Online-PDH©

Online Continuing Education for Professional Engineers
Since 2009

Fundamentals of the Bridge Inspection Process

PDH Credits:

6 PDH

Course No.:

FBR101

Publication Source:

US DOT – FHWA (BIRM)

“Bridge Inspector's Reference Manual: Section 3, Fundamentals of Bridge Inspection”

Pub. # FHWA NHI 03-001

Release Date:
Dec. 2006 (Revised)

DISCLAIMER:
All course materials available on this website are not to be construed as a representation or warranty on the part of Online-PDH, or other persons and/or organizations named herein. All course literature is for reference purposes only, and should not be used as a substitute for competent, professional engineering council. Use or application of any information herein, should be done so at the discretion of a licensed professional engineer in that given field of expertise. Any person(s) making use of this information, herein, does so at their own risk and assumes any and all liabilities arising therefrom.

Copyright © 2009 Online-PDH - All Rights Reserved
1265 San Juan Dr. - Merritt Island, FL 32952
Phone: 321-501-5601

Table of Contents

Section 3
Fundamentals of Bridge Inspection

Section 3

Fundamentals of Bridge Inspection

Topic 3.1 Duties of the Bridge Inspection Team

3.1.1 Introduction

Bridge inspection is playing an increasingly important role in providing a safe infrastructure for the nation. As the nation's bridges continue to age and deteriorate, an accurate and thorough assessment of each bridge's condition is critical in maintaining a dependable highway system.

There are five basic types of inspection:

- Initial (inventory)
- Routine (periodic)
- Damage
- In-depth
- Special (interim)

These are discussed in Article 3.2 of the AASHTO *Manual for Condition Evaluation of Bridges*. Although this topic is organized for "in-depth" inspections, it applies to all inspection types. However, the amount of time and effort required for performing each duty will vary with the type of inspection performed.

This section presents the duties of the bridge inspection team. It also describes how the inspection team can prepare for the inspection and some of the major inspection procedures. For some duties, the inspection program manager may be involved.

3.1.2 Duties of the Bridge Inspection Team

There are five basic duties of the bridge inspection team:

- Planning the inspection
- Preparing for the inspection
- Performing the inspection
- Preparing the report
- Identifying items for repairs and maintenance

The duties of the inspector are simply the tasks that must be performed in order to fulfill the responsibilities that come with the job.

3.1.3 Planning the Inspection

In order to make the inspection orderly and systematic, the lead inspector should make plans in advance. Planning the inspection is necessary for an efficient, cost-effective effort which will also result in a thorough and complete inspection.

Basic activities include:

- Determination of the type of inspection
- Selection of the inspection team which must include a qualified team leader on site for all initial, routine, in-depth, fracture critical member or underwater inspections
- Evaluation of required activities (e.g., nondestructive testing and underwater inspection)
- Development of an inspection sequence
- Establishment of a schedule

3.1.4 Preparing for the Inspection

Preparation measures needed prior to the inspection include organizing the proper tools and equipment, reviewing the bridge structure files, and locating plans for the structure. The success of the on-site field inspection is largely dependent on the effort spent in preparing for the inspection. The major preparation activities include:

- Reviewing the bridge structure file
- Identifying the components and elements
- Developing an inspection sequence
- Preparing and organizing notes, forms, and sketches
- Arranging for traffic control
- Making arrangements for required methods of access
- Reviewing safety precautions
- Organizing tools and equipment
- Arranging for subcontract special activities
- Accounting for other special considerations

Review Bridge Structure File

The first step in preparing for a bridge inspection is to review the many available sources of information about the bridge, such as:

- "Design" and "As-built" bridge plans
- Previous inspection reports
- Maintenance and repair records
- Rehabilitation/Retrofit plans
- Geotechnical data
- Hydrologic data
- Roadway plans

- Utility plans
- Right-of-way plans

Bridge Plans

The bridge plans contain information about the bridge type, the number of spans, the use of simple or continuous spans, and the materials of construction (see Figure 3.1.1). They also contain information about the presence of composite action between the deck and girders, the use of framing action at the substructure members, and the kind of connection details used. The year of construction and the design loading are also usually contained in the bridge plans.

Figure 3.1.1 Inspectors Reviewing Bridge Plans

Previous Inspection Reports

Previous inspection reports provide valuable information about the history of the bridge, documenting its condition in previous years. This information can be used to determine which components and elements of the bridge warrant special attention. It also allows the inspector to compare the current levels of deterioration with those noted during previous inspections to help determine the rate of deterioration.

Maintenance and Repair Records

Maintenance and repair records allow the inspector to report all subsequent repairs during the inspection phase, noting the types, extent, and dates of the repairs.

Rehabilitation Plans

Rehabilitation plans show modifications and replacements performed on the structure. Just as with the design plans, "As-Built (or record) drawings are preferable.

Geotechnical Data

Geotechnical data provides information about the foundation material below the structure. Sand, silt, or clay is more susceptible to settlement and scour problems than is rock. Therefore, structures founded on these materials should generally be given more attention with respect to foundation and scour issues than those founded on rock.

Hydrologic Data

Hydrologic data provides information about the shape and location of the channel, the presence of protection devices, flood frequencies, and water elevations for various flood intervals. This information is needed for scour evaluation, expected flood flows, and water velocity.

Roadway Plans

Roadway plans may provide some information if the structure plans are not available.

Additional Data

Utility plans can be used to determine the types and numbers of utility attachments, and right-of-way plans can be used to determine the limits of the right-of-way, which can be a factor in determining access requirements.

Identify Components and Elements

Another important activity in preparing for the inspection is to establish the structure orientation, as well as a system for identifying the various components and elements of the bridge (see Figure 3.1.2). If drawings or previous inspection reports are available, the identification system used during the inspection should be the same as that used in these sources.

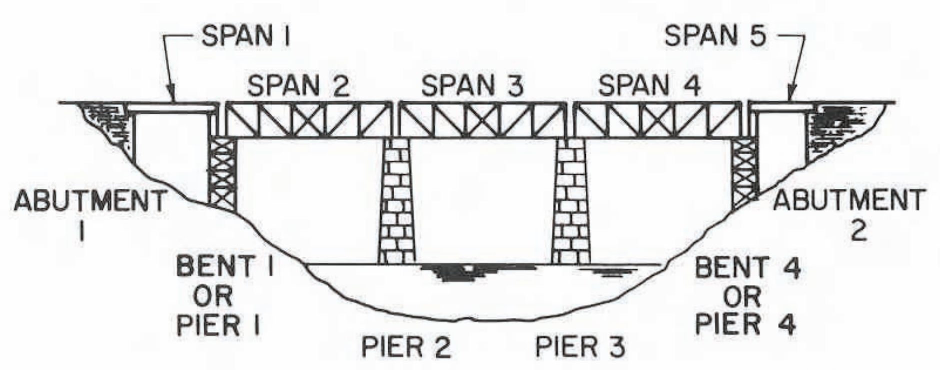

Figure 3.1.2 Sample Bridge Numbering Sequence

If no previous records are available, then the inspector should establish an identification system. The numbering system presented in this subtopic is one possible system, but some states may use a different numbering system.

The route direction can be determined based on mile markers or stationing, and this direction should be used to identify the beginning and the end of the bridge.

Deck Element Numbering System

The deck element numbering system should include the deck sections (between construction joints), expansion joints, railing, parapets, and light standards. These elements should be numbered consecutively, from the beginning to the end of the bridge.

Superstructure Element Numbering System

The superstructure element numbering system should include the spans, the beams, and, in the case of a truss, the panel points. The spans should be numbered consecutively, with Span 1 located at the beginning of the bridge. Multiple beams should be numbered consecutively from left to right facing in the route direction. Similar to spans, floorbeams should be numbered consecutively from the beginning of the bridge, but the first floorbeam should be labeled as Floorbeam 0. This will coordinate the floorbeam and the bay numbers such that a given floorbeam number will be located at the end of its corresponding bay.

For trusses, the panel numbers should be numbered similarly to the floorbeams, beginning with Panel Point 0. Label both the upstream and downstream trusses. Points in the same vertical line have the same number. If there is no lower panel point in a particular vertical line, the numbers of the lower chord will skip a number (see Figure 3.1.3). Some design plans number to midspan on the truss and then number backwards to zero using prime numbers. However, this numbering system is not recommended for field inspection use since the prime designations in the field notes may be obscured by dirt.

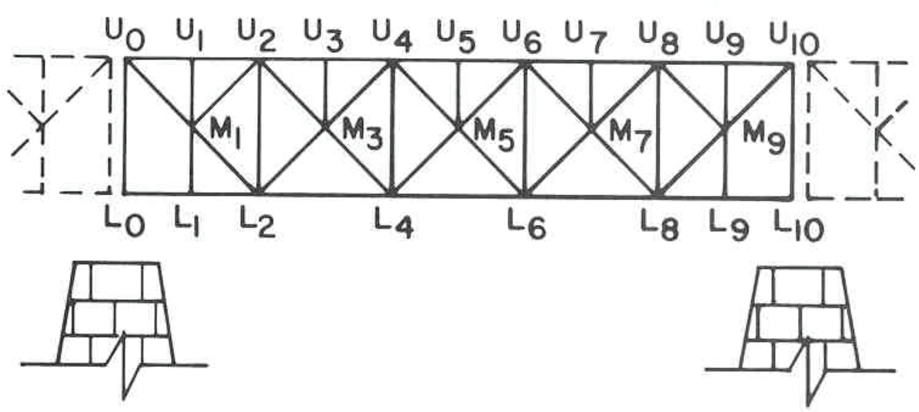

Figure 3.1.3 Sample Truss Numbering Scheme

Substructure Element Numbering System

The substructure element numbering system should include the abutments and the piers. Abutment 1 is located at the beginning of the bridge, and Abutment 2 is located at the end. The piers should be numbered consecutively, with Pier 1 located closest to the beginning of the bridge (see Figure 3.1.2). Alternatively, all the substructure units may be numbered consecutively without noting abutments or piers.

Develop Inspection Sequence

An inspection normally begins with the deck and superstructure elements and proceeds to the substructure. However, there are many factors that must be considered when planning a sequence of inspection for a bridge, including:

- Type of bridge
- Condition of the bridge components
- Overall condition
- Inspection agency requirements
- Size and complexity of the bridge
- Traffic conditions
- Special procedures

A sample inspection sequence for a bridge of average length and complexity is presented in Table 3.1.1. While developing an inspection sequence is important, it is of value only if following it ensures a complete and thorough inspection of the bridge.

1) Roadway Elements

- Approach roadways
- Traffic safety features
- General alignment
- Approach alignment
- Deflections
- Settlement

2) Deck Elements

- Bridge deck surface
- Expansion joints
- Sidewalks and railings
- Drainage
- Signing
- Electrical-lighting
- Barriers, gates, and other traffic control devices
- Bridge deck soffit

3) Superstructure Elements

- Bearings
- Main supporting members
- Secondary members and bracings
- Utilities
- Anchorages

4) Substructure Elements

- Abutments
- Skewbacks (arches)
- Slope protection
- Piers
- Footings
- Piles
- Curtain walls

5) Channel and Waterway Elements

- Channel profile and alignment
- Channel streambed
- Channel embankment
- Channel embankment protection
- Fenders
- Dolphins
- Hydraulic opening
- Water depth scales
- Navigational lights and aids

Table 3.1.1 Sample Inspection Item List

Prepare and Organize Notes

Preparing notes, forms, and sketches prior to the on-site inspection eliminates unnecessary work in the field. Copies of the agency's standard inspection form should be obtained for use in recordkeeping and as a checklist to ensure that the condition of all elements is noted.

Photocopy sketches from previous inspection reports so that defects previously documented can simply be updated. Preparing extra copies provides a contingency for sheets that may be lost or damaged in the field.

If previous sketches are not available, then pre-made, generic sketches may be used for repetitive features or members. Possible applications of this timesaving procedure include deck sections, floor systems, bracing members, abutments, piers, and retaining walls. Numbered, pre-made sketches and forms can also provide a quality control check on work completed.

Traffic Control

Bridge inspection, like construction and maintenance activities on bridges, often presents motorists with unexpected and unusual situations (see Figure 3.1.4). Most state agencies have adopted the federal *Manual on Uniform Traffic Control Devices for Streets and Highways* (*MUTCD*). Some state and local jurisdictions, however, issue their own manuals. When working in an area exposed to traffic, the bridge inspector should check and follow the governing standards. These standards will prescribe the minimum procedures for a number of typical applications and the proper use of standard traffic control devices, such as cones, signs, and flashing arrow boards.

Figure 3.1.4 Traffic Control Operation

Principles and procedures, which enhance the safety of motorists and bridge inspectors in work areas, include the following:

- Traffic safety should be a high priority element on every bridge inspection project where the inspectors' activities are exposed to traffic or likely to affect normal traffic movements.
- Traffic should be routed through work areas with geometrics and traffic control devices comparable to those employed for other highway

situations.

- Traffic movement should be inhibited as little as practicable.
- Approaching motorists should be guided in a clear and positive manner throughout the bridge inspection site.
- On long duration inspections, routine inspection of traffic control devices should be performed.
- All persons responsible for the performance of traffic control operations should be adequately trained.

In addition, schedules may have to be adjusted to accommodate traffic control needs. For example, the number of lanes that can be closed at one time may require conducting the inspection operation with less than optimum efficiency. While it might be most efficient to inspect a floor system from left to right, traffic control may dictate working full length, a few beams at a time.

Special Considerations

Time Requirements

The inspection report or the bridge record file should state the amount of time required for the inspection. The inspection time requirements should be broken down into office preparation, travel time, field time, and report preparation. The overall condition of the bridge will play a major role in determining how long an inspection will take. Previous inspection reports provide an indication of the bridge's overall condition. It generally takes more time to inspect and document a deteriorated element (e.g., measuring, sketching, and photographing) than it does to simply observe and document that an element is in good condition.

Peak Travel Times

In populated areas, an inspection requiring traffic restrictions may be limited to certain hours of the day, such as 10:00 AM to 2:00 PM. Some days may be banned for inspection work altogether. Actual inspection time may be less than a 40-hour work week in these situations, and schedules should be adjusted accordingly.

Set-up Time

Set-up time must be considered both before and during the inspection. For example, rigging efforts may require several days before the inspectors arrive on the site. Also, other equipment, such as compressors and cleaning equipment, may require daily set-up time. Adequate time should be provided in the schedule for set-up and take-down time requirements. The time to install and remove traffic control devices must also be considered.

Access

Access requirements must also be considered when preparing for an inspection. Bridge members may be very similar to each other, but they may require different amounts of time to gain access to them. For example, it may take longer to maneuver a lift device to gain access to a floor system near utility lines than for one that is free of obstructions. On some structures, access hatches may need to be opened to gain access to a portion of the bridge.

Weather

Adverse weather conditions may not halt an inspection entirely, but may play a significant role in the inspection process. During adverse weather conditions, climbing should generally be avoided. There must be an increased awareness of safety hazards, and keeping notes dry can be difficult. During seasons of poor weather, a less aggressive schedule should be adopted than during the good weather months.

Safety Precautions

While completing the inspection in a timely and efficient manner, the importance of taking safety precautions cannot be overlooked. The inspection team must follow the general guidelines for safe inspections. Confined space entry procedures must be in accordance with OSHA and the owners' requirements. For climbing inspections, the three basic requirements for safe climbing must be followed. For additional information about safety precautions, refer to Topic 3.2.5.

Permits

When inspecting a bridge owned by or crossing a railroad, an access permit generally must be obtained before proceeding with the field inspection. A permit must also be obtained when inspecting bridges passing over navigable waterways. Environmental permits and permits to work around endangered species may be required for some bridges and bridge sites.

Tools

To perform a complete and accurate inspection, the proper tools and equipment must be used. Bridge location and type are two main factors in determining required tools and equipment. Refer to Topic 3.4 for a complete list of inspection tools and equipment.

Subcontract Special Activities

Consideration must be given to time requirements when special activities must be scheduled. These activities may include one or more of the following:

- Maintenance and protection of traffic (M.P.T.)
- Access, including rigging, inspection vehicle(s), or a combination there of
- Coordination with various railroads, including obtaining the services of railroad flagmen

3.1.5 Performing the Inspection

This duty is the on-site work of accessing and examining bridge components and waterway, if present.

Inspection procedures as presented in the NBIS should always be followed.

Basic activities include:

- Visual examination of bridge components

- Physical examination of bridge components
- Evaluation of bridge components
- Examination and evaluation of the waterway beneath the structure, if any, and approach roadway geometry

General Inspection Procedures

Duties associated with the inspection include maintaining the proper structure orientation and member numbering system, and following proper inspection procedures.

The procedures used to inspect a bridge depend largely on the bridge type, the materials used, and the general condition of the bridge. Therefore, the inspector must be familiar with the basic inspection procedures for a wide variety of bridges. A first step in the inspection procedure is to establish the orientation of the site and of the bridge. The orientation should include the compass directions, the direction of waterway flow, and the direction of the inventory route. Also record inspection team, air temperature, weather conditions, and time.

After the site orientation has been established, the inspector is ready to begin the on-site inspection. The inspector must be careful and attentive to the work at hand, and no portion of the bridge should be overlooked. Those portions that are most critical to the structural integrity of the bridge should be given special attention. (Refer to Topic 8.1 for a description of fracture critical members in steel bridges.)

The prudence used during the inspection must be combined with thorough and complete recordkeeping. Observations should be careful and attentive, and every defect should be recorded. A very careful inspection is worth no more than the records kept during that inspection.

Numbers or letters should be crayoned or painted on the bridge to identify and code components and elements of the structure. The purpose of these marks is to keep track of the inspector's location and to guard against overlooking any portion of the structure.

The inspector should note the general approach roadway alignment, and sight along the railing and edge of the deck or girder to detect any misalignment or settlement.

Approach Slabs and Decks

The inspector should check the approach pavement for unevenness, settlement, or roughness. Also check the condition of the shoulders, slopes, drainage, and approach guardrail.

The deck and any sidewalks should be examined for various defects, noting size, type, extent, and location of each defect. The location should be referenced using the centerline or curb line, the span number, and the distance from a specific pier or joint.

Examine the expansion joints for sufficient clearance and for adequate seal. Record the width of the joint opening at both curb lines, noting the air temperature and the general weather conditions at the time of the inspection.

Finally, check that safety features, signs, and lighting are present, and note their condition.

Superstructures

The superstructure must be inspected thoroughly, since the failure of a main supporting member could result in the collapse of the bridge. The most common forms of main supporting members are:

- Beams and girders
- Floorbeams and stringers
- Trusses
- Catenary and suspender cables
- Eyebar chains
- Arch ribs
- Frames
- Pins and hanger plates

Bearings

The bearings must also be inspected thoroughly, since they provide the critical link between the superstructure and the substructure. Record the difference between the rocker tilt and a fixed reference line, noting the direction of tilt, the air or bearing material temperature, and the general weather conditions at the time of the inspection.

Substructures

The substructure, which supports the superstructure, is made up of abutments, piers, and bents. If "as-built" plans are available, the dimensions of the substructure units should be compared with those presented on the plans. Since the primary method of bridge inspection is visual, all dirt, leaves, animal waste, and debris should be removed to allow close observation and evaluation. Substructure units should be checked for settlement by sighting along the superstructure and noting any tilting of vertical faces. In conjunction with the scour inspection of the waterway, the substructure units should be checked for undermining, noting both its extent and location.

Waterways

Waterways are dynamic in nature, with their volume of flow and their path continually changing. Therefore, bridges passing over them must be carefully inspected for the effects of these changes.

A record should be maintained of the channel profile and alignment, noting any meandering of the channel both upstream and downstream. Report any skew or improper location of the piers or abutments relative to the stream flow.

Scour, the erosion of a riverbed area caused by stream flow, is the primary concern when evaluating the effects of waterways on bridges (see Figure 3.1.5). The existence and extent of scour must be determined using a grid system and noting the depth of the channel bottom at each grid point.

Figure 3.1.5 Inspection for Scour and Undermining

Embankment erosion should be noted both upstream and downstream of the bridge, as should debris and excessive vegetation. Record their type, size, extent, and location. Note also the high water mark, referencing it to a fixed elevation such as the bottom of the superstructure.

Inspection of Bridge Elements

The inspector must be familiar with several general terms used to describe bridge defects:

- Corrosion – rusting
- Cracking - breaking away without separating into parts
- Splitting - separating into parts
- Connection slippage – relative movement of connected parts
- Overstress - deformation due to overload
- Collision damage - damage caused when a bridge is struck by vehicles or vessels

Refer to Section 2 for a more detailed list and description of types and causes of deterioration for specific materials. As described in Section 2, each material is subject to unique defects. Therefore, the inspector should be familiar with the different inspection procedures used with each material.

Timber Inspection

When inspecting timber structures, determine the extent and severity of decay, weathering and wear, being specific about dimensions, depths, and locations. Sound and probe the timber to detect hidden deterioration due to decay, insects, or marine borers.

Note any large cracks, splits, or crushed areas. While collision or overload damage may cause these defects, the inspector should be factual, avoiding speculation as to the causes. Note any fire damage, recording the measurements of the remaining sound material. Document any exposed untreated portions of the wood, indicating the type, size, and location.

Concrete and Masonry Inspection

When inspecting concrete structures, note all visible cracks, recording their type, width, length, and location. Any rust or efflorescence stains should also be recorded. Concrete scaling can occur on any exposed face of the concrete surface, and its area, location, depth, and general characteristics should be recorded. Inspect concrete surfaces for delamination or hollow zones, which are areas of incipient spalling, using a hammer or a chain drag. Delamination should be carefully documented using sketches showing the location and pertinent dimensions.

Unlike delamination, spalling is readily visible. Spalling should also be documented using sketches or photos, noting the depth of the spalling, the presence of exposed reinforcing steel, and any deterioration or section loss that may be present on the exposed bars.

The examination of stone masonry and mortar is similar to that of concrete. The joints should be carefully inspected for cracks and other forms of mortar deterioration. Inspection techniques are generally the same as for concrete. (See Topic 2.2 for the examination of concrete.)

Masonry arches or masonry-faced concrete arches should be checked for mortar cracks, vegetation, water seepage through cracks, loose or missing stones or blocks, weathering, and spalled or split blocks and stones.

Steel and Iron Inspection

When inspecting steel or iron structures, determine the extent and severity of corrosion, carefully measuring the amount of cross section remaining. All cracks should be noted, recording their length, size, and location. Bent or damaged members should be documented, noting the type of damage and amount of deflection.

Loose rivets or bolts can be detected by striking them with a hammer while holding a thumb on the opposite end of the rivet or bolt. Movement will be felt if it is loose. In addition, any missing rivets or bolts should also be noted.
Note any frozen pins, hangers, or expansion devices. One indication of this is if the hangers or expansion rockers are inclined or rotated in a direction opposite to that expected for the current temperature. In cold weather, a rocker bearing should lean towards the fixed end of the bridge, while in hot weather, it should lean away from the fixed end. A locked bearing is generally caused by heavy rust on the bearing elements.

For the inspector’s evaluation to be substantiated, all inspection findings must be documented or recorded. Documentation is referred to as the “condition remarks” on the inspection form or in the inspection report.

3.1.6 Preparing the Report

Documentation is essential for any type of inspection. The inspector must gather enough information to ensure a comprehensive and complete report. Report preparation is a duty, which reflects the effort that the inspector puts into performing the inspection. Both must be comprehensive. The report is a record of both the bridge condition and the inspector's work.

Basic activities in preparing the inspection report include:

- Completion of agency forms
- Objective written documentation of all inspection findings
- Providing photo references and sketches
- Objective evaluation of bridge components
- Recommendations and cost estimates
- Summary

A sample bridge inspection report can be found in Appendix B of this manual.

3.1.7 Identifying Items for Repairs and Maintenance and Follow-up for Critical Findings

The final basic duty is to identify items for repairs and maintenance. The inspector must identify such items to promote public safety and maximize longevity of the bridge.

Most recommendations concerning repairs will be in the category of programmed repairs (i.e., repairs that will be incorporated into preprogrammed repair and maintenance schedules). Examples of maintenance activities include: flushing the deck, flushing the scuppers and down spouting, lubricating the bearings and painting the structure.

The inspector must carefully consider the benefits to be derived from making repairs and the consequences if such repairs are not made. Also, the inspector should check the previous report recommendations to see what repairs and/or maintenance was identified and the priority of such items. If the repairs were to be completed before the next inspection, it is the responsibility of the inspector to note if the repairs have been completed and appear satisfactory.

The updated NBIS regulations require a procedure for follow-up on critical findings. A statewide or Federal agency wide procedure must be established to assure that critical findings are addressed in a timely manner. The FHWA must be periodically notified of the actions taken to resolve or monitor critical findings. Critical findings are defined as a structural or safety related deficiency that requires immediate follow-up inspection or action. It is the responsibility of Bridge Owners to implement procedures for addressing critical deficiencies including:

- Immediate critical deficiency reporting steps
- Emergency notification of police and the public
- Rapid evaluation of the deficiencies
- Rapid implementation of corrective or protective actions
- A tracking system to ensure adequate follow-up
- Provisions for identifying other bridges with similar structural details for follow-up inspections

3.1.8 Types of Bridge Inspection

The type of inspection may vary over the useful life of a bridge to reflect the intensity of inspection required at the time of inspection. The five types of inspections listed below will allow a Bridge Owner to establish appropriate inspection levels consistent with the inspection frequency and the type of structure and details.

Initial (Inventory)

An initial inspection is the first inspection of a bridge as it becomes a part of a bridge file, but the elements of an initial inspection may also apply when there has been a change in configuration of the structure (e.g., widening, lengthening, supplemental bents, etc.) or a change in bridge ownership. The initial inspection is a fully documented investigation and is accompanied by load capacity ratings. First, this inspection provides all Structure Inventory and Appraisal (SI&A) data. Second, it provides baseline structural conditions and identification of existing problems.

Routine (Periodic)

Routine inspections are regularly scheduled inspections consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from "initial" or previously recorded conditions, and to ensure that the structure continues to satisfy present service conditions. Inspection of underwater portions of the substructure is limited to observations during low-flow periods and/or probing for signs of undermining. The areas of the structure to be closely monitored are those determined by previous inspections and/or load rating calculations to be critical to load-carrying capacity.

According to the NBIS, each bridge must be inspected at regular intervals not to exceed twenty-four months. However, certain bridges require inspection at less than the biennial cycle. Criteria must be established to determine inspection frequency and intensity based on such factors as age, traffic characteristics, and known deficiencies. Certain bridges may also be inspected at greater then the twenty-four month interval, not to exceed forty-eight months, with prior FHWA approval. This may be appropriate when past inspection findings and analysis justifies the increased inspection interval.

Underwater structural elements are to be inspected at regular intervals not to exceed sixty months. However, certain underwater structural elements require inspection at less than the sixty month cycle. Criteria must be established to determine inspection frequency and intensity based on such factors as construction material, environment, age, scour characteristics, condition rating from past inspections and known deficiencies. Certain underwater structural elements may also be inspected at greater then the sixty month interval, not to exceed seventy-two months, with prior FHWA approval. This may be appropriate when past inspection findings and analysis justifies the increased inspection interval.

Fracture critical members (FCMs) are to be inspected at regular intervals not to exceed twenty-four months. However, certain FCMs require inspection at less than the twenty-four month cycle. Criteria must be established to determine inspection frequency and intensity based on such factors as age, traffic characteristics, and known deficiencies.

Damage

A damage inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions. The scope of inspection should be sufficient to determine the need for emergency load restrictions or closure of the bridge to traffic and to assess the level of effort necessary to effect a repair. A timely in-depth inspection may eliminate the need for this inspection.

In-Depth

An in-depth inspection is a close-up, inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures. Hands-on inspection may be necessary at some locations. When appropriate or necessary to fully ascertain the existence of or the extent of any deficiencies, nondestructive field tests may need to be performed. The inspection may include a load rating to assess the residual capacity of the member or members, depending on the extent of the deterioration or damage. For small bridges, the in-depth inspection should include all critical members of the structure. For large and complex structures, these inspections may be scheduled separately for defined segments of the bridge or for designated groups of elements, connections, or details.

According to the NBIS, criteria must be established to determine the level and frequency of this type of inspection.

Special (Interim)

A special inspection is an inspection scheduled at the discretion of the Bridge Owner. It is used to monitor a particular known or suspected deficiency, such as foundation settlement or scour, fatigue damage, or the public's use of a load posted bridge. Guidelines and procedures on what to observe and/or measure must be provided, and a timely process to interpret the field results should be in place. These inspections are not usually comprehensive enough to meet NBIS requirements for periodic inspections.

According to the NBIS, criteria must be established to determine the level and frequency of this type of inspection.

Table of Contents

Section 3

Fundamentals of Bridge Inspection

Topic 3.2 Safety Practices

3.2.1 Key Concerns for Bridge Inspection Safety

While completing the inspection in a timely and efficient manner is important, safety is also a major concern in the field. Bridge inspection is inherently dangerous and therefore requires continual watchfulness on the part of each member of the inspection team. Attitude, alertness, and common sense are three important factors in maintaining safety. To reduce the possibility of accidents, bridge inspectors need to be concerned about safety.

Five key motivations for bridge inspection safety:

- Injury and pain - Accidents can cause pain, suffering, and even death. Careless inspectors can severely injure or even kill themselves or others on the inspection team. Resulting pain and discomfort can hamper the inspector for the rest of their life.

- Family hardship - A worker’s family also suffers hardship when an accident occurs. Not only is there loss of income, but there is also the inability to participate in family activities. In the case of major disability, the burden of caring for the injured person falls on family members.

- Equipment damage - The repair or replacement of damaged equipment can be very costly. There is also a cost associated with the loss of time while the equipment is not available for use.

- Lost production - The employer loses revenues associated with the employee’s work, and also loses time and money spent on safety training and equipment. Additional inspectors must be trained to replace the injured worker.

- Medical expenses - Whether coverage is an employee benefit, personal insurance, or out of pocket, someone has to pay for medical expenses. Ultimately, the tax-paying public pays the bill for accidents through higher insurance premiums.

Inspectors should constantly be aware of safety concerns. Spending the effort to be safe pays big dividends in avoided expenses and grief.

3.2.2 Safety Responsibilities

The employer is responsible for providing a safe working environment, including:

- Clear safety regulations and guidelines
- Safety training
- Proper tools and equipment

The supervisor is responsible for maintaining a safe working environment, including:

- Supervision of established job procedures
- Guidance in application of safety procedures
- Guidance in proper use of equipment
- Enforcement of safety regulations

Bridge inspectors are ultimately responsible for their own safety. The bridge inspector's responsibilities include:

- Recognition of physical limitations – An inspector must be able to recognize his limitations and convey those limitations to his fellow inspectors.
- Knowledge of rules and requirements of job – An inspector should verify he understands a particular task and that he is qualified to perform that task. If a procedure appears to be unsafe, the inspector should question it and constructively try to develop a better way.
- Safety of fellow workers – Do not act in a manner that will endanger fellow inspectors. Warn co-workers if they are doing something unsafe.
- Reporting an accident – If there is an accident, it is essential to report it to a designated individual in your agency or company within the prescribed time frame, usually within 24 hours. Any injury must be promptly reported in order to assure coverage, if necessary, under workmen's compensation or other insurance.

3.2.3 Personal Protection

Proper Inspection Attire

It is important to dress properly for the job. Field clothes should be properly sized for the individual, and they should be appropriate for the climate. For general inspection activities, the inspector should wear leather boots with traction lug soles. For climbing of bridge components, the inspector should wear boots with a steel shank (with non-slip soles without heavy lugs), as well as leather gloves. Wearing a tool pouch enables the inspector to carry tools and notes with hands free for climbing and other inspection activities.

Inspection Safety Equipment

Safety equipment is designed to prevent injury. However, the inspector must use the equipment correctly in order for it to provide protection. The following are some common pieces of safety equipment:

Hard Hat

A hard hat can prevent serious head injuries in two ways. First, it provides protection against falling objects. The bridge site environment during inspection activities is prone to falling objects. Main concerns are:

- Deteriorated portions of bridge components dislodged during inspection
- Equipment dropped by coworkers overhead
- Debris discarded by passing motorists

Secondly, a hard hat protects the inspector's head from accidental impact with bridge components. When inspections involve climbing or access equipment, the inspector is frequently dodging various configurations of superstructure elements. These superstructure elements can be sharp edged and are always unyielding. If the inspector makes a mistake in judgement during a maneuver and impacts the structure, a hard hat may prevent serious injury.

During the inspection, the inspector never knows when protection will be needed. Therefore, a hard hat should be worn at all times. Also, if the inspector will be free climbing, it is a good practice to wear a chinstrap with the hard hat.

Figure 3.2.1 Inspector Wearing A Hard Hat

Reflective Safety Vest

When performing activities near traffic, the inspector is required to wear a safety vest. The vest should conform to current OSHA standards. The combination of bright color and reflectivity makes the inspector more visible to passing motorists. Safety is improved when the motorist is aware of the inspector's presence.

Figure 3.2.2 Inspector Wearing A Reflective Safety Vest

Safety Goggles

Eye protection is necessary when the inspector is exposed to flying particles. Glasses with shatterproof lenses are not adequate if side protection is not provided. It is also important to note that only single lens glasses should be worn when climbing (no bifocals).

Eye protection should be worn during activities such as:

- Using a hammer
- Using a scraper or wire brush
- Grinding
- Shot or sand blasting
- Cutting
- Welding

During welding activities, protection with appropriate lenses specifically designed for welding should be used.

Gloves

Although one may not immediately think of gloves as a piece of safety equipment, they can prove to be an important safety feature. Wearing gloves will protect the inspector's hands from harmful effects of deteriorated members. In many inspections, structural members have been deteriorated to the point where the edges of the members have become razor sharp. These edges can cause severe cuts and lacerations to the inspector's hands that may become infected.

Figure 3.2.3 Inspector Wearing Safety Goggles and Gloves

Life Jacket

A life jacket should always be worn when working over water or in a boat. If an accident occurs, good swimmers may drown if burdened with inspection equipment. Also, if knocked unconscious or injured due to a fall, a life jacket will keep the inspector afloat. A life jacket should also be worn when wearing hip or chest waders. If an inspector should slip or step in an area that is too deep, their waders can fill with water and drag them under, making swimming impossible.

Figure 3.2.4 Inspector Wearing a Life Jacket

Dust Mask / Respirator

A respirator or dust mask can protect the inspector from harmful airborne contaminants and pollutants. Agency or OSHA regulations should be consulted for approved types and appropriate usage.

Conditions requiring a respirator include:

- Sand blasting
- Painting
- Exposure to dust from pigeon droppings (exposure to pigeon droppings may result in histoplasonosis, a potentially very serious illness)
- Work in closed or constricted areas

Figure 3.2.5 Inspector Wearing a Respirator

Safety Harness and Lanyard

The safety harness and lanyard are the inspector's lifeline in the event of a fall. Use this equipment as required by conditions. Make sure you satisfy agency and OSHA requirements.

For example, some agencies require a safety belt or harness be worn in the following situations:

- At heights over 6.0 m (20 feet)
- Above water
- Above traffic

Figure 3.2.6 Safety Harness with a Lanyard

To reduce the possibility of injury, the maximum lanyard length limits a fall to 1.8 m (6 feet) per OSHA regulations. Further protection can be achieved using a shock absorber between the lanyard and the safety harness. The shock absorber reduces g-forces through the controlled extension of nylon webbing, which is pre-folded and sewn together. Two lanyards are required and one lanyard should be tied off to a solid structural member or to a safety line rigged for this purpose at all times. The inspector should used the second lanyard to allow safe movement around obstacles connecting the second lanyard before disconnecting the first lanyard in order to safely move along the structure.

Do not tie off to scaffolding or its supporting cable. One of the reasons for tying off is to limit your fall in case the rigging or scaffold fails. When working from a snooper or bucket truck, tie off to the structure if possible. Extreme caution must be exercised not to allow the equipment to be moved out from under someone tied to the bridge. If the machine is being moved frequently, it is best to tie off to the bucket or boom.

Boats

When performing an inspection over water, it is required to have a manned boat in the water at all times. In the event of an accident in which someone were to fall into the water, the boat can rescue them quickly. This is especially important if the individual has been rendered unconscious. In addition, it can also be used to retrieve any equipment that may have been accidentally dropped by an inspector.

3.2.4 Causes of Accidents

General Causes

Accidents are usually caused by human error or equipment failure. Part of safety awareness is acknowledging this and planning ahead to minimize the effects of those errors or failures.

Accidents caused by equipment failure can often be traced to inadequate or improper maintenance. Inspection, maintenance, and update of equipment can minimize failures. Accidents caused by people are usually caused by an error in judgment, thoughtlessness, or trying to take shortcuts.

Specific Causes

Specific causes of accidents include the following:

- Improper attitude – distraction, carelessness, worries over personal matters.
- Personal limitations – lack of knowledge or skill, exceeding physical capabilities.
- Physical impairment – previous injury, illness, side effect of medication, alcohol or drugs.
- Boredom – falling into an inattentive state while performing repetitive, routine tasks.
- Thoughtlessness - lack of safety awareness and not recognizing hazards.
- Shortcuts - sacrificing safety for time.
- Faulty equipment – damaged ladder rungs, worn rope, frayed cables or access equipment not inspected regularly.
- Inappropriate or loose fitting clothing.

3.2.5 Safety Precautions

Safety precautions can be divided into four main categories: General Precautions, Climbing Safety, Confined Spaces, and Culverts.

General

Some general guidelines for safe inspections are as follows:

- Keeping well rested and alert – Working conditions encountered during an inspection are varied and can change rapidly requiring the inspector be fit and attentive.
- Maintaining proper mental and physical condition – Inspection tasks

require a multitude of motor skills. To perform at acceptable levels, the inspector must be physically fit and free from mental distractions.

- Using proper tools – Do not try to use tools and equipment not suited for the job.
- Keeping work areas neat and uncluttered – Tools and equipment scattered carelessly about the work area present hazards that can result in injury.
- Establishing systematic procedures – Establish procedures early in the job and utilize them so everyone knows what to expect of one another.
- Follow safety rules and regulations – Adhere to the safety rules and regulations established by the Occupational Safety and Health Administration (OSHA), the agency, and your employer.
- Use common sense and good judgment – Do not engage in horseplay, and do not take short cuts or foolish chances.
- Avoid use of intoxicants or drugs – Intoxicants impair judgement, reflexes, and coordination.
- Medication – Prescription and over-the-counter medications can cause drowsiness or other unwanted and potentially dangerous side effects.
- Electricity – This is a potential killer. All cables and wires should be assumed to be hot (live), even if they appear to be only telephone cables. The conditions encountered on many bridges are conducive to electric shock. These conditions include steel members, humidity, perspiration, and damp clothing. Transmission lines on a structure should be identified prior to the inspection. All power lines should be shut down. In rural areas, electric fences can be a hazard and should be avoided. Be aware that fiberglass posts eliminate the need for the distinctive porcelain insulation, which once identified electric fences.
- Assistance – Always work in pairs. An inspector should not take any action without someone else there to help in case of an accident. Always make sure someone else knows where you are. If someone seems to be missing, locate that person immediately.
- Inspection over water – A safety boat must be provided when working over water. It should be equipped with a life ring and have radio communication with the inspection crew.
- Waders – Caution should be used when wearing waders. If the inspector falls into a scour hole, the waders can fill with water, making swimming impossible.
- Inspection over traffic – It is best to avoid working above traffic. If it cannot be avoided, equipment, such as tools and clip boards, should be tied off.
- Entering dark areas – Use a flashlight to illuminate dark areas prior to entering as a precaution against falls, snakebites, and stinging insects.
- Homeless people – Caution should be exercised when approaching a bridge where homeless people are present. Explain to them an inspection of the bridge is taking place, and the inspection team will leave the site as soon as possible. Leave the bridge site immediately if there are any illegal

activities or perceived danger.

Climbing Safety

There are three primary areas of preparation necessary for a safe climbing inspection:

1. Organization
2. Inspection Access Equipment
3. Mental attitude

Figure 3.2.7 Inspection Involving Extensive Climbing

Organization

Organization of the Inspection - A good inspection procedure incorporates a climbing strategy that minimizes climbing time. For example, beginning the day with an inspection of a truss span from one bent and finishing at the next bent by lunch time eliminates unproductive climbing across the span.

The inspection procedure should have an inspection plan so the inspection team knows where to go, what to do, and what tools are needed to perform the inspection. An organized inspection reduces the chance of the inspector falling or getting stuck in a position in which he is unable to get down.

Weather conditions are a primary consideration when organizing a climbing inspection. Moderate temperatures and a sunny day are desirable.

Rain conditions warrant postponement of steel bridge inspections, as wet steel is extremely slippery.

After a rainy day, the inspector must be sure that boots are free of mud, and he must use extreme caution in areas where debris accumulation may cause a slippery surface.

Traffic should not be obstructed during bad weather. Inspection of the top of concrete decks must also be avoided during or just after it rains.

Figure 3.2.8 Inclement Weather Causing Slippery Bridge Members and Poor Visibility for Motorists

Inspection Equipment

The inspection team should be well equipped.

Personal attire should be checked for suitability to the job:

- Clothing – proper for climbing activities and temperature.
- Jewelry – rings, bracelets, and necklaces should never be worn; in an accident, jewelry can become snagged and cause additional injury.
- Eyeglasses – only single lens glasses should be worn; bifocals should not be worn because split vision impairs the inspector’s ability to climb safely.

Inspection equipment should be checked for proper use and condition.

Ladders

Accidents involving ladders are the most common type of inspection-related accident.

In order to use a ladder properly, these things are needed:

- Proper ladder length for the job.
- 3:1 tilt with blocked and secured bottom.
- An assistant for ladders over 7.6 m (25 feet), and making sure the top is tied off.
- Inspecting the ladder, prior to use, for cracked or defective rungs and rails.
- Correct climbing technique using both hands, facing the ladder, and keeping the inspector's belt buckle over the rungs.
- Using a hand line to lift equipment or tools.

Figure 3.2.9 Proper Use of Ladder

Scaffolding

Scaffolding should be checked for the height and load capacity necessary to support the inspection team.

Load tests can be performed on the ground with planned equipment and personnel. A daily inspection for cracks, loose connections, and buckled or weak areas should be performed prior to use.

Timber Planks

Single planks should never be used. Two or more planks securely cleated together should be used. Plank ends should be securely attached to their supports. All planks should be inspected for knots, splits, cracks, and deterioration prior to use.

Inspection Vehicles

Use of platform trucks, bucket trucks, and underbridge inspection vehicles may be necessary to access all elements during an inspection. Confirm that they are in safe operating condition. Such equipment must only be used when placed on a firm surface at a slope not exceeding the rated capacity of the equipment.

Figure 3.2.10 Bucket Truck

Catwalks and Travelers

Permanent inspection access devices are ideal. However, the inspector should be on guard for misalignment and deterioration of elements, such as flooring, hand-hold rods, and cables.

Figure 3.2.11 Inspection Catwalk

Rigging

The inspector should be familiar with proper rigging techniques. Support cables should be at least 13 mm (1/2 inch) in diameter. The working platform or "stage" should be at least 510 mm (20 inches) wide. A line or tie-off cable separate from the primary rigging should be used.

Use common sense with regard to rigging. Do not blindly trust the people arranging the rigging. Mistakes by riggers can cause life threatening accidents. If a procedure is unsafe or doubtful, question it and get it changed if necessary. Do not rely on ropes or planks left on the bridge by prior work. They may be rotted or not properly attached.

Figure 3.2.12 Inspection Rigging

Mental Attitude

The inspector must be mentally prepared to do a climbing inspection. A good safety attitude is of foremost importance. Three precautions that must be addressed are:

- Avoid emotional distress – Do not climb when emotionally upset. The inspector who climbs must have complete control; otherwise the chances of falling increase.

- Awareness of surroundings – Always be aware of dangers associated with inspection location when climbing. Do not become so engrossed in the job as to step into mid-air.
- Realize limitations – An inspector must be confident the job can be performed safely. If there is a feature that cannot safely be inspected with the equipment available, do not inspect it. Highlight this fact in the notes so that appropriate equipment can be scheduled if necessary. Do not hide the fact that a particular bridge member was not inspected.

Confined Spaces Precautions

Safety Concerns

Inspection of box girder bridges, steel box pier caps, steel arch rings, arch ties, cellular concrete structures, and long culverts often includes confined spaces. Confined space entry is regulated by OSHA and requires proper training, equipment, and permitting.

There are four major concerns when inspecting a confined space:

- Lack of oxygen – oxygen content must remain above 19% for the inspector to remain conscious
- Toxic gases – generally produced by work processes such as painting, burning, and welding or by operation of internal combustion engines
- Explosive gases – natural gas, methane, or gasoline vapors may be present naturally or due to leaks
- Lack of light – many confined spaces are totally dark (inspector cannot see any potential hazards such as depressions, drop-offs, or dangerous animals)

Safety Procedures

When a confined area must be inspected, the safety procedures prescribed by OSHA and any additional agency requirements must be used. The following is a general description of the basic requirements. Refer to OSHA for specifics.

Pre-entry air tests:

- Test for oxygen with an approved oxygen testing device
- Test for other gases, such as carbon monoxide, hydrogen sulfide, methane, natural gas, and combustible vapors

Mechanical ventilation:

- Pre-entry – Oxygen and gas levels must be acceptable for a minimum prescribed time prior to entry.
- During occupancy – Ventilation should be continuous regardless of activities. Test for oxygen and other gases at prescribed intervals during occupancy.

Basic safety procedures:

- Avoid use of flammable liquids in the confined area.
- Position inspection vehicles away from the area entrance to avoid carbon monoxide fumes.
- Position gasoline powered generators "down-wind" of operations.
- Operations producing toxic gases should be performed "down-wind" of the operator and the inspection team.
- Carry approved rescue air-breathing apparatus.
- Use adequate lighting with an appropriate backup system and lifelines when entering dark areas, such as box girders and culverts.
- Inspection should be performed in pairs, with a third inspector remaining outside of dark or confined areas.

Culverts

There are several hazards that can be encountered when performing a culvert inspection. Being aware of these situations and exercising proper precautions will protect the inspector from these dangerous and potentially life threatening hazards. The following are some of the hazardous conditions an inspector may encounter.

- Inadequate Ventilation
- Drowning
- Toxic Chemicals
- Animals
- Quick Conditions
- Insufficient Number of Inspectors

Inadequate Ventilation

Culverts with inadequate ventilation can develop low oxygen levels or high concentrations of toxic and/or explosive gases. This is a big concern when one culvert end may be blocked or inspection is being performed on a long culvert.

If air quality is suspect, tests should be made to determine the concentration of gases. Testing devices may be as simple as badges worn by inspectors that change colors when in the presence of a particular gas. Devices may also be sophisticated instruments that measure the concentration of several gases.

Confined space entry requirements should be observed when inspecting a long culvert or any culvert with restricted ventilation.

Drowning

Extensive streambed scour may result in channel depressions. During periods of low flow the depth of water in these holes may be significantly greater than the remainder of the streambed. This could give the inspector the impression that wading is safe. It is advisable that the inspector use a probing rod to check water depth wherever he/she plans to walk.

Storms may generate high flows in culverts very quickly. This creates a dangerous situation for the inspectors. It is not uncommon for culverts to carry peak flow long before a storm reaches the culvert site. Inspectors should be cautious whenever storms appear imminent.

Toxic Chemicals

Occasionally, stream flow may contain hazardous chemicals from any of a number of sources. Fires, explosions, and serious illness could result from the presence of such chemicals if appropriate precautions are not taken.

Animals

An accumulation of dirt or debris may provide a home for snakes, rodents, or other animals. These could provide a dangerous environment for the inspector. An inspector's ability to react to these hazards may be compromised by poor lighting, limited access and inadequate room to move. Also, any dead animals present create health hazards.

Quick Sand Conditions

Quicksand conditions can occur in sandy streambeds, especially at the outlet end of the culvert. Inspectors should be aware of this and should proceed with caution in geographical areas known to have these problems.

Table of Contents

Section 3
Fundamentals of
Bridge Inspection

Topic 3.3 Traffic Control

3.3.1 Introduction

Bridge inspection usually only requires traffic control procedures for a relatively short term closure (only a day or two). Long term closures for construction activity which use concrete barriers are not included in this topic.

Figure 3.3.1 Traffic Control Operation

Bridge inspection, like construction and maintenance activities on bridges, often presents motorists with unexpected and unusual situations. Most state agencies have adopted the federal *Manual on Uniform Traffic Control Devices for Streets and Highways* (*MUTCD*). Some states and local jurisdictions, however, issue their own standard manuals or drawings.

When working in an area exposed to traffic, the bridge inspector should check and follow existing agency standards. These standards will prescribe the minimum procedures for a number of typical applications and the proper use of standard traffic control devices such as cones, signs, and flashing arrow-boards (see Figure 3.3.1). Sometimes after initial installation, traffic control may need revision to provide adequate protection to motorists, pedestrians or inspectors.

3.3.2 Philosophy and Fundamental Principles

All traffic control devices used on street and highway construction or maintenance work should conform to the applicable specifications of the *MUTCD* and the agency.

Inspection time should be minimized to reduce exposure to potential hazards without compromising the thoroughness of the inspection. Principles and procedures which have been shown to enhance the safety of motorists, pedestrians, and bridge inspection in the vicinity of work areas include the following:

Inform the Motorists

Traffic safety in work zones should be an integral and high priority element of every inspection project, from the planning stage to performance of the inspection. The safety of the motorist, pedestrian, and worker must be kept in mind at all times.

The basic safety principles governing the design of traffic control for roadways and roadsides should also govern the design of inspection sites. The goal should be to route traffic through such areas with geometrics and traffic control devices comparable to those for normal highway situations. Notice of work site locations and guidance through these sites must be clearly communicated to the driver.

A traffic control plan, in detail appropriate to the complexity of the work project, should be prepared and understood by all responsible parties before the site is occupied. Any changes in the traffic control plan should be approved by an official trained in safe traffic control practices.

Control The Motorists

Traffic movement should be inhibited as little as practical. Traffic control in work sites should be designed on the assumption that motorists will only reduce their speeds if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practical.

The objective is a traffic control plan that uses a variety of traffic control measures and devices in whatever combination necessary to assure smooth, safe vehicular movement past the work area and at the same time provide safety for the equipment and the workers on the job. Frequent and abrupt changes in geometrics, such as lane narrowing, dropped lanes, or main roadway transitions that require rapid maneuvers, should be avoided.

Provisions should be made for the safe operation of work vehicles, particularly on high speed, high volume roadways. This includes the use of roof mounted flashing lights or flashers when entering or leaving the work zone. This also includes considering the number of lanes that can be closed at one time for an operation. While it might be most cost efficient to inspect a floor system from left to right, traffic control may dictate working full length, a few beams at a time.

Provide a Clearly Marked Path

A good traffic control plan provides safe and efficient movement of motorists and pedestrians and the protection of bridge inspectors at work areas.

Adequate warning, delineation, and channelization should be provided to assure the motorist positive guidance in advance of and through the work area. Proper signing and other devices which are effective under varying conditions of daylight and weather must be used.

The maintenance of roadside safety requires constant attention during the life of the work because of the potential increase in hazards. All traffic control devices should be removed immediately when no longer needed.

To accommodate run-off-the-road incidents, disabled vehicles or other emergency situations, it is desirable to provide an unencumbered roadside recovery area that is as wide as practical.

Channelization of traffic should be accomplished by the use of signing, cones, barricades, and other lightweight devices which will yield when hit by errant vehicles.

Whenever practical, equipment and materials should be stored in such a manner as not to be vulnerable to run-off-the-road vehicle impact. When safe storage is not available, adequate attenuation devices should be provided.

3.3.3 Inspector Safety Practices

Work Zone

Traffic represents as great, or even greater, threat to the inspector's safety than climbing high bridges. The work zone is intended to be a safe haven from traffic so the inspectors can concentrate on doing their jobs.

As such, the work zone needs to be clearly marked so as to guide the motorist around it and, insofar as possible, prevent errant vehicles from entering (see Figure 3.3.2). The work zone should be as compact as possible to minimize traffic disruption, but must be wide enough and long enough to permit access to the area to be inspected and allow for safe movement of workers and equipment. The end of the work zone should be clearly signed as a courtesy to the motorist.

Figure 3.3.2 Work Zone

Vehicles and Equipment

Inspection vehicles and equipment need to be made visible to the motorists with flashing marker lights or arrow boards as appropriate (see Figure 3.3.3).

Vehicles entering and exiting the work zone should use a roof mounted flashing light or flashers to distinguish themselves from other motorists. Also, all vehicles should use extreme caution when moving in and out of the work zone. Allow traffic ample time to react to the vehicle's movements.

Figure 3.3.3 Inspection Vehicles with Flashing Light

Workers

Individuals in a work zone must wear approved safety vests and hard hats for visibility and identification. They also help make the inspector look “official” to the public. The inspectors should also stay within the work zone for their own safety.

3.3.4 Requirements of Traffic Control Devices

Each bridge inspection project is different and has traffic concerns that are unique to that location. Selection of the proper traffic control device's for each location is dependent upon many factors. Though there are several different types of traffic control devises, there are some basic requirements for efficient traffic control devices:

1. Traffic control devices must be visible and attention getting.

   - Bright colors make devices easier to see for motorists.
   - All signs must be legible and color distinguishable at night as well as during the day. Nighttime sign visibility is provided through retroreflectivity, which is accomplished by spherical glass beads or prismatic reflectors in the sign material.
   - New sign messages such as "Slow Down. My Daddy Works Here" and "Give Us A Brake. Slow Down" cause the driver to think on a more personal level.

2. Traffic control devices must give clear direction.

3. Traffic control devices must command respect. They should be official (*MUTCD*).

4. Traffic control devices must elicit the proper response at the proper time.

   - The decision process includes the classical chain of sensing, perceiving, analyzing, deciding, and responding.
   - The average perception-reaction time of a driver is 2.5 seconds. At 100 km/hr (60 mph), the 2.5 seconds translates to 67 m (220 feet). Additional time and distance is required for a specific action taken such as "hitting the brakes".
   - Traffic control must accommodate a wide range of vehicles (from small compact cars to large combination tractor-trailers) and driver skills, which may be impaired by alcohol, drugs, drowsiness, or use of cellular telephones.

All of these requirements for traffic control devices have been factored into the various agencies' guidelines for work area traffic control. These guidelines represent efforts by trained people. Do not change traffic patterns without consulting agency standards or traffic control personnel.

3.3.5 Types of Traffic Control Devices

Signs

Examples of traffic control signs include the following:

- Regulatory - "Speed Limit 40 mph", "DO NOT PASS", may require special authority (see Figure 3.3.4)
- Warning - "Bridge Inspection", "Work Area Ahead", "Slow" (see Figure 3.3.5)
- Guide Signs - Directional and destination signs; not used for bridge inspection traffic control unless a detour is established
- Changeable Message Signs – Can display more than one message

Figure 3.3.4 Work Area Speed Limit Sign (Regulatory)

Figure 3.3.5 Traffic Control Sign (Warning)

Channelizing Devices

The functions of channelizing devices are to warn and alert drivers of hazards created by construction or maintenance activities in or near the traveled way and to guide and direct drivers safely past the hazards.

Devices used for channelization should provide a smooth and gradual transition in moving traffic from one lane to another, onto a bypass or detour, or in reducing the width of the traveled way. They should be constructed so as not to inflict any undue damage to a vehicle that inadvertently strikes them.

Channelizing devices are elements in a total system of traffic control devices for use in highway construction and maintenance operations. These elements should be preceded by a subsystem of warning devices that are adequate in size, number, and placement for the type of highway on which the work is to take place.

Typical channelizing devices include the following:

- Cones (see Figure 3.3.6)
- Drums (see Figure 3.3.7)
- Wands
- Vertical panels
- Portable concrete barrier sections (these are seldom applicable to bridge inspection due to the short duration of the work)

Figure 3.3.6 Traffic Control Cones

Figure 3.3.7 Traffic Control Drums

Lighting

Another type of control device is lighting. Examples of lighting include the following:

- Flashers - attached to signs or other devices to attract attention or for night visibility
- Arrowboards - for lane control (see Figure 3.3.8)
- Floodlights - to illuminate the work area at night and/or to assist motorists in negotiating a restricted area. Floodlights should only be required for

bridge inspection in emergencies or in extremely high traffic volume areas where lane restrictions are only feasible at night. They should be aimed so that a driver's vision is not impaired.

- Message boards – for lane control. Message boards can be programmed remotely using a cellular phone (see Figure 3.3.9)

Figure 3.3.8 Arrowboard

Figure 3.3.9 Message Board

Flaggers

A number of hand signalizing devices, such as STOP/SLOW paddles, lights, and red flags, are used to control traffic through work zones. The sign paddle bearing the clear messages "STOP" or "SLOW" provides motorists with more positive guidance than flags and is generally the primary hand signaling device. If permitted by the agency, flag use should be limited to emergency situations and at spot locations that can best be controlled by a single flagger.

Since flaggers are responsible for human safety and make the greatest number of public contacts of all construction personnel, it is important that qualified personnel be selected. A flagger should possess the following minimum qualifications:

- Good common sense
- Good physical condition, including sight and hearing
- Mental alertness
- Courteous but firm manner
- Neat appearance
- Sense of responsibility for safety of public and crew
- Training in safe traffic control practices

The use of hard hat and suitable clothing, such as an approved vest, shirt, or jacket, should be required for flaggers. For nighttime conditions, similar outside garments should be reflectorized.

Flaggers are provided at work sites to stop traffic intermittently as necessitated by work progress. They also maintain continuous traffic past a work site at reduced speeds to help protect the work crew. For both of these functions, the flagger must, at all times, be clearly visible to approaching traffic for a distance sufficient to permit proper response by the motorist to the flagging instructions and to permit traffic to reduce speed before entering the work site. In positioning flaggers, consideration must be given to maintaining color contrast between the work area background and the flagger's protective garments.

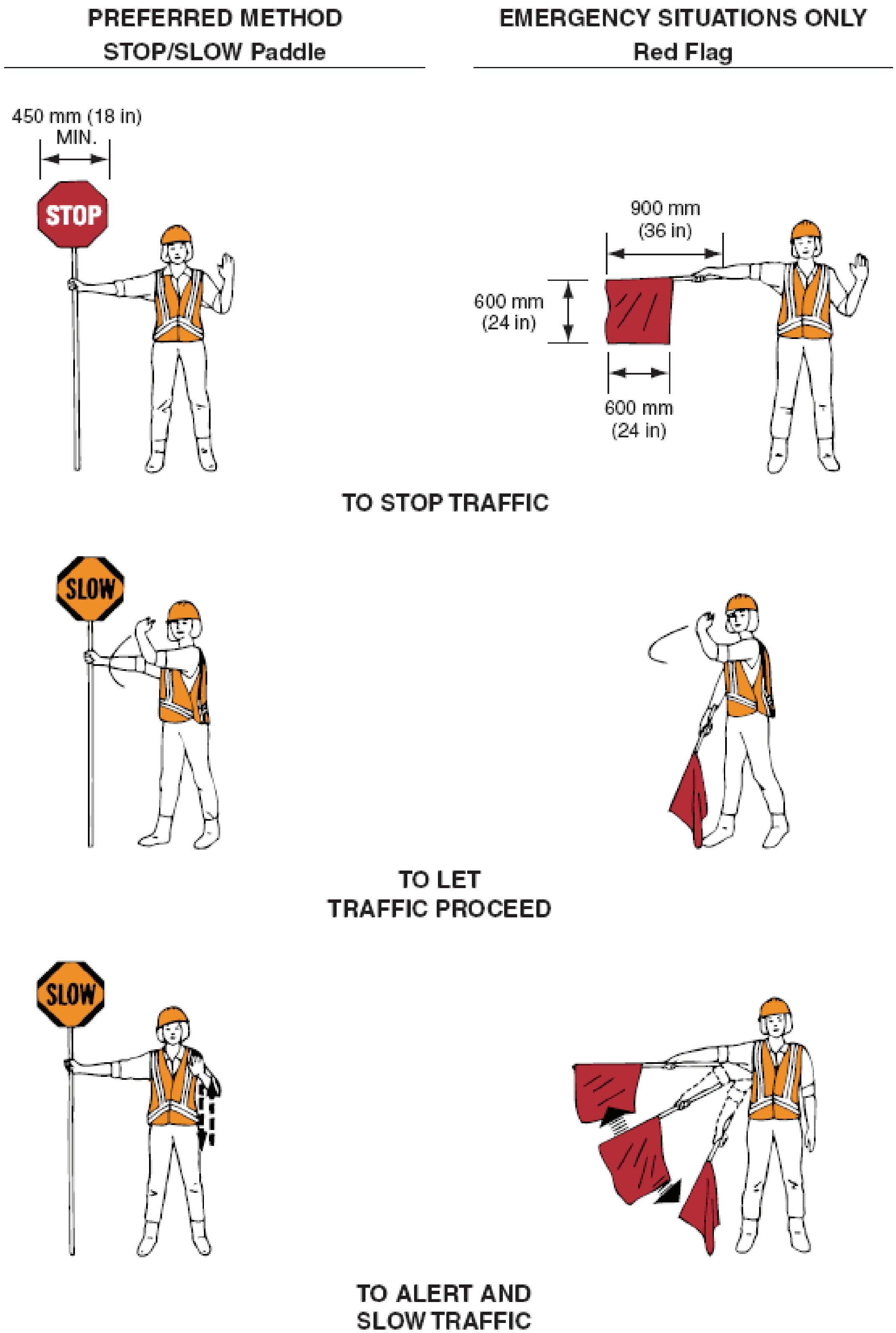

Figure 3.3.10 Use of Hand Signaling Devices by Flagger (from *Manual on Uniform Traffic Control Devices (MUTCD)*)

The following methods of signaling with sign paddles should be used (see Figure 3.3.10):

- To stop traffic - The flagger should face traffic and extend the STOP sign paddle in a stationary position with the arm extended horizontally away from the body. The free arm is raised with the palm toward approaching traffic.
- When it is safe for traffic to proceed - The flagger should face traffic with the SLOW sign paddle held in a stationary position with the arm extended horizontally away from the body. The flagger motions traffic ahead with the free hand.
- When it is desired to alert or slow traffic - The flagger shall face traffic with the SLOW sign paddle held in a stationary position with the arm extended horizontally away from the body.

The following methods of signaling with a flag should be used:

- To stop traffic - The flagger should face traffic and extend the flag horizontally across the traffic lane in a stationary position so that the full area of the flag is visible hanging below the staff. For greater emphasis, the free arm may be raised with the palm toward approaching traffic.
- When it is safe for traffic to proceed - The flagger should stand parallel to the traffic movement and, with flag and arm lowered from view of the driver, motion traffic ahead with the free arm. Flags should not be used to signal traffic to proceed.
- Where it is desired to alert or slow traffic - The flagger should face traffic and slowly wave the flag in a sweeping motion of the extended arm from the shoulder level to straight down without raising the arm above a horizontal position.

Lights approved by the appropriate highway authority or reflectorized sign paddles or reflectorized flags should be used to flag traffic at night.

Whenever practicable, the flagger should advise the motorist of the reason for the delay and the approximate period that traffic will be halted. Flaggers and operators of machinery or trucks should be made to understand that every reasonable effort must be made to allow the driving public the right-of-way and prevent excessive delays.

Flagger stations should be located far enough in advance of the work site so that approaching traffic will have sufficient distance to reduce speed before entering the project. This distance is related to the approach speed and physical conditions at the site; however, 60 to 90 m (200 to 300 feet) is desirable. In urban areas, where speeds are low and streets are closely spaced, the distance necessarily must be decreased.

The flaggers should stand either on the shoulder adjacent to the traffic being controlled or in the barricaded lane (see Figure 3.3.11). At a spot obstruction, a position may have to be taken on the shoulder opposite the barricaded section to operate effectively. Under no circumstances should a flagger stand in the lane being used by moving traffic. The flagger must be clearly visible to approaching traffic at all times. For this reason, the flagger must stand alone, never permitting a group of workers to congregate around the flagger station. The flagger should be stationed sufficiently in advance of the work force to warn them of approaching danger, such as out-of-control vehicles.

Figure 3.3.11 Flagger with Stop/Slow Paddle

Flagger stations should be adequately protected and preceded by proper advance warning signs. At night, flagger stations should be adequately illuminated.

At short lane closures where adequate sight distance is available for the safe handling of traffic, the use of one flagger may be sufficient.

One-way Traffic Control

Where traffic in both directions must, for a limited distance, use a single lane, provisions should be made for alternate one-way movement to pass traffic through the constricted work zone. At a spot obstruction, such as a short bridge, the movement may be self-regulating. However, where the one-lane section is of any length, there should be some means of coordinating movements at each end so that vehicles are not simultaneously moving in opposite directions in the work zone and so that delays are not excessive at either end. Control points at each end of the route should be chosen so as to permit easy passing of opposing lines of vehicles.

Alternate one-way traffic control may be facilitated by the following means:

- Flagger control
- Flag-carrying or official car
- Pilot car
- Traffic signals

Flagger control is usually used for bridge inspection, where the one-lane section is short enough so that each end is visible from the other end. Traffic may be controlled by means of a flagger at each end of the section. One of the two should be designated as the chief flagger to coordinate movement. They should be able to communicate with each other verbally or by means of signals. These signals should not be such as to be mistaken for flagging signals.

Where the end of a one-way section is not visible from the other end, the flaggers may maintain contact by means of radio or field telephones. So that a flagger may know when to allow traffic to proceed into the section, the last vehicle from the opposite direction can be identified by description or license.

Shadow Vehicles

Shadow Vehicles with truck Mounted attenuators (TMAs) are used to prevent vehicles from entering the work zone if the motorist drifts into the lane closure. Each agency has its own specific requirements, but a shadow vehicle should generally be employed any time a shoulder or travel lane will be occupied by workers or equipment.

- The requirements for the truck itself vary, but high visibility with flashing lights, a striped panel, or an arrow board on the rear of a vehicle of a specified minimum weight are generally required.
- Some agencies recommend the use of truck or trailer mounted attenuators (see Figure 3.3.12). This protects the motorist, as well as the inspectors.

Figure 3.3.12 Shadow Vehicle with Attenuator

Police Assistance

On some inspection jobs, police assistance may be helpful and even required. The presence of a patrol car aids in slowing and controlling the public. At a signalized intersection near a job site, a police officer may be required to ensure traffic flows properly and smoothly.

3.3.6 Public Safety

Since the fundamental goal of bridge inspection is to enhance public safety, it would make little sense to endanger that same public by inadequate traffic control measures. Traffic control does take time, money, and effort. It is, however, a necessary part of the business of bridge inspection.

In the broadest sense, the motorist is the customer of everyone in the transportation industry. Like everyone else, bridge inspectors need to treat customers well by inconveniencing them as little as possible and protecting their safety. This means providing well thought out, clear, and effective traffic control measures.

Pedestrians also must be considered. If a walkway must be closed, it should be properly signed and barricaded. An alternate route for the pedestrian should be indicated, if necessary through or preferably around the work zone.

Training

Each person whose actions affect inspection, maintenance and construction zone safety (from the upper-level management personnel to construction and maintenance field personnel) should receive training appropriate to the job decisions each individual is required to make. Only those individuals who are qualified by means of adequate training in safe traffic control practices and have a basic understanding of the principles established by applicable guidelines and regulations should supervise the selection, placement, and maintenance of traffic control devices in bridge safety inspection, maintenance, and construction areas.

Responsibility

Legally and morally, it is the inspector's responsibility to follow the regulations and guidelines of the agency having jurisdiction.

The primary goal of good traffic control is safety – safety of the workers, motorists, and pedestrians. A secondary goal is to be able to defend yourself and your employer should there be an accident. Accidents bring lawsuits. Lawsuits bring inquiries about who is responsible. One thing investigated during a lawsuit will be whether or not the standards and regulations were followed. Anything not done in accordance with published standards, regulations, and directives could bring blame upon whoever violated the regulation. Being blamed for an accident is expensive and damaging.

Table of Contents

Section 3
Fundamentals of
Bridge Inspection

Topic 3.4 Inspection Equipment

3.4.1 Equipment Necessity

Several factors play a role in what type of equipment is needed for an inspection. Bridge location and type are two of the main factors in determining equipment needs. If the bridge is located over water, certain pieces of equipment such as life jackets and boats are important to have. Also, if the bridge is made of timber, then specific pieces of equipment like increment borers and ice picks are needed, whereas they would not be necessary on a steel or concrete bridge. Another factor influencing equipment needs is the type of inspection. It is therefore important to review every facet about the bridge before beginning an inspection. A few minutes spent reviewing the bridge files and making a list of the necessary equipment can save hours of wasted inspection time in the field if the inspectors do not have the required equipment.

3.4.2 Standard Tools

In order for the inspector to perform an accurate and comprehensive inspection, the proper tools must be used. Standard tools that an inspector should have available at the bridge site can be grouped into seven basic categories:

- Tools for cleaning (see Figure 3.4.1)
- Tools for inspection (see Figure 3.4.2)
- Tools for visual aid (see Figure 3.4.3)
- Tools for measuring (see Figure 3.4.4)
- Tools for documentation
- Tools for access
- Miscellaneous equipment

Figure 3.4.1 Tools for Cleaning

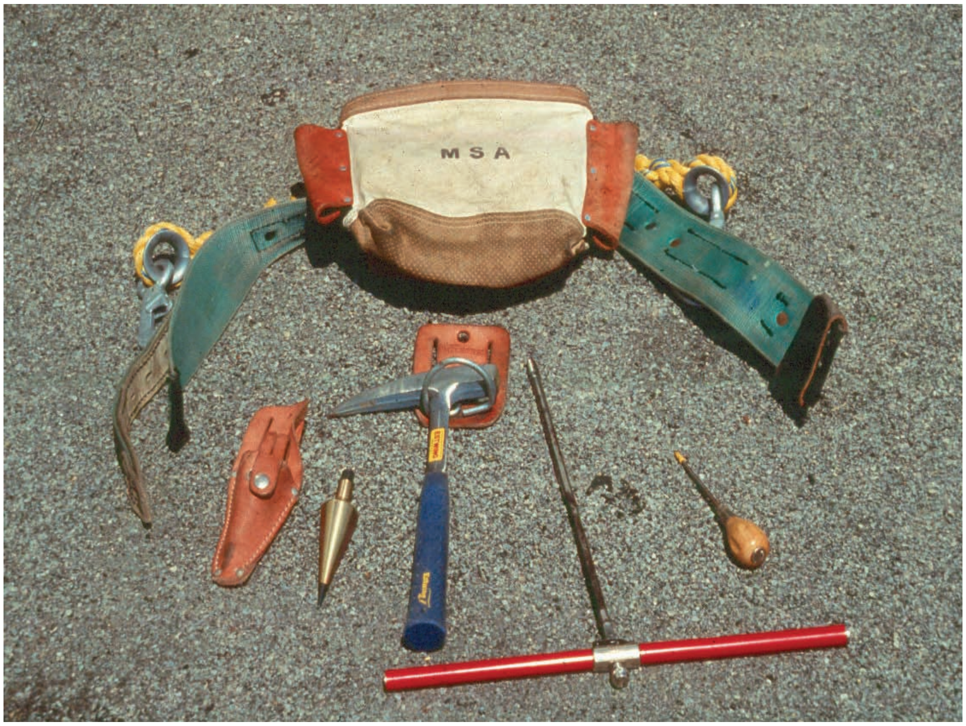

Figure 3.4.2 Tools for Inspection

Figure 3.4.3 Tools for Visual Aid

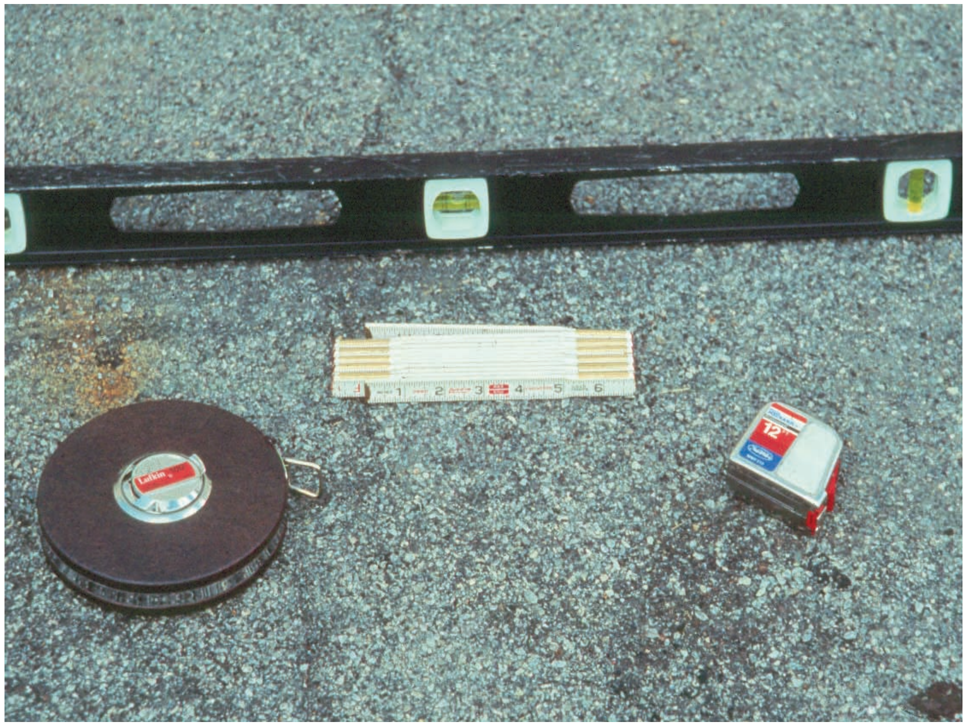

Figure 3.4.4 Tools for Measuring

Tools for Cleaning

Tools for cleaning include:

- Wisk broom - used for removing loose dirt and debris
- Wire brush - used for removing loose paint and corrosion from steel elements
- Scrapers (2 inch or 50 mm) - used for removing corrosion or growth from element surfaces
- Flat bladed screwdriver - used for general cleaning and probing
- Shovel - used for removing dirt and debris from bearing areas

Tools for Inspection

Tools for inspection include:

- Pocket knife - used for general duty
- Ice pick - used for surface examination of timber elements
- Hand brace and bits - used for boring suspect areas of timber elements
- Increment borer - used for internal examination of timber elements
- Chipping hammer with leather holder (16 ounce geologist's pick) - used for loosening dirt and rust scale, sounding concrete, and checking for sheared or loose fasteners
- Plumb bob - used to measure vertical alignment of a superstructure or substructure element
- Tool belt with tool pouch - used for convenient holding and access of small tools
- Chain drag - used to identify areas of delamination on concrete decks
- Range pole / probe - used for probing for scour holes

Tools for Visual Aid

Tools for visual aid include:

- Binoculars - used to preview areas prior to inspection activity and for examination at distances
- Flashlight - used for illuminating dark areas
- Lighted magnifying glass (e.g., five power and 10 power) - used for close examination of cracks and areas prone to cracking
- Inspection mirrors - used for inspection of inaccessible areas (e.g., underside of deck joints)
- Dye penetrant - used for identifying cracks and their lengths

Tools for Measuring

Tools for measuring include:

- Pocket tape (6 foot rule) - used to measure defects and element and joint dimensions
- 25 foot and 100 foot tape - used for measuring component dimensions
- Calipers - used for measuring the thickness of an element beyond an exposed edge
- Optical crack gauge - used for precise measurements of crack widths
- Paint film gauge - used for checking paint thickness
- Tiltmeter and protractor - used for determining tilting substructures and for measuring the angle of bearing tilt
- Thermometer - used for measuring ambient air temperature and superstructure temperature
- 4 foot carpenter's level - used for measuring deck cross-slopes and approach pavement settlement
- D-Meter (ultrasonic thickness gauge) - used for accurate measurements of steel thickness
- Electronic Distance Meter (EDM) - used for accurate measurements of span lengths and clearances when access is a problem
- Line level and string line

Tools for Documentation

Tools for documentation include:

- Inspection forms, clipboard, and pencil - used for record keeping for most bridges
- Field books - used for additional record keeping for complex structures
- Straight edge - used for drawing concise sketches
- 35 mm camera - used for visual documentation of the bridge site and conditions
- Polaroid camera - used to provide instant documentation for serious conditions which require immediate review by office personnel
- Digital camera - used to provide digital images of defects which can be downloaded and e-mailed for instant assessment
- Chalk, keel, paint sticks, or markers - used for element and defect identification for improved organization and photo documentation
- Center punch - used for applying reference marks to steel elements for movement documentation (e.g., bearing tilt and joint openings)
- "P-K" nails - Parker Kalon masonry survey nails used for establishing a reference point necessary for movement documentation of substructures

and large cracks

Tools for Access

Some common tools for access include:

- Ladders - used for substructures and various areas of the superstructure
- Boat - used for soundings and inspection; safety for over water work
- Rope - used to aid in climbing
- Waders - used for shallow streams

Tools for access are described in further detail in Topic 3.5.2.

Miscellaneous Equipment

Miscellaneous equipment should include:

- "C"-clamps - used to provide a "third hand" when taking difficult measurements
- Penetrating oil - aids removal of fasteners, lock nuts, and pin caps when necessary
- Insect repellent - reduces attack by mosquitoes, ticks, and chiggers
- Wasp and hornet killer - used to eliminate nests to permit inspection
- First-aid kit - used for small cuts, snake bites, and bee stings
- Dust masks or respirators - used to protect against inhalation in dusty condition or work around pigeon droppings
- Coveralls - used to protect clothing and skin against sharp edges while inspecting
- Life jacket - used for safety over water
- Cell phone - used to call in emergencies
- Toilet paper - used for other "emergencies" (better safe than sorry)

3.4.3 Special Equipment

For the routine inspection of a common bridge, special equipment is usually not necessary. However, with some structures, special inspection activities require special tools. These special activities are often subcontracted by the agency responsible for the bridge. The inspector should be familiar with special equipment and its application.

Survey Equipment

Special circumstances may require the use of a transit, a level, an incremental rod, or other survey equipment. This equipment can be used to establish a component's exact location relative to other components, as well as an established reference point.

Nondestructive Testing Equipment

Nondestructive testing (NDT) is the in-place examination of a material for structural integrity without damaging the material. NDT equipment allows the inspector to "see" inside a bridge element and assess deficiencies that may not be visible with the naked eye. Generally, a trained technician is necessary to conduct NDT and interpret their results. For a more detailed description of NDT, refer to Topics 13.1.2, 13.2.2, and 13.3.2.

Underwater Inspection Equipment

Underwater inspection is the examination of substructure units and the channel below the water line. When the waterway is shallow, underwater inspection can be performed above water with a simple probe. Probing can be performed using a range pole, piece of reinforcing steel, a survey rod, a folding rule, or even a tree limb.

When the waterway is deep, underwater inspection must be performed by trained divers. This requires special diving equipment that includes a working platform, fathometer, ground penetrating radar, air supply systems, radio communication, and sounding equipment. Refer to Topic 11.3 for a more detailed description of underwater inspection equipment.

Other Special Equipment

An inspection may require special equipment to prepare the bridge prior to the inspection. Such special equipment includes:

- Air-water jet equipment - used to clean surfaces of dirt and debris
- Sand or shot blasting equipment - used to clean steel surfaces to bare metal
- Burning, drilling, and grinding equipment

3.4.4 Recent Developments in Equipment

In addition to the standard and special equipment listed previously, there are new equipment and technology available to aid in bridge inspection. The developments in various types of advanced testing techniques are described in Topics 13.1, 13.2 and 13.3. The following information represents some of the advances in inspection tools and data collection.

Rotary Percussion

Rotary percussion is a technique whereby a uniform tapping is produced by rolling a gear-toothed wheel to determine concrete defects. This allows for quicker inspection on overhead and vertical surfaces, similar to using a chain drag for horizontal surfaces. Advantages of rotary percussion testing tools include ability to detect near-surface delaminations, quickness of testing, low equipment cost, relatively low level of user's skill required, and low sensitivity to the surroundings.

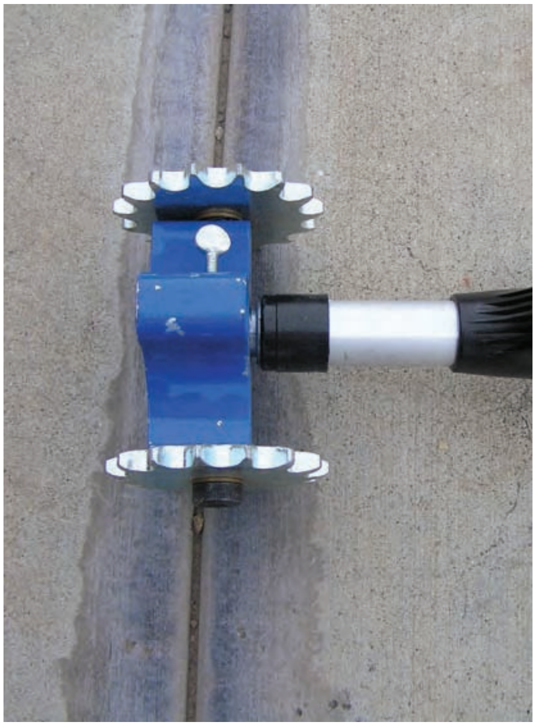

Figure 3.4.5 Rotary Percussion

Scour Measurement

The SHIFLO is a specialized device used to measure the depth of scour during flood flows. It consists of a depth finder mounted on a water ski. The use of a water ski allows for depth readings of be taken in extremely fast flowing water and also allows for excellent maneuverability of the depth finder into locations under a bridge.

Scour Monitoring

ScourWatch™

ScourWatch™, is a secure web-based bridge scour monitoring software product that allows transportation engineers to predict, identify, prepare for, and record potentially destructive flooding events. ScourWatch™ identifies the occurrence of a flood event and collects and processes relevant bridge information, several sources of real-time hydrological and any bridge scour monitoring device data. Transportation officials will be able to efficiently dispatch emergency personnel, bridge safety inspectors, and maintenance workers before, during, and after a flood event affects a state's bridge inventory.

ScourWatch™ is designed to be an active/pro-active bridge scour monitoring system. Creates a list of scour critical bridges experiencing their respective critical event.

Scour Monitoring Collar

The Magnetic Sliding Collar (MSC) is a scour monitoring device. The magnetic sliding collar device consists of a stainless steel pipe driven into the channel bottom with a sliding collar that drops down the pipe as the scour progresses. The location of the collar is detected by the magnetic field created by magnets on the collar. Installations conducted in cooperation with state highway agencies demonstrated that this simple, low-cost instrument is adaptable to various field situations, and can be installed with the equipment and technical skills normally available at the district level of a state highway agency.

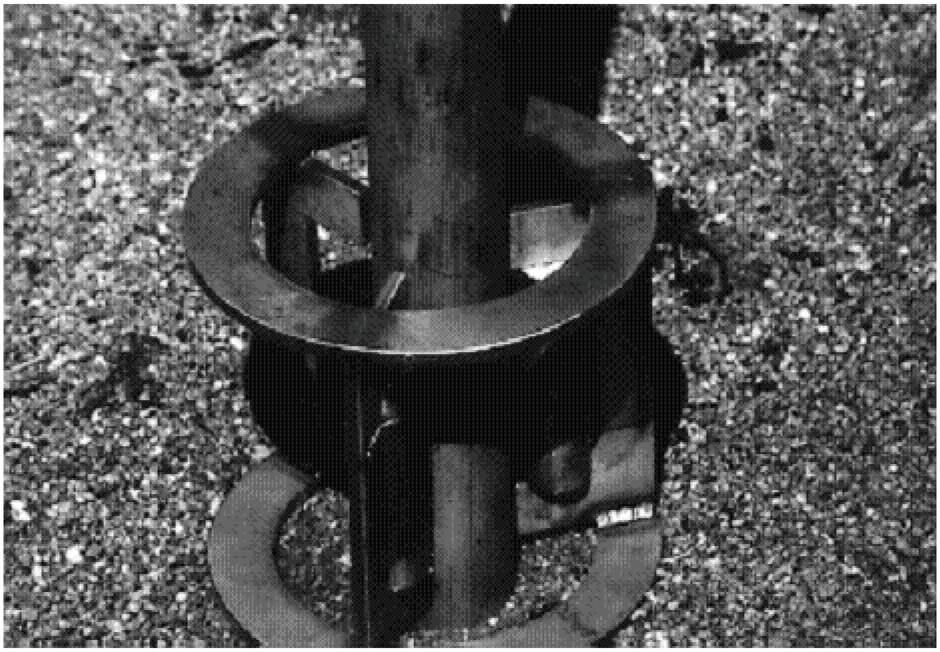

Figure 3.4.6 Scour Monitoring Collar

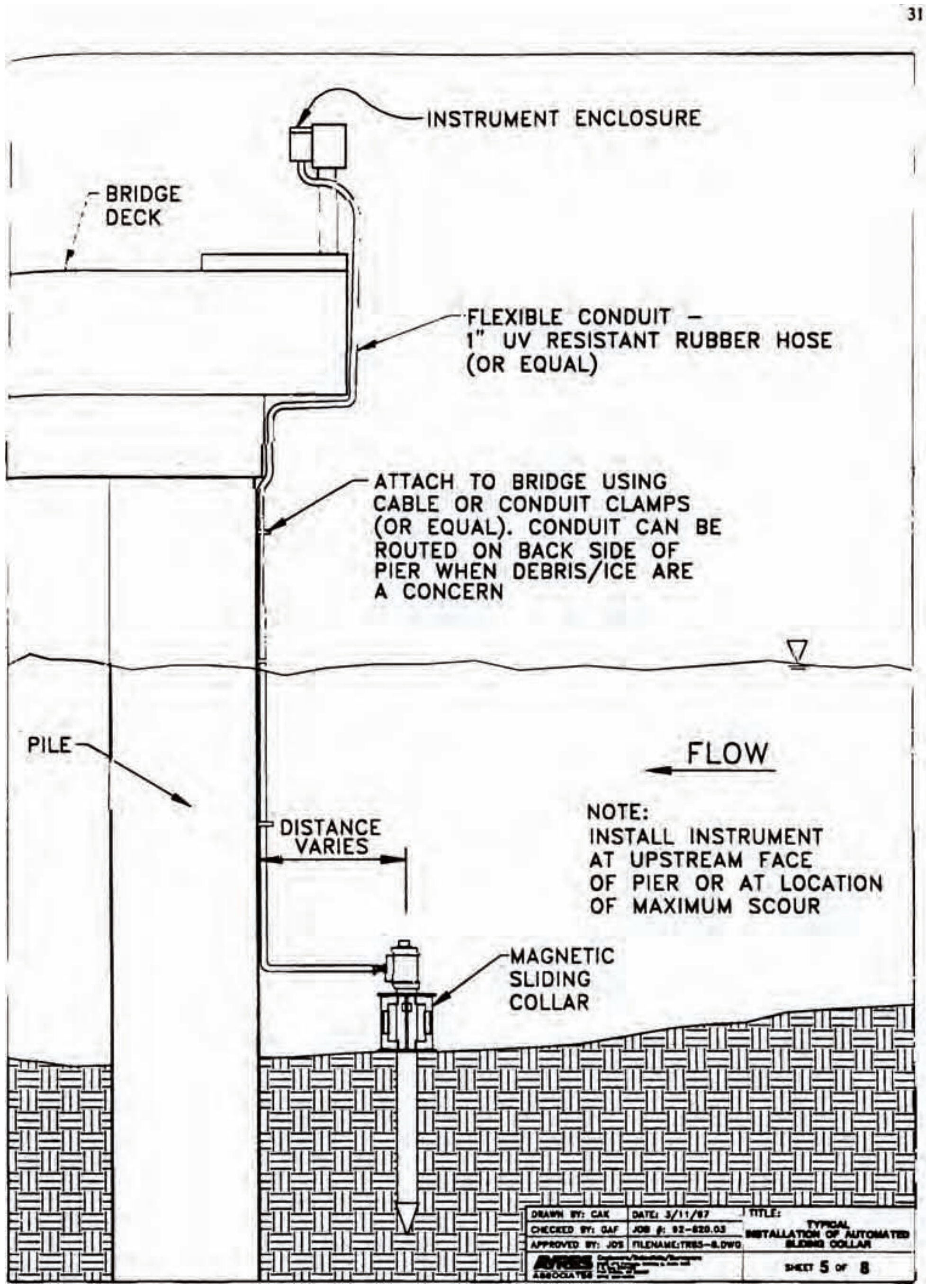

Figure 3.4.7 Scour Monitoring Collar Schematic

Remote Camera

The basic components of computer-based image system include an imaging sensor, most commonly solid-state camera; the image acquisition boards, which convert optical images into an array of digital information, representing the brightness values of the surface; and dedicated processor. The computer-based imaging system can provide two main types of information: spatial measurements and surface analysis. Spatial information encompasses two-dimensional or three-dimensional analysis, measurements and recognition. The surface analysis provides information regarding the color or gray-scale attributes of the target. For example, imaging systems are able to distinguish a flaw from the rest of the surface, and determine size, shape, location and even smallest color attributes of the defect. The field of view that can be processed in a fraction of the second and can be on the order of 200 to 500 times the size of the smallest feature of interest.

Figure 3.4.8 Remote Camera

High Speed Underclearance Measurement System

The system can mount on any vehicle with a trailer hitch receiver. The system measures the underclearance of a bridge at normal highway speeds. Along with the underclearance data, the GPS information is gathered. Software is used for the data acquisition, display and analysis. The bridge beam height is read to the nearest tenth of a foot. The GPS information can be pasted into a map program to obtain the structure location for future reference.

Figure 3.4.9 High Speed Underclearance Measurement System

Robots

Robotic devices for many applications are being developed by university researchers. High level and underwater bridge inspection are among these applicatons.

One example is the serpentine robot being developed that possesses multiple joints that give it a superior ability to flex, reach, and approach all points on the bridge. This robot is under development.

Other developments in robotic devices are discussed in more detail in Topic 13.3.

Laser Scanning

Laser scanning technology can create accurate and complete 3D as-built models quickly and safely. These digital models are automatically combined with CAD design models to allow generation of "as-built" drawings for existing structures. This method can replace tedious field measurements for rehabilitation projects.

Data Recording

Hardware

Data recording hardware can include regular office computers, notebook computers, tablet PCs or PDAs (pen based tablets). Some versions of these devices have been made to be more rugged and even "wearable" for use in the field.

Many State agencies are using Electronic Data Collection for bridge inspection. See Topic 3.X for a detailed description of the hardware and software some State agencies are using.

Software

Specialized software packages can provide a comprehensive set of solutions to manage, inspect, maintain and repair bridges. They allow the user to maintain a comprehensive asset inventory database, collect inspection data from electronic devices, keep history of inspection & maintenance records, assign inspection & maintenance requirements to each structural component, automatically generate inspection reports, and offer decision support.

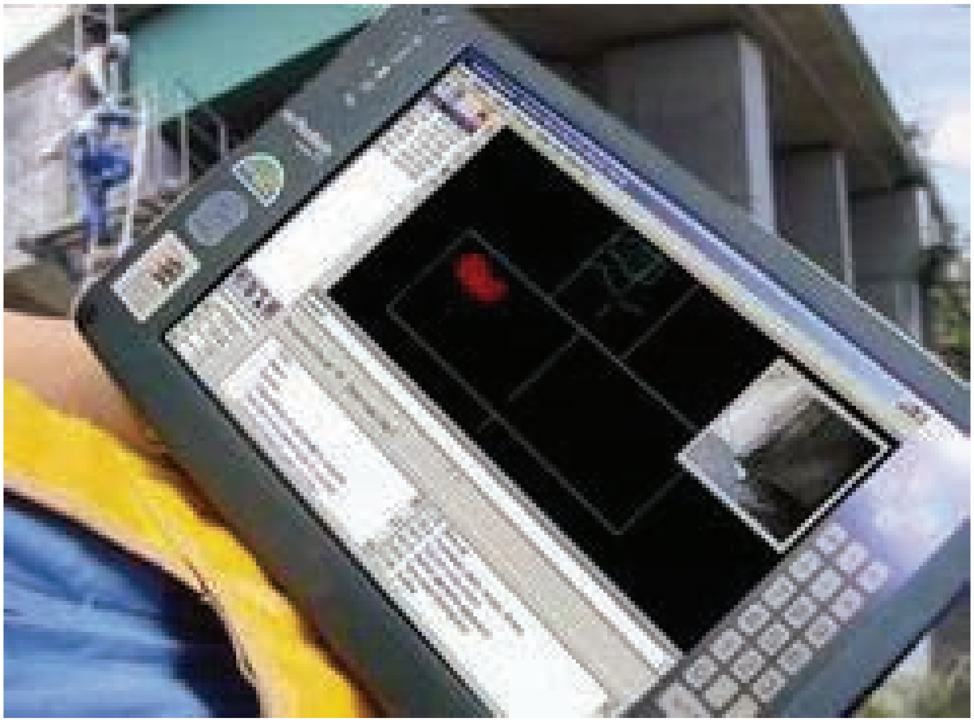

Figure 3.4.10 Pen Based Tablet

3.4.5 Primary Safety Concerns

Proper inspection equipment can play a key role in maintaining the safety for the traveling public and the inspectors. When inspectors do not have the right equipment, they may attempt to use an alternate piece of equipment that is not really designed for the job. This cannot only prove dangerous for the inspector, but for the public as well. Inspectors should never try to substitute with improper inspection equipment in the interest of saving time or money. The best way to avoid these circumstances is to ensure the inspectors have the proper equipment for the job and that equipment is serviced or replaced periodically. This responsibility lies not only with the inspector but also their employer. It is important that the employer make every effort to properly equip all inspection teams. Also, the inspector should be familiar with every piece of equipment and how to use and operate it properly and safely.

Table of Contents

Section 3
Fundamentals of
Bridge Inspection

Topic 3.5 Methods of Access

3.5.1 Introduction

The two primary methods of gaining access to hard to reach areas of a bridge are access equipment and access vehicles. Common access equipment includes ladders, rigging, and scaffolds, while common access vehicles include manlifts, bucket trucks, and snoopers. In most cases, using a manlift or bucket truck will be less time consuming than using a ladder or rigging to inspect a structure. The time saved, however, must offset the higher costs associated with operating access vehicles.

3.5.2 Types of Access Equipment

The purpose of access equipment is to position the inspector close enough to the bridge component so that a "hands-on" inspection can be performed. The following are some of the most common forms of access equipment.

Ladders

Ladders can be used for inspecting the underside of a bridge or for inspecting substructure units. However, a ladder should be used only for those portions of the bridge that can be reached safely, without undue leaning or reaching.

Figure 3.5.1 Inspection with a Ladder

Ladders can also be used to climb down to access elements of the bridge. The hook-ladder, as it is commonly referred to, is fastened securely to the bridge framing.

Figure 3.5.2 Use of a Hook-ladder

When using a hook-ladder, the inspector should be tied off to a separate safety line, independent of the ladder.

Rigging

Rigging of a structure consists of cables and platforms. Rigging is used to gain access to floor systems and main load carrying members in areas where access by other means is not feasible or where special inspection procedures are required (e.g., nondestructive testing and pin removal). Rigging is often used over water, over busy highways or railroads where sufficient clearance exists. Rigging is a good choice for a load posted bridge that does not have the capacity to support an inspection vehicle.

Figure 3.5.3 Rigging for Substructure Inspection

Figure 3.5.4 Rigging for Superstructure Inspection

Scaffolds

Scaffolds provide an efficient access alternative for structures that are less than 12 m (40 feet) high and over level ground with little or no traffic nearby.

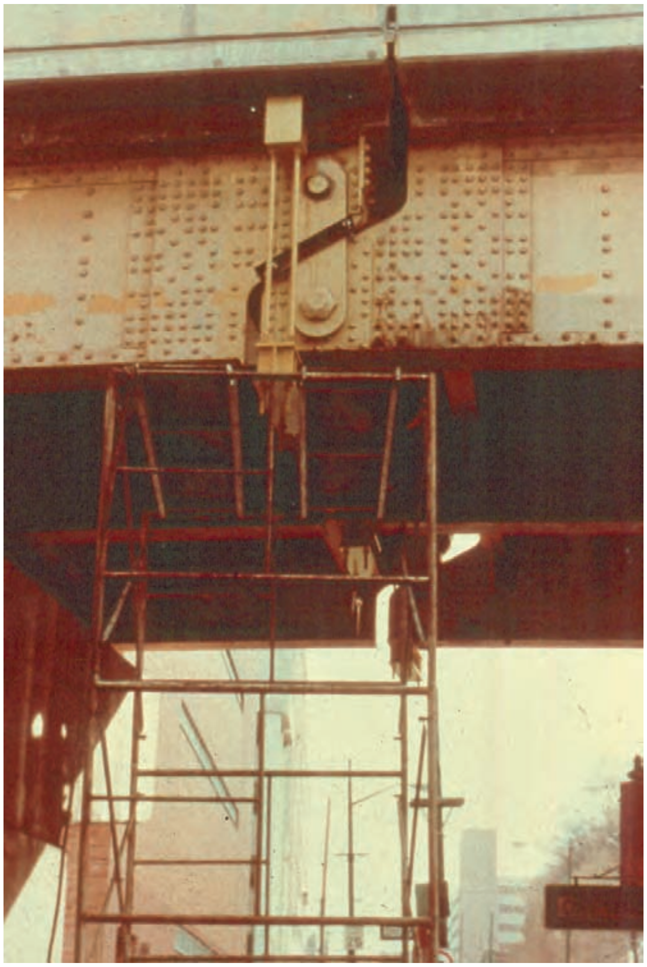

Figure 3.5.5 Scaffold

Boats or Barges

A boat or barge may be needed for structures over water. A boat can be used for inspection, as well as providing access to areas for taking photographs. Also, a safety boat is required when performing an inspection over water.

Figure 3.5.6 Inspection Operations from a Barge

A barge may also be used in combination with other access equipment or vehicles to perform an inspection. The barge may be temporarily anchored in place to provide a platform for a manlift or for underwater inspections.

Climbers

Climbers are mobile inspection platforms or cages that "climb" steel cables. They are well suited for the inspection of high piers and other long vertical faces of bridge members.

Figure 3.5.7 Climber

Floats

A float is a wood plank work platform hung by ropes. Floats are generally used for access in situations where the inspector will be at a particular location for a relatively long period of time.

Figure 3.5.8 Float (foreground) and Spider (background)

Bosun (or Boatswain) Chairs / Rappelling

Bosun (or boatswain) chairs are suspended with a rope and can carry only one inspector at a time. They can be raised and lowered with block and tackle devices. Rappelling is a similar access method to the Bosun chair but utilizes different equipment and techniques. However, both methods require the use of independent safety lines.

Figure 3.5.9 Bosun Chair

Free Climbing

On some structures, if other methods of access are not practical, inspectors must climb the bridge elements. Safety awareness should be foremost in the inspector's mind when utilizing this technique. Climbing can be divided into two categories. The first category is free climbing, in which the inspector climbs freely, unsecured to the bridge. (Whenever possible, a safety line should be provided for the inspector to secure a lanyard.) The second category employs rappelling techniques and safety equipment.

Figure 3.5.10 Climbing

Permanent Inspection Structures

On some structures, inspection access is included in the design and construction of the bridge. These are typically found on long span structures or more complex designs. Although these inspection platforms only give access to a limited portion of the bridge, they do provide a safe and effective means for the inspector to work. The following are some examples of permanent inspection structures.

Catwalks

A catwalk is an inspection platform typically running parallel to the girders from abutment to abutment under the superstructure. Catwalks can be used to inspect parts of the deck/superstructure and some portions of the substructure. The range of inspection area is limited to those locations near the catwalk.

Figure 3.5.11 Catwalk

Traveler

A traveler is another permanent inspection platform similar to a catwalk except that it is movable. A traveler platform is typically perpendicular to the girders and the platform runs on a rail system between substructure elements. Having the platform perpendicular to the girders allows the inspectors a wider range of movement and enables them to see more if not all of the superstructure elements.

Figure 3.5.12 Traveler Platform

Handrails

Handrails are also used to aid an inspector. Handrails can be used in a number of different locations on the bridge. On the main suspension cables, on top of the pier caps, and on the girder web are just a few locations where handrails may be built. Handrails are typically provided to assist the inspector when free climbing on the bridge and give the inspector a place to secure their lanyard and safety harness.

Figure 3.5.13 Handrail

Inspection Robots

Currently, efforts are being made for robots to be used for inspection purposes. Though still early in the development stage, robots may prove to be an important addition to the inspector's access equipment. Although a robot can never replace a qualified inspector, it can provide information that may not be visible to the human eye. A robot equipped with sonar capabilities can detect internal flaws in bridge members. Also, a robot can be used in situations that are too difficult to reach or extremely dangerous for a human.

3.5.3 Types of Access Vehicles

There are many types of vehicles available to assist the inspector in gaining access for "hands-on" inspection of bridge elements. The following are some of the most common types of access vehicles.

Manlift

A manlift is a vehicle with a platform or bucket capable of holding one or more inspectors. The platform is attached to a hydraulic boom that is mounted on a carriage. An inspector "drives" the carriage using controls in the platform. This type of vehicle is usually not licensed for use on highways. However, some manlifts are nimble and can operate on a variety of terrains. Although four wheel drive models are available, manlifts are limited to use on fairly level terrain. Manlifts come in a number of different sizes with vertical reaches ranging from 12 m (40 feet) to over 52 m (170 feet).

Figure 3.5.14 Manlift

Bucket Truck

A bucket truck is similar to a manlift. However, a bucket truck can be driven on a highway, and the inspector controls only the bucket. As with the manlift, a bucket truck should be used on fairly level terrain. Bucket trucks have a number of different features and variations:

- Lift capability - varies 7.5 to 15 m (25 to 50 feet).
- Rotating turret - turning range (i.e., the rotational capability of the turret) varies with each vehicle.
- Outriggers - bucket trucks that offer extended reach and turning range have outriggers or supports that are lowered from the chassis of the vehicle to help maintain stability.
- Telescoping boom - some booms may be capable of extending and retracting, providing a greater flexibility and reach area from a given truck location.
- Truck movement - some vehicles offer stable operations without outriggers and can move along the bridge during inspection activities. Vehicles that require outriggers for stable operations cannot be moved during the inspection unless the outriggers have wheels.
- Multiple booms - some bucket trucks have more than one boom, and provide reach up to 15 m (50 feet).

Figure 3.5.15 Bucket Truck

Underbridge Inspection Vehicle

An underbridge inspection vehicle is a specialized bucket truck with an articulated boom designed to reach under a structure while parked on the bridge deck. A rotating turret provides maximum flexibility, and outriggers with wheels allow the truck to be moved during operations. Usually the third boom has the capacity for extending and retracting, allowing for greater reach under a structure. Some of the larger underbridge inspection vehicles have four booms, allowing an even greater reach.

Figure 3.5.16 Underbridge Inspection Vehicle

Many of the features on an underbridge inspection vehicle are standardized on all models. Some of the common features include:

- Rotating turret - provides maximum flexibility.
- Outriggers with wheels - allow for moving the truck during operations.
- Telescoping third boom - usually the third boom has the capability for extending and contracting; this allows for greater reach under a structure.

Variations and options available on different models include:

- Capacity - Some underbridge inspection vehicles have a two or three person bucket on the end of the third boom. Other models are equipped with a multiple-person platform on the third boom with a ladder on the second boom. Still other models may have the capability of interchanging a bucket and a platform in the shop.
- Platform – The platform is lowered by an articulated boom and can then telescope out to provide inspection access to a wide range of the superstructure and substructure. The inspector is now free to walk from beam to beam without having to reposition the platform. This

combination allows for an efficient and thorough inspection.

- Telescoping second boom - Some underbridge inspection vehicle models have a second boom that can extend and contract, providing greater movement in the vertical direction.
- Articulated third (or fourth) boom - Some underbridge inspection vehicle models have a small third or fourth boom that allows for greater vertical movement under the structure. This option is particularly useful on bridges with deep superstructure members.

Figure 3.5.17 Underbridge Inspection Vehicle (Snooper) with Platform

3.5.4 Method of Access and Cost Efficiency

In most cases, even the most sluggish lift device will be quicker than using a ladder or rigging to inspect a structure. The time saved, however, must offset the higher costs associated with obtaining and operating the vehicle.

In assessing the time-saving effectiveness of a lift device, the following questions should be answered:

- Can the bridge be inspected by other reasonable methods?
- What types of access vehicle or access equipment are available?
- How much of the bridge can be inspected using the access vehicle?
- How much of the bridge can be inspected from one setup of the access vehicle?
- How much time does it take to inspect at each setup?
- How much time does it take to move from one setup to the next?

- Does the vehicle require an independent operator or driver other than the inspector?
- Will the use of the access vehicle require special traffic control?
- Can the bridge carry the weight of an inspection vehicle?

The inspection time and vehicle costs can then be compared to costs associated with using standard access equipment.

3.5.5 Safety Considerations

Safety should be a primary concern on any job site, not only of the workers but of the public as well. The equipment and vehicles being used also have safety considerations.

Access Equipment

Before the bridge inspection begins, an equipment inspection should be performed. As a minimum, inspect access equipment as per the manufacture's guidelines. Using faulty equipment can lead to serious accidents and even death. The inspector should check all the equipment and verify that it is in good working condition with no defects or problems. If rigging or scaffolding is being used, it should be checked to ensure that it was installed properly and all cables and planks are secured tightly. OSHA-approved safety harnesses with shock absorbing lanyards should be worn at all time when using access equipment and vehicles.

Access Vehicles

If the inspector is not familiar with the inspection vehicle being used, he should take the time required to become accustomed to the operation. In some cases, formal operator training may be necessary or required. When operating any inspection vehicle, always be aware of any overhead power lines or any other hazards that may exist. It is also important to be aware of any restrictions on the vehicle, such as weight limits for the bucket, support surface slope limits, and reach restrictions. Always be alert to your location. Do not boom out into unsafe areas such as unprotected traffic lanes or near electrical lines.