changes in size and spacing are accurately determined.

(4) Destructive testing provides information only in areas tested and should be conducted at low stress areas (e.g., near flanges at ends of beams or near mid-depth of webs at mid-spans). Follow requirements of Section 5 of the MBE and American Concrete Institute (ACI) 214.4R for material sampling and testing. Destructive testing is best used in conjunction with NDE, such as ground-penetrating radar, to verify or supplement the results of NDE.

d. Patch or repair areas where destructive procedures were used to obtain material samples.

7.15. <u>Ratings from Nondestructive Load Testing</u>.

a. When rating factors are insufficient or analytical models are not adequate or are overly complex, physical load testing can be performed to determine load capacity. Section 8 of the

MBE describes these practices in detail. To utilize these practices, employ a qualified engineer with at least 5 years of experience in nondestructive load testing.

b. The MBE describes two loading practices: the diagnostic load test and the proof load test. The diagnostic load test applies load to specific bridge components to gain further understanding about how they perform individually and interact with components surrounding them. The proof load test will “prove” that the bridge can support a predetermined load.

c. The data gathered from the loading practices in the field can then be analyzed for application in the rating factor equation. The rating factor derived can then be applied to the load rating and safe posting load equations.

7.16. Assigned Load Ratings.

a. If a relatively modern bridge does not have a load rating evaluation, it is acceptable to determine the inventory and operating level ratings based on the design loading. However, a number of conditions must be met. These conditions are listed in the FHWA September 29, 2011 memorandum and C6A.1 and C6B.1of the MBE for bridges designed in LRFD and LFD, respectively. If all of the conditions are met and an assigned load rating is preferred, a Responsible Engineer will develop a documented summary that demonstrates that the conditions are met and will file the summary in the bridge file.

b. Special NBI coding is required for National Bridge Inventory (NBI) Items 63 and 65 (codes A-F). See the FHWA November 15, 2011 memorandum for further guidance. All QC and QA reviews will apply.

7.17. Load Ratings Based on Field Evaluation and Engineering Judgment.

a. It is acceptable to determine a load rating based on field evaluation and documented engineering judgment. If plans are inadequate to make reasonable assumptions or are not available, or severe deterioration exists, the Responsible Engineer can participate in field evaluation and develop documentation including sound engineering judgment to serve as the load rating. A thorough hands-on inspection and observation of performance under typical loading will serve as the field evaluation.

b. Special NBI coding is required for NBI Item 63 and 65. See the FHWA February 2, 2011 memorandum for further guidance. All QC and QA reviews will apply.

7.18. Load Rating Documentation.

a. File all load ratings for a structure in the CEBIS Bridge File under "Evaluations: Load Ratings and Capacity."

b. A valid load rating should follow the standard load rating report format. See the BRL. Request approval from the National LRE for any deviations from this format.

c. For computations using computer models, the load rater should perform a review, hand check or other independent verification of the output and assumptions to demonstrate the conclusions from the model being used are appropriate. Include a description of the computer model (elements, boundary conditions, and load application) and comparison of differences between the model and expected actual behavior. The documentation should state why the differences are acceptable and the effect on the results. Results should include load effect diagrams as applicable.

d. Provide sufficient computer input in order to be able to recreate the computer analysis and provide sufficient computer output in order to discern the results or the values used in further analysis.

e. Ensure the most recent load rating information is current in the NBI reporting Items 41, 63, 64, 65, 66, and 70 in CEBIS.

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Chapter 8
Fatigue and Fracture

8.1. Definition.

a. Fracture critical members are defined in the NBIS as follows: "A steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse."

b. Bridges include FCM that are subject to full tension (e.g., axial members) and FCM that are subject to partial tension (e.g., flexural members). Any attachment that is welded to a tension zone of an FCM and with a minimum length of 4 inches in the direction of the tension stress is considered part of the tension component. For this case, the attachment, is considered an FCM. The definition of FCM implies lack of redundancy; therefore, redundant tension members are not FCM. These provisions should also be applied to nonredundant aluminum structures.

8.2. Identifying FCM, Fatigue Sensitive Details, and Fracture Susceptible Details. The MBE describes typical FCM and the USACE Fatigue and Fracture Library provides a comprehensive list of fatigue sensitive details (see the BRL). These references may be used when identifying FCM, and fatigue and fracture susceptible details.

8.2.1. Fracture Critical Members.

a. Cracks in steel members that occur in tension zones are of greater concern than those that occur elsewhere. Frequently a crack is a result of fatigue damage near a weld, a material flaw, defect in the base material, or changes in member cross section. After cracking occurs, failure of the member could be sudden and could lead to collapse of the bridge. For this reason, steel bridges with structural systems that lack redundancy require special attention in inspection planning and execution. Examples of such systems include (are not limited to) the following:

(1) One- or two-girder systems, including single boxes with welding.

(2) Suspension systems with two eyebar components.

(3) Steel pier caps and cross girders.

(4) Two-truss systems.

(5) Suspended spans with two girders.

(6) Welded tied arches.

(7) Pin and hanger connections on two- or three-girder systems.

b. Specific locations that require special attention include:

(1) Areas vulnerable to corrosion (under deck joints, on surfaces where water collects, in places where dissimilar materials meet).

(2) Areas where there is a change in the bridge cross-section, where stress is concentrated, or that are subject to out-of-plane bending.

(3) Longitudinal web stiffeners (at the ends or at splices).

(4) Coped sections and/or re-entrant corners.

(5) Eyebars.

(6) Shear connectors.

(7) Pin and hanger assemblies.

(8) Punched holes.

(9) Rivet and bolt heads.

(10) Tack welds and field welds (especially at weld ends or returns).

c. Use the preceding list to identify FCM. Alternatively, use the AASHTO Guide Specifications for Analysis and Identification of Fracture Critical Members and System Redundant Members. Where doubt exists, an analysis that is consistent with the preceding guidance must be conducted to determine FCM.

8.2.2. Fatigue Sensitive Details.

a. Fatigue is the initiation and propagation of cracks due to a repeated variation of stress within a tension member or element. Load-induced and distortion-induced fatigue are considered in bridge behavior. Load-induced fatigue results from stresses for which components and details are explicitly designed. Distortion-induced fatigue results from secondary stresses not normally quantified in the typical analysis and design. For steel and aluminum material typically used in bridges, fatigue is primarily a function of stress range, number of load cycles, and type of detail.

b. Only live load stresses are considered in fatigue, while dead load and residual stresses do not impact fatigue life (except where stress range is always in compression). For bridges, the load cycles are a function of truck traffic. Low magnitude stress cycles, regardless of the number, do not add appreciably to fatigue damage.

c. Detail categories are listed in the AASHTO LRFD Bridge Design Specifications and range from A to E (greatest to least fatigue resistance). A description of each fatigue category and examples are provided in the AASHTO Specifications. Different details within a given category provide a comparable level of fatigue resistance that is a function of stress concentration and stress flow. The Fatigue and Fracture Library for the Inspection, Evaluation, and Repair of Vehicular Steel Bridges provides examples of fatigue sensitive details.

d. Additional fatigue sensitive details that are not categorized in AASHTO may include extraneous welds, undocumented tack welds, poor quality welds, or induced flaws like gouges and notches.

8.2.3. Fracture Susceptible Details. Fatigue cracks are susceptible to fracture when the fatigue crack grows to a critical size. All fatigue sensitive details are considered fracture susceptible details. Other fracture susceptible details include those that include high constraint due to intersecting welds, intersecting members, or thick weldments.

8.3. Inspection.

8.3.1. Inspection Plans for Steel Bridges.

a. For bridges with fatigue and fracture potential, include the following information in the inspection plan:

(1) Location and description of all FCM.

(2) Location and description of all fatigue sensitive details.

(3) Location and description of all fracture susceptible details.

(4) Type of access required.

(5) Inspection frequency.

(6) Inspection procedures.

(7) NDT requirements.

b. Identify all fatigue sensitive and fracture susceptible details on all bridges, whether FCMs are present or not.

8.3.2. FCM Inspections.

a. Develop an FCM inspection plan for bridges with FCM. Development of FCM inspection procedures will consider methods of access, inspection tools including NDT and other specialized equipment, reporting and recording methods for various defect types, and crack identification and verification techniques. The criticality of a feature is determined by considering past experience with similar type details or structures, calculated remaining fatigue life, current indications, material properties, and consequences and likelihood of failure.

b. Identify access that places the inspector no further than 24 inches from the surface being inspected. Ensure the FCM has a light source that provides at least 1,000 lumens of illumination. See Chapter 2: Inspection Types and Intervals and Chapter 3: Inspection Procedures for more guidelines on FCM inspections and elements of these inspections that should be considered for the inspection plan.

c. The FCM inspection plan for each bridge is developed by the District BSPM or Team Leader. The inspection plan will receive an independent technical review. See the BRL for a sample plan.

8.3.3. Inspection Requirements.

a. A detailed close-up (within 24 inches) visual "hands-on" inspection in the field is the primary method of detecting cracks. This inspection requires that critical areas be cleaned prior to the inspection with additional lighting and magnification used as needed. Use NDT procedures on members where cracks or flaws are suspected or indicated through visual inspection.

b. Test all butt joints on FCM by Ultrasonic Testing (UT) methods to inspect for discontinuities within the weld. Use photographs and sketches to illustrate the conditions found. Compare previous photographs and sketches from prior inspections with existing. See Chapter 2: Inspection Types and Intervals and Chapter 3: Inspection Procedures for more guidance on inspecting FCMs.

c. The baseline inspection interval for FCMs is 24 months. Some bridges may require a shorter interval due to existing condition or extreme fatigue loading. For these cases, determine inspection intervals for FCM based on number and magnitude of load cycles, overall condition of the bridge, internal or system redundancy, potential for fracture, and length of remaining life determined from a fatigue analysis.

d. Justifications for FCM inspection intervals other than 24 months for non-Reportable bridges must be thoroughly documented and submitted to the MSC for review and approval. See

Chapter 2: Inspection Types and Intervals for guidelines on determining inspection intervals other than the baseline.

e. See the Fatigue and Fracture Library for the Inspection, Evaluation, and Repair of Vehicular Steel Bridges in the BRL for detailed information on inspection and evaluation of fatigue and fracture details.

8.4. Reporting.

a. Identify and report on all bridges with FCMs, fatigue sensitive details, and fracture susceptible details using standard procedures and forms provided (see the BRL). The condition of the inspected members should be recorded clearly in the inspection report. The report should include assessment and recommendation for follow-up inspections. The recommendation should include the frequency, methods, and procedures of the inspection. Include the following information in all FCM reports:

(1) Location and description of FCM, fatigue sensitive, and fracture susceptible details for each bridge;

(2) Inspection procedures;

(3) Date of the last inspection;

(4) Description of areas visually inspected;

(5) Description of areas inspected by NDT;

(6) Description of inspection findings;

(7) Amount of corrosion and associated field measurements of remaining section;

(8) Location and dimensions of cracks;

(9) Extent of external damage due to impact or external factors; and

(10) Description of any recommended follow-up action resulting from the most recent inspection.

b. Use the standard CEBIS report format for reporting. See Chapter 6: Bridge Management System for more information on inspection reports.

c. Report critical findings immediately to the District BSPM when there is a potential for imminent failure. See Chapter 4: Critical Findings for overall reporting guidelines on critical findings.

8.5. Evaluations.

a. Conduct a fatigue evaluation on all bridges with Category D-E fatigue sensitive details (include Category C details if stress cycles and stress ranges have the potential to induce fatigue damage). Live load stresses and traffic volumes must be known. Perform a qualitative analysis for bridges with low traffic volumes and low stresses; otherwise, follow the procedures in the AASHTO Manual.

b. When cracks are detected in FCM, perform a fatigue and fracture evaluation of the member (which may or may not lead to additional requirements), initiate repairs, or implement a strict inspection plan that includes an appropriate short inspection interval. The evaluation should determine the remaining useful life and the critical crack size. When fatigue loads are unknown, conduct testing to measure fatigue stress, and when fracture toughness of the steel is not documented, conduct testing to determine the potential for brittle fracture at low temperatures.

c. Each evaluation must be conducted under the direction of a qualified engineer and must be reviewed by a qualified engineer. In addition to District Quality Control (DQC), fatigue evaluations must have an ATR completed by a qualified engineer.

Chapter 9
Scour Evaluations and Plans of Actions

9.1. Purpose. The purpose of this chapter is to provide guidance and outline the requirements to perform scour evaluations. These evaluations are used to identify bridges that are scour critical and to provide information to develop remedial action plans using USACE standard procedures and forms. A scour critical bridge is defined as a bridge with a foundation element that has been determined to be unstable for the assessed, observed, or calculated scour condition.

9.2. Background. An assessment for vulnerability to scour and stream instability from floods must be performed for all USACE bridges that cross waterways according to ER 1110-2-111. Each district is responsible to evaluate, rate, and monitor these bridges for scour and stream instability and protect, as necessary, the foundations from failures due to scour. This process is an ongoing effort that requires re-evaluation and updating in response to observed changes.

9.3. Data Collection for Scour Evaluation.

a. Complete a Level 1 scour analysis (see the BRL) for each bridge over a waterway. The Level 1 analysis is completed as part of the initial or a routine inspection. Photos should be included that show the current stream and bank conditions for comparison in future inspections. At a minimum, take soundings of streambed elevations during the routine inspection. See Chapter 2: Inspection Types and Intervals for more detail. The specific location and extent of any deterioration, damage, or undermining should be recorded in the report, including:

(1) Stream channel and stream banks;

(2) Substructure elements;

(3) Foundation (e.g., footings and seals);

(4) Channel protection devices (e.g., check dams, levees, spurs, dikes, guide banks); and

(5) Scour countermeasures (e.g., riprap or armoring).

b. The four most important Structure Inventory and Appraisal data items for scour evaluations are Items 60, 61, 71, and 113:

(1) Item 60: Substructure,

(2) Item 61: Channel and Channel Protection,

(3) Item 71: Waterway Adequacy, and

(4) Item 113: Scour Critical Bridges.

c. Items 91 through 94 are also related to coding for scour:

(1) Item 91: Designated Inspection Frequency,

(2) Item 92: Critical Feature Inspection,

(3) Item 93: Critical Feature Inspection Date, and

(4) Item 94: Bridge Improvement Cost.

9.4. <u>Scour Evaluations</u>.

a. A scour evaluation identifies the susceptibility of erosion of streambed material and the degree of foundation element stability. The evaluation should be based on as-built foundation details, current condition of the foundation, stream bed cross-section profile, and stream flow rates. Scour evaluations are site specific and additional information may be required to do an accurate analysis.

b. As the bridge foundation condition changes and/or the stream bed characteristics change, a reanalysis of scour susceptibility is required. If a bridge is determined to be scour critical, has observed evidence of scour exceeding the design analysis, or has unknown foundations; the District BSPM develops a Scour Critical POA to monitor, mitigate, or close the bridge.

c. At a minimum, a scour evaluation must include a qualitative Level 1 analysis. This Level 1 analysis classifies a bridge as low risk, scour susceptible, or scour critical, and specifies the need for, and priority of, a quantitative Level 2 analysis. If the results of the Level 2 hydraulic engineering analysis classify the bridge as scour critical, the District BSPM must ensure that a POA is developed and implemented, including installation of countermeasures that prevent scour, monitoring, or both, as needed.

9.4.2. Level 1 Analysis.

a. The Level 1 Analysis identifies bridges with the potential for scour. Each bridge is evaluated by reviewing all available data including; as-built plans, hydraulic studies, soundings and other underwater investigations, streambed and foundation soil information, and historical use. The analysis may include site visits if needed (see HEC-18 and HEC-20, available in the BRL, for further information on collecting data). The result of this analysis is the classification of bridges for scour vulnerability as Low Risk, Scour Critical, or Scour Susceptible.

b. Bridges with Low Risk have no history of scour problems and have a low likelihood for scour problems in the future. Low Risk bridges can generally be coded 8 in Item 113 of the

Inventory Data. Bridge types and locations generally considered Low Risk (when they have no history of scour) are:

(1) Single span bridges with protected abutments,

(2) Bridges with foundations well above the flood plain,

(3) Bridges founded on dam structures where the dam is inspected and evaluated under the Dam Safety Program,

(4) Bridges over dams or pools with small flows,

(5) Bridges over lined channels,

(6) Bridges with spread footings on non-erodible bedrock, and

(7) Culverts with floors.

c. Continued monitoring for scour during Routine and Underwater Inspections is required. A re-evaluation for scour after significant flooding events is also required for Low Risk Bridges.

d. HEC-18, "Evaluating Scour at Bridges Fifth Edition" and "Level 1 and Level 2 Scour Evaluation Guidelines" in the BRL outline the typical steps in a Level 1 analysis. See the Scour Coding Guide in the BRL for instructions on selecting a code for the NBI Inventory Data Item 113.

9.4.3. Level 2 Analysis.

a. To conduct the Level 2 analysis, hydrologic data and streambed material properties are required. Results from the Level 2 analysis are used to more precisely classify the bridge as scour critical or at low risk for scour. If the bridge is scour critical, then a POA is required. The typical steps in a Level 2 analysis are outlined in "Level 1 and Level 2 Scour Evaluation Guidelines" in the BRL.

b. See the Scour Coding Guide in the BRL for instructions on selecting a code for the NBI Inventory Data Item 113. The completed scour evaluations, information required to do the evaluation, and the best mitigation option for this bridge are to be incorporated into the Bridge File for the bridge.

9.5. Scour Critical Plans of Actions.

a. All bridges categorized as Scour Critical with unknown foundations (or as defined in the Scour Coding Guide in the BRL) are required to have a POA. The POA should recommend additional monitoring and/or countermeasures to address potential foundation deficiencies and critical findings, and to make the bridge less vulnerable to damage or failure due to scour.

b. A POA has three primary components:

(1) Development and implementation of a monitoring program;

(2) Timely installation of countermeasures to reduce the risk from scour (e.g., riprap); and

(3) Schedule for construction of appropriate countermeasure(s) to eliminate the risk from scour.

c. All POAs should address each of these components and explain the preferred actions. See the BRL for the standard POA template and instructions for its use.

9.5.2. Monitoring.

a. Scour Monitoring Organization and Responsibilities.

(1) According to ER 1110-2-111 the District BSPM is responsible for implementing and overseeing the POA which includes:

(a) Developing the Scour Monitoring Team;

(b) Deployment of the Scour Monitoring Team during and after Trigger Flood Events;

(c) Consulting with Inspectors and Engineers on problems identified in the field; and

(d) Ordering the bridge closed after identifying distress and re-opened after determining the bridge is safe for use.

(e) Ensuring that the scour monitoring activity and associated trigger description are entered into FEM by appropriate Operations personnel.

(2) The Scour Monitoring Team will monitor the bridge during and after a Trigger Flood Event (defined in Paragraph 9.5.2). The Scour Monitoring Team will consist of the following:

(a) Qualified Bridge Inspectors: Responsible for routine inspections of the bridge and its foundation.

(b) Responsible Engineers: Responsible for developing and modifying the Scour Monitoring Plan and conducting scour evaluations and countermeasure designs.

(c) Site personnel: Responsible for monitoring the bridge during the Trigger Flood Event and quantifying additional scour or other damage due to the flood.

b. Monitoring Events and Procedures.

(1) During Routine and Underwater Inspections and for Trigger Flood Events, monitor conditions consistent with the POA.

(2) The base Trigger Flood Event is any flood exceeding a defined discharge for the bridge waterway. Qualified Hydraulic Engineers in consultation with other qualified engineers (Geotechnical, Structural, others as required) and the District BSPM determine the defined discharge, typically based on a recurrence interval. Use a statistical analysis to quantify the Trigger Flood Event when no design discharge is quantified and if sufficient historical flow data is available for the waterway. At any time when engineering data, experience, or judgment warrants the change; the scour monitoring team may modify the base Trigger Flood Event recurrence interval.

(3) The Scour Monitoring Team monitors the bridge during the Trigger Flood Event. The District BSPM deploys the Scour Monitoring Team as the trigger point is reached. The District BSPM will maintain verbal contact with the monitoring team at all times during the monitoring procedures. The District BSPM should be available at all time during the monitoring process. A backup contact will be identified and available when the District BSPM is not available.

(4) During the flood, the Scour Monitoring Team will identify the location of the flood water elevation relative to a fixed location on the bridge using weighted tape measures, poles, or other measuring devices. The Scour Monitoring Team also monitors the bridge for evidence of bridge distress. Evidence of bridge distress includes, but is not limited to:

(a) Bridge deck sagging;

(b) Pressure flow conditions (water above the bottom chord);

(c) Excessive debris buildup;

(d) Bridge or approach embankment overtopping;

(e) High-velocity flow impinging directly on abutments or unarmored embankments;

(f) Abutment armor failure;

(g) Vertical or lateral displacement of the superstructure;

(h) Excessive horizontal or vertical separation at bridge deck joints;

(i) Visible damage to the bridge deck, low chord, or substructure; and

(j) Sinkholes in the roadway behind the abutments.

(5) If at any time, monitoring personnel do not feel the bridge is safe or if they are uncomfortable working on the bridge due to flood conditions at the bridge, they should close the bridge to traffic and stay off of the structure until inspected for stability.

(6) After the flood waters have subsided, the Scour Monitoring Team will conduct a Damage Inspection (see Chapter 2: Inspection Types and Intervals). This inspection includes an evaluation of the banks for additional cutting and undermining; the channel for new or additional scour or soil deposits; and foundation members for damage, movement, and local scour adjacent to the foundation members. The Scour Monitoring Team reviews photos and notes from previous inspections and compares them to existing conditions.

(7) Monitoring of all scour critical bridges and bridges with unknown foundations is required during and after flood events. The POA should include specific instructions to bridge inspectors or site personnel on what to look for, at what locations, and methods of inspection to use. The POA should address bridge closure to traffic, closure procedures and provide an information and communications plan that outlines whom to contact. The risk of scour hazard, as determined from the scour evaluation, dictates the intensity of the monitoring effort.

9.5.3. Interim Countermeasures to Reduce Risk from Scour.

a. There are a number of scour critical bridges for which the installation of countermeasures to reduce the risk from scour may represent the most practical and cost-effective solution. Typical examples of these measures which could reduce, but not eliminate, the scour threat include:

(1) Emergency placement of riprap around exposed foundations.

(2) Use of grout bags and grout to underpin footings that have been undermined (see HEC-23 design guidelines).

(3) Installation of bendway weirs or spurs at a bend that is migrating toward a bridge abutment so as to redirect the flow away from the abutment (see HEC-23).

(4) Placement of guide banks to move scour away from the abutment foundation (see HEC-23).

b. While countermeasures reduce the risk from scour, they may be subject to failure over an extended period of time or even during a single flood event. Careful evaluation of countermeasures is required during routine inspections, underwater inspections and after flood events, especially when used at scour critical bridges.

c. Countermeasures can reduce the risk of failure due to scour where it is not practical or economically justified to undertake repairs. Examples include:

(1) A bridge that has a few years of service life remaining before it is scheduled for replacement.

(2) Small bridges with limited under-clearances where it is difficult to install measures to make the bridge safe.

(3) Structures on low volume roads where the risks to the public from a bridge failure are minimal.

9.5.4. Designed Countermeasures.

a. Countermeasures consist of materials or systems intended to prevent, delay or reduce the severity of scour and stream instability. Countermeasures designed to make a bridge stable for the assessed or calculated scour condition generally involve greater expenses than interim countermeasures described in Section 9.4.2.

b. The design of countermeasures to withstand scour associated with a design flood is typically made through the use of a hydrologic and hydraulic study of the river and involves an interdisciplinary team. Measures may include structural changes to the foundations of the bridge, riprap revetments, or a wide range of other countermeasures designed and installed according to appropriate criteria as set forth in HEC-23 or other guidance.

9.6. Unknown Foundations.

a. The scour criticality cannot be directly determined for bridges with unknown foundations. FHWA provides additional guidance for bridges with unknown foundations in Federal Highway Administration Memorandum “Action: Technical Guidance for Bridges Over Waterways with Unknown Foundations” by King W. Gee dated January 9, 2008 (see the BRL). The goal of this guidance is to reduce or eliminate the number of bridges over waterways identified as having unknown foundations, allowing risk-based evaluation of these bridges for their scour vulnerability.

b. A POA, with a monitoring plan and closure protocols, is required until the foundation is determined and the potential scour depths known. FHWA guidance recommends a risk-based approach to prioritizing and determining the level of effort that should be devoted to developing POAs and determining corrective actions for these bridges.

c. Districts should make every attempt (e.g., review of available documentation, the use of geophysics) to determine the foundation type and depth. Once the foundation has been determined, a scour evaluation determines potential scour depths and if the bridge is scour susceptible or critical.

9.7. Reporting Procedures.

9.7.1. Scour Evaluations. The bridge scour evaluation must include a recommendation for coding Item 113, a summary of the information utilized in the evaluation, and the written POA to mitigate scour risk, if applicable. This evaluation is incorporated into the Bridge File.

9.7.2. Routine and Underwater Inspections. Routine and Underwater Inspection reports must include locations and extents of scour, condition of banks and bank protection, evidence of stream migration, and other observations affecting scour and foundation stability as identified in FHWA guidance on channel and stream bed inspection. Sketches or photos of areas of local scour at piers and abutments must also be included.

9.7.3. During Floods. Prepare recording sheets including time of recording should document the water surface elevation of the flood. Channel bottom elevations will be determined based on the mudline depth below the water surface in comparison to a well-defined reference point. The reference point should be marked with paint or some other semi-permanent marker and the location photographed and identified on a sketch. Photos should be taken where possible showing the flood water elevation relative to the bridge deck and foundation members. Documentation of all signs of distress is required in the Damage Inspection Report.

9.7.4. After Floods

a. A record will be made that shows all locations of cutting and bank undermining, scour or soil deposits in the channel, damage and movement of foundation members, local scour at the foundation, as well as area and depth measurements of local scour. Photos or sketches are required of all affected areas.

b. The Damage Inspection Report includes all notes, sketches, and photos recorded during and after a flood event. The report will include a summary of actions taken and findings from the monitoring and be included in the Bridge File.

9.8. Closure Procedures.

a. Bridge closure is required before the flood water surface elevation reaches the bottom chord of the bridge. Bridge closure is also required if there are any signs of distress related to the flood in structural members. If at any time, monitoring personnel do not feel the bridge is safe or if they consider working on the bridge too dangerous due to flood conditions, closing the bridge to traffic is required. At this time the bridge is restricted to all personnel until inspections indicate it is safe.

b. The District BSPM is responsible for closing and re-opening of the bridge. During floods, the District BSPM will maintain open lines of communication with the Scour Monitoring Team at all times and will order the Team to close the bridge based on flood water elevations and signs of distress reported by the Scour Monitoring Team. If an emergency closure is needed, the Scour Monitoring Team has the authority to close the bridge according to Chapter 4: Critical Findings.

c. Once the bridge is closed, it will not be re-opened until completion of a post flood inspection. The bridge will remain closed if piles have been exposed or footings undermined, or if the bridge members show signs of distress. The bridge re-opening only occurs upon assurance of bridge stability. The District BSPM should consult qualified Responsible Engineers when safety is in doubt.

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Chapter 10
Railway Bridges.

10.1. Regulation. Except as modified herein, 49 CFR 237 will be used to specify qualifications of personnel and to determine requirements for bridge load capacity determination and bridge inspection for Railway Bridges. In lieu of requirements or standards developed specifically for railway bridges, apply appropriate guidance for fracture and fatigue evaluation accounting for the differences in use, construction, and behavior of railway versus roadway bridges. QA/QC procedures will be consistent with Chapter 5: Quality Measures and Section 7.5: Quality Control and Quality Assurance.

10.2. Personnel and Qualifications. See ER 1110-2-111.

10.3. Inspections. The AREMA Bridge Inspection Handbook provides general guidance for inspection of railway bridges. This document provides an excellent resource that clarifies or defines standard terms and items that are important and unique to railway bridges. Inspectors of railway bridges will be familiar with this EM and the AREMA Bridge Inspection Handbook.

10.3.1. Inspection Frequencies.

a. Routine Inspections. Conduct routine inspections annually, but not to exceed 540 days using a qualified inspection team that will follow procedures defined in Chapter 3: Inspection Procedures.

b. Other Inspections. Conduct inspections other than routine inspections according to Chapter 2: Inspection Types and Intervals.

10.4. Evaluations.

10.4.1. Load Ratings and Restrictions.

a. The Railroad Bridge Engineer (RBE) must determine load capacity consistent with the AREMA Manual and 49 CFR 237. In determination of load capacity, the RBE will evaluate the superstructure and the substructure in terms of the Cooper E-80 Loading (see the AREMA Manual). Other standard loading or loading consisting of specific equipment based on normal use of the bridge will also be evaluated. The AREMA Manual for Railway Engineering provides guidance on design and analysis for railway bridges that will be used in selection of limit states and the determination of strength.

b. Railway bridges must be rated according to the AREMA Manual for the Maximum and Normal Rating.

(1) Maximum Rating. Represents the load level that can be supported on a railway bridge at infrequent intervals with applicable speed restrictions. Consideration of fatigue loading is not required.

(2) Normal Rating. Represents that load which can be operated on a railway bridge indefinitely without inducing damage. Normal ratings will be determined with and without fatigue considerations.

c. For railway bridges that have normal load ratings less than normal load requirements, determine and document necessary operational restrictions within ninety (90) days of load capacity determination. Operational restrictions may involve speed restrictions, coordination with track operation personnel, or other operational constraints.

d. Issue written instructions to the personnel who are responsible for the configuration and operation of trains to prevent the operation of cars, locomotives, or other equipment over a bridge that would exceed the capacity or dimensional constraints of the bridge. Instructions regarding weight limitations must be expressed in terms of maximum equipment weight and either minimum equipment lengths or axel spacing. If fatigue governs the normal rating, determine and document the remaining fatigue life of the structure.

10.4.2. Scour Evaluations. Railway bridges will be evaluated for scour according to Chapter 9: Scour Evaluations and Plans of Actions. Develop a Scour Critical Plan of Action for those bridges determined to be scour critical.

Chapter 11
Post Seismic Inspection Requirements

11.1. Purpose. The purpose of this section is to provide a list of required actions to be taken when a major seismic event occurs. These can include tsunamis, landslides and mudflows. This section will explain what to look for, where to look, and what to do afterwards. An earthquake event can be isolated to one structure or widespread and over a much larger geographical area.

11.2. Background.

a. Earthquake magnitude is typically reported based on the Richter Scale at the epicenter of the earthquake. As a result, the magnitude of an event at each bridge site is unknown. To quickly assess how widespread the potential damage might be and gauge the level of response effort, use the Modified Mercalli Scale in table 11.1 below. By interviewing people at various locations as to what they felt, the size of the affected area and the scope of the response effort can be determined. Damage will depend on the type of structure, the construction, the type of soil the structure was built on and proximity to the epicenter. The Modified Mercalli Intensity Scale is as follows:

Table 11.1
Modified Mercalli Intensity Scale

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

b. A post bridge seismic inspection, depending on the intensity and damage, will require a Level I, II or III inspection effort throughout all areas that experienced a magnitude (5) or greater earthquake as defined on the Modified Mercalli Scale.

11.3. <u>Inspection Requirements</u>. USACE bridges require a follow up damage inspection after an earthquake. The District BSPM is responsible for the following:

a. Richter Scale magnitude 4.0 to 4.9 with an epicenter within 50 miles of the bridge: The BSPM must conduct a first look response of all bridges within the affected area. This inspection is considered an initial rapid survey. The BSPM will log observations and information from police, public, and media and make sure the notification, communication, and response plans are working. The assessment results are whether or not the bridge (and approaches) collapsed or not. A damage survey needs to be performed and be reported immediately.

b. Richter Scale magnitude from 5.0 to 5.9 with an epicenter within 50 miles of the bridge: BSPM will perform a Level I inspection on all structures within 50 miles of the epicenter within the first 24 hours following the event. These inspections will identify all damaged bridges and record the nature and extent of the damage on each.

(1) For emergency response purposes, the following questions regarding the bridges' serviceability need to be answered:

(a) Is the bridge damaged?

(b) If yes, how badly?

(c) Is the bridge usable?

(d) If so, how many lanes?

(e) Under what conditions, or limitations?

(2) The inspection teams will use the following as a guideline to help prioritize their inspection order:

(a) Life-Line Routes (defined as a route used to provide essential services during the first 72 hours following an event);

(b) Life-Line Alternate Routes;

(c) Interstate Routes;

(d) Major Arterial Routes; and

(e) Secondary Highways.

(3) This level of inspection will only assess whether the structure should remain open or closed. The guideline used by the personnel performing this level of inspection is whether they would feel safe driving over the bridge with a loaded truck (Inspector to define what load is considered). The inspectors will take whatever action is necessary at the moment to help protect the general public. They will notify the District BSPM as to the status of the bridge based on their appraisal and mark the right-hand approaches to the bridge ends according to the standard tagging procedures in Section 11.4. The inspectors will include the following information in a field report:

(a) Provide pictures of the bridge closure.

(b) Provide pictures and sketches of any structural damage so it can be used as a communication tool.

(c) Document the date and time.

c. Richter Scale magnitude from 6.0 to 7.9 with an epicenter within 100 miles of the bridge: BSPM will perform a Level II inspection on all structures within 50 miles of the epicenter and within the first 24 hours following the event. All damaged structures will receive a follow-up condition assessment performed by engineering personnel within the first 72 hours. For a Level II inspection, the team leader in charge will be able to exercise the delegated authority for closing a structure. The BSPM will provide the team leader with guidelines that would warrant closing a bridge. When this inspection is complete, the inspection team will take the following actions:

(1) Notify the BSPM the status of the bridge.

(2) Mark the bridge ends according to the standard procedure in Section 11.4.

(3) Complete a bridge inspection report on each structure inspected.

(4) Forward a copy of the bridge inspection report to the BSPM, MSC, and HQBSPM.

d. Richter Scale magnitude 8.0 or greater with an epicenter within 300 miles of the bridge: BSPM will perform a Level III inspection on all structures within 300 miles of the epicenter. A timeframe cannot be estimated due to the magnitude of the damage and the uncertainty of being able to navigate the terrain. After all bridges within the affected area(s) have been inspected and actions have been taken to ensure their safety, a more detailed inspection or investigation should be undertaken by a structural forensic team, assigned by the HQBSPM.

e. A Level III Inspection should only occur on selected structures that warrant a detailed inspection. If the inspection teams are not familiar with the area, or they plan to employ access equipment, or need traffic control, the team will coordinate all work activities with the BSPM to help guide the team through alternate routes if heavy damage has occurred. The purpose of the Level III, in-depth inspection is to analyze the damaged portion of the bridge and study the failure mechanisms to determine if repairs, structural retrofits or modifications are warranted.

f. Once these inspections are completed, the team leader will again notify the BSPM the status of the bridge, based on their appraisal, and mark the bridge ends according to the standard bridge tagging procedure in Section 11.4, and submit a bridge inspection report to the BSPM.

11.3.1. Inspection of Bearings, Anchorages, and Pedestals.

a. The bridge bearings, anchorages and pedestals are generally at the highest risk for failure due to lateral and vertical seismic loads. A bearing failure can lead to an abrupt redistribution of load, plastic hinging of the superstructure, failure of deck to girder connections, diaphragm failure, loss of support and collapse of the bridge.

b. Although different bearings have different configurations, older bearing designs have a higher risk of failure at the connection between the bearing and the girder, at keeper plates, at the connection between the bearing and the masonry plate, or at the anchor bolts that connect the masonry plate to the support. Steel rocker bearings are particularly vulnerable to damage during an earthquake.

c. The inspection of bearing components needs to cover the following:

(1) Sole plate,

(2) Pintle,

(3) Anchor bolts and holes,

(4) Masonry plates,

(5) Rockers/bolsters,

(6) Keeper plates,

(7) Wing plates,

(8) Stiffener plates,

(9) Web plates,

(10) Check for unseating of expansion hinges and joints, and

(11) Check for failures due to lack of restraint from short seat widths at expansion joints (6-8” typ.).

11.3.2. Inspection of Columns.

a. Column capacity is dependent on details, variability and the time period designed. Other factors that place columns at risk for failure include flexural and shear response based on axial load ratio, aspect ratio, and reinforcement ratio. The following discussion outlines some background information and differences in failure mechanisms:

b. Pre-1971: Cast-in-place (CIP) concrete columns designed before 1971 standards cannot obtain full flexural capacity due to column shear failure occurring prior to development of column yield moments.

(1) Once the column yield moment is reached, the strength will degrade quickly due to the deficiency of transverse reinforcement of the plastic hinge region. Fracture of the transverse reinforcement and buckling of the column longitudinal reinforcement will typically occur during an extreme seismic event. During this time period, a common practice was to lap splice the longitudinal column reinforcement at the critical moment location just above the footing.

(2) Another common practice was to embed the column longitudinal bars into the footing or bent cap without 90-degree hooks to ensure proper bar development. In most cases, the typical lap splice or embedment depth is less than 20 bar diameters, this is insufficient to develop the yield strength of the reinforcement. Columns designed in this fashion will not obtain the yield moment of the section, are very brittle and can lead to structural collapse.

c. 1971–1994: CIP concrete columns designed between 1971 and 1994 do not adequately consider the cyclic degradation of concrete shear strength within the plastic hinge. A column will develop the yield moment of the section but degrade after repeated cycles due to shear failure in the hinge. Fracture of the transverse reinforcement is likely as is buckling of the column longitudinal reinforcement.

d. After 1994: CIP concrete columns designed after 1994 have heavier confinement of the plastic hinge region with transverse reinforcement spaced at less than 6 longitudinal bar diameters. These designs typically are very ductile. The confinement ensures that the column longitudinal bars do not buckle and that shear failure of the column and plastic hinge does not occur.

11.3.3. Column Inspection Requirements. Inspection and assessment of concrete columns requires identifying and documenting damage and a performance assessment.

a. Identify the Damage.

(1) Check for diagonal and horizontal cracks. This includes possible column shear failure at plastic hinge regions and shear failure of flared columns.

(2) Check for incipient concrete spalling, crushing and any failures due to inadequate lap splice of column long bars near footing (< 20 db). This should include failures due to inadequate development of column long bars into footing (< 20 db, without std. hooks) and any failures of the lap splicing of column transverse rebar in cover.

(3) Check for longitudinal bar buckling and longitudinal reinforcement pull-out.

(4) Check for rupture of transverse reinforcement.

(5) Determine the damage level based on the observations above according to table 11.2 below.

Table 11.2
Column Performance Assessment

Damage Level	Damage Classification	Field Observations	Description	Operation
I	None	Onset of hairline cracks.	Barely visible residual cracks	Fully operational
II	Minor	Some minor cracking. Theoretical first yield of longitudinal reinforcement.	Residual crack width about 0.008 in.	Operational with some restrictions
III	Moderate	Initiation of inelastic deformation. Onset of concrete spalling. Development of diagonal cracks. Residual crack	Residual crack width 0.04 in.-0.08 in. Length of spalled region > 1/10 cross section depth	Operational with significant restrictions
IV	Major	Wide crack widths with extended spalling over local region	Residual crack width > 0.08 in. Diagonal cracks extend over 2/3 cross section depth. Length of spalled region > 1/2 cross section depth	Near Collapse. Close bridge to all traffic.
V	Local Failure/Collapse	Visible permanent deformation. Buckling of main reinforcement. Rupture of transverse reinforcement. Crushing of core concrete.	Lateral capacity below 85% of maximum. Measurable dilation > 5% of original member dimension.	Collapsed. Close bridge to all traffic.

b. Inspection and Assessment of Foundations. Bridge foundations have generally performed well in earthquakes. Typical foundation damage tends to be minor compared to the column damage. Early (pre-1971) bridge foundations are generally very small and have only a bottom matt of reinforcement and no shear reinforcement. They cannot carry a negative moment induced by soil overburden or tension piles and flexure or shear failure of the footing or column-footing connection is possible.

c. Soil liquefaction or lateral spreading due to seismic motions is possible at some bridge locations. Vertical settlement or lateral movement of bridge foundations may occur causing foundation, column and potentially superstructure damage. Total structural collapse is not common unless the movement is large enough to unseat the superstructure at an expansion joint.

d. Inspection of Abutment and Shear Keys. Failure of shear keys due to transverse motion and punching shear failure of the back wall is likely. Neither failure will cause total structural collapse and is typically repairable. Liquefaction, lateral spreading or poor soil compaction at the abutment has caused vertical settlement or lateral movement in a number of earthquakes. Unless this movement is large enough to unseat the superstructure, total structural collapse is not common.

11.4. <u>Standard Bridge Tagging Procedure</u>. When an inspection is completed, each structure will be tagged (see Figure 11.1) so the condition of each structure can be easily determined and the date and time the inspection was performed. The right bridge end of each approach will be tagged so that it is clearly visible to approaching traffic. The tags should be painted on fixed vertical surfaces, such as the inside face of the concrete parapet wall, wingwall, inside face of the approach guardrail, or attached to a bridge approach sight marker.

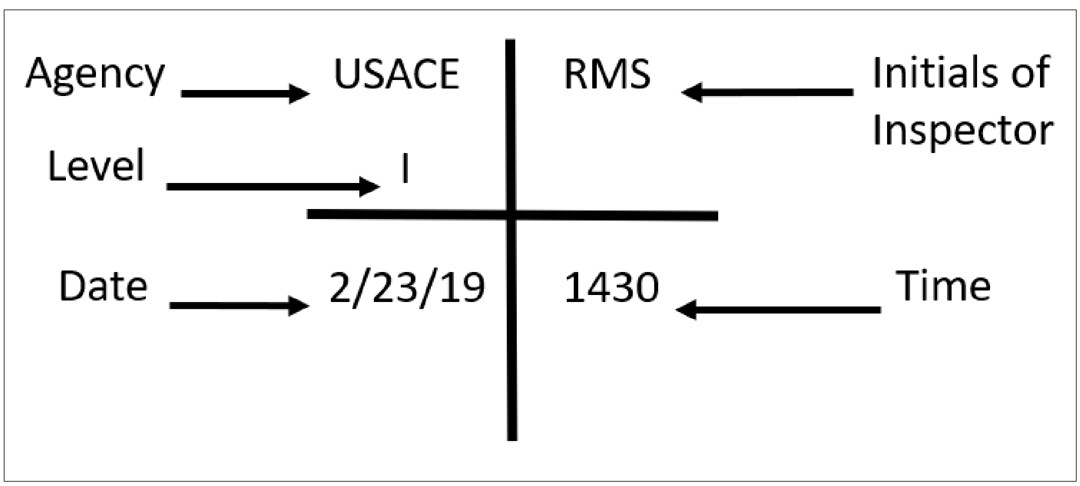

Figure 11.1. Standard Inspection Tagging.

a. Translated: "A Level 1 inspection was made by a USACE bridge inspector whose initials are R.M.S. at 2:30 PM on February 23, 2019."

b. If the tag is GREEN, the bridge appears to have little or no damage. The bridge inspector recommends the bridge can be crossed safely in a loaded truck and that it should remain open with no restrictions.

c. If the tag is RED, the inspector feels the bridge appears unsafe for any traffic and should be closed immediately, due to visible structural distress, partial failure, or collapse. The bridge is marked at the end in red and the incident command center is called to arrange for barricades and for someone to man the barricades at all times. A good example for physically closing a bridge would be to park vehicles across both road approaches and have someone standby at both ends of the bridge, until other policing personnel arrive onsite to take charge of the situation. The local incident commander will notify the policing agencies and the general public, via public safety announcements on commercial radio and television stations.

d. Figure 11.2 indicates that another inspector made a subsequent inspection. The tag reads: "A USACE Bridge Inspector, with the initials of G.L.B., made a Level II bridge inspection on February 24, 2019 at 3:30 PM." If the follow-up inspection agrees with the Level I inspection and remedial action, the tag would be updated and painted with the same color. Or the inspector could change the status of the bridge by changing the color of the tag. In either case, the inspector will X out the first inspection marking and place another tag beside it, using the appropriate color of paint. The inspector will then notify the District BSPM and update the standard field bridge inspection form and report.

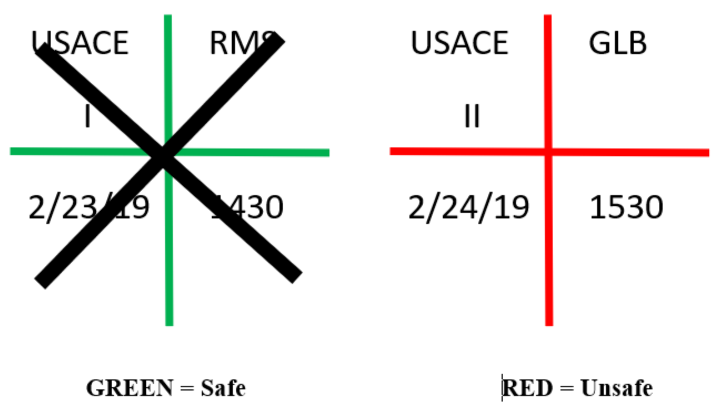

Figure 11.2. Level II Inspection Tagging.

e. Finally, figure 11.3 shows a third, more detailed inspection is made at the direction of the District BSPM:

GREEN = Safe **RED = Unsafe**

Figure 11.3. Level III Inspection Tagging.

f. In this case, “A USACE bridge inspection team, with the initials I.S. performed a detailed forensic inspection of the bridge, on February 25, 2019 at 5:30 PM.” If the inspector placed a green tag on the bridge end, the bridge is considered safe and no further action is required. Red would mean the bridge is unsafe and needs extensive repairs or rehabilitation. When tagging with red, keep the bridge barricaded.

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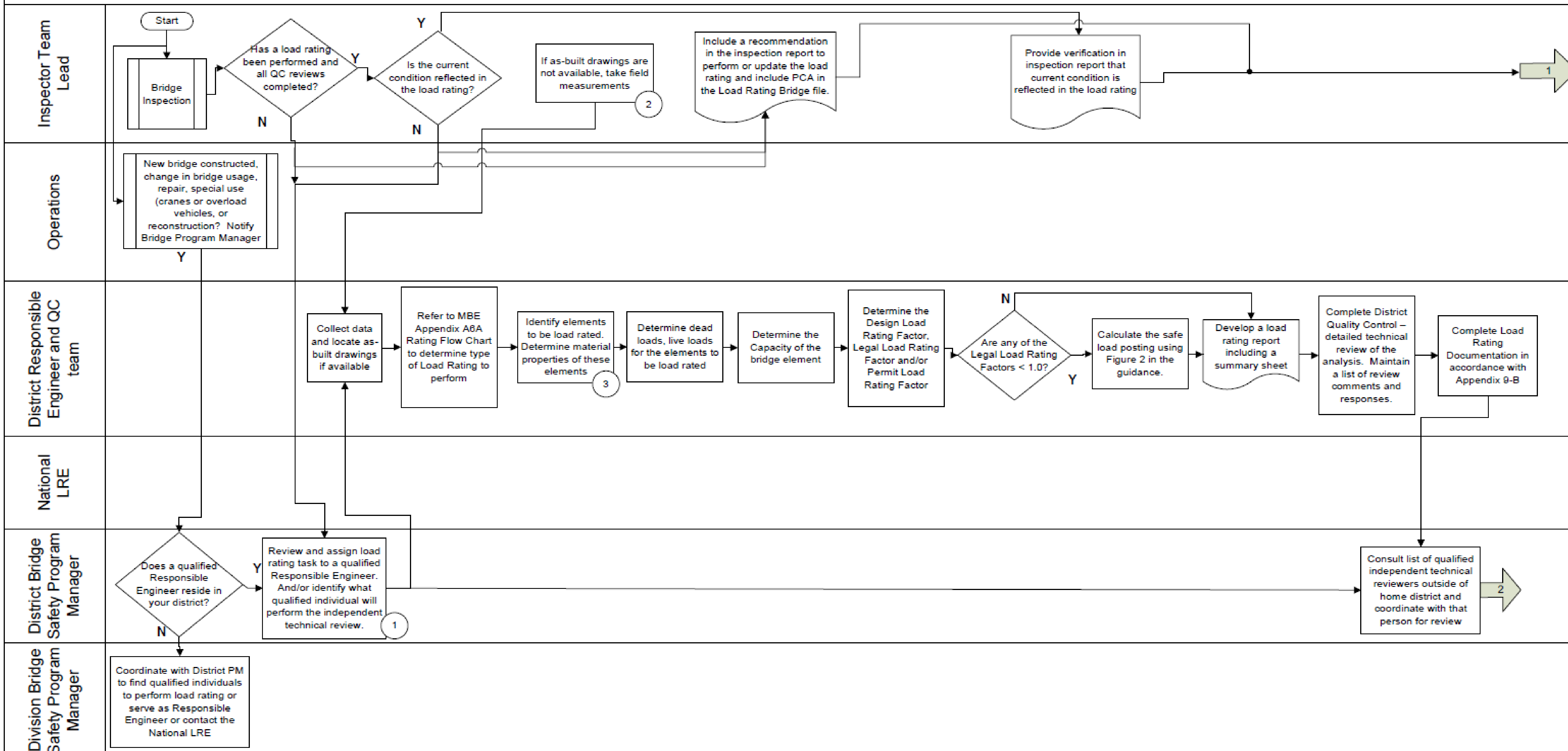
rr. Crane Manufacturers Association of America (CMAA) Specification No. 70, *Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes,* 2015. http://www.mhi.org/downloads/industrygroups/cmaa/specifications/toc/70.pdf

Appendix B
Load Rating Procedure Flowchart

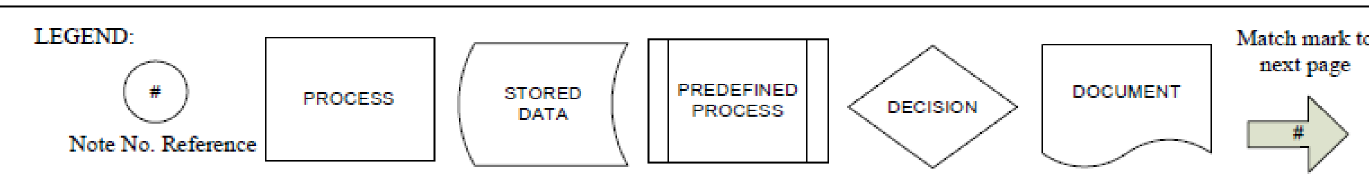
Bridge Load Rating Procedure



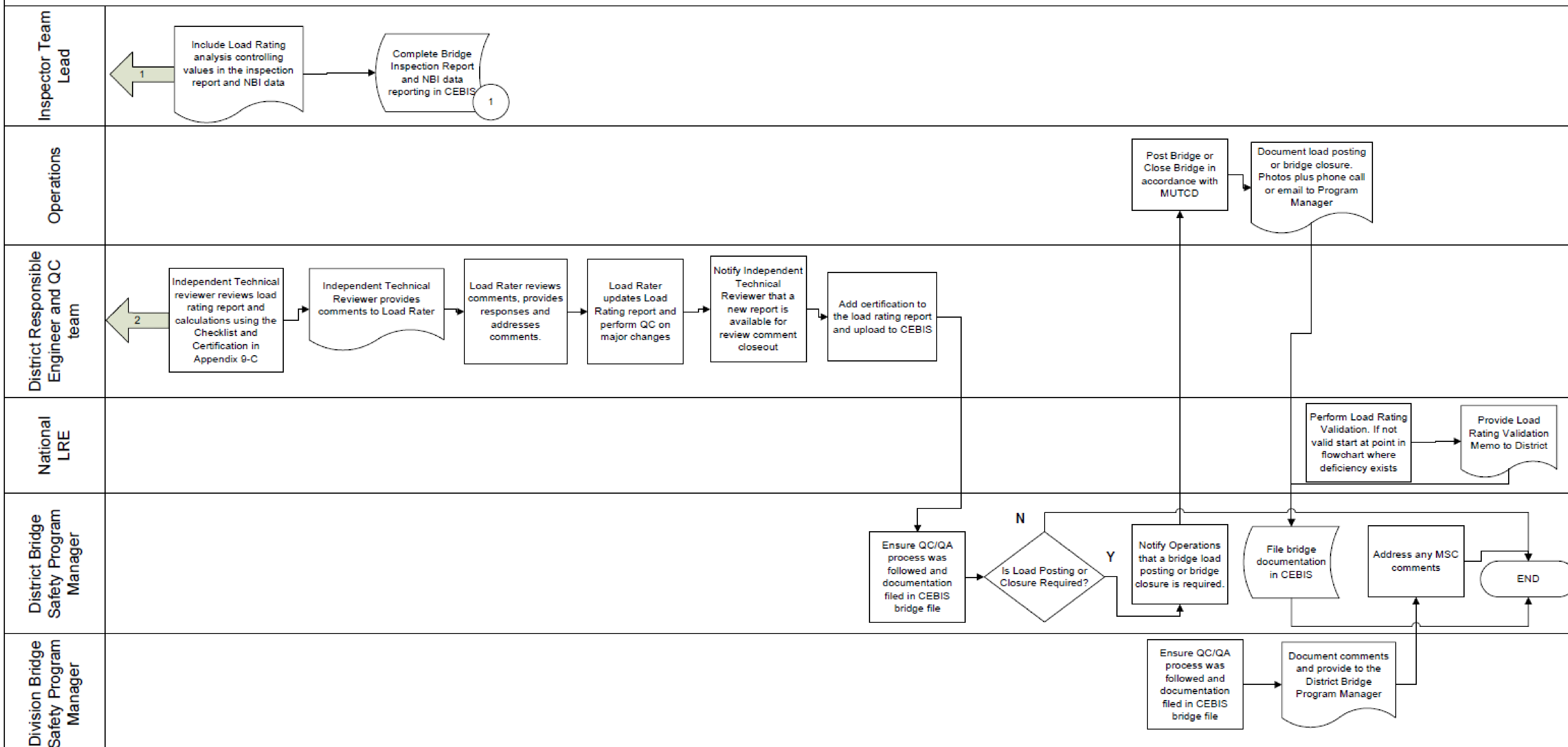
FlowChart Notes

Notes:

1. Qualified Responsible Engineers shall be listed in the District Program Management Plan. A list of qualified Independent Technical Reviewers is in the CEBIS BRL for reference.
2. See MBE Section 4 for appropriate field measurements to take.
3. Primary members shall be load rated. In addition, connection elements may require load rating, refer to the MBE for additional guidance.



Bridge Load Rating Procedure



FlowChart Notes

Notes:
1. All NBI data codes (63, 64, 65, and 66) shall be reviewed by the inspector to ensure that current coding is appropriate for the method used for the load rating. If data is being entered in CEBIS in English units, enter the data in these fields in English units rather than metric as indicated by the coding guide. The units will convert to Metric when the data is sent to FHWA.

LEGEND: