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## 1.4 FUNDAMENTALS OF STRUCTURE INSPECTION

### 1.4.1 Introduction

The practice of inspecting Wisconsin's structures is complex but well defined. An inspector needs to perform many duties before, during, and after the physical inspection of a structure. To start, inspectors need to meet strict qualifications set by the State, as guided by the federal government. These inspector qualifications set minimum limits on the inspector's knowledge and experience. In addition to the mental requirements, structure inspection can be physically demanding work. Therefore, an inspector needs to be physically fit. Next, inspectors should understand the duties they are expected to perform. These duties range from protecting the public's safety to performing the inspection, preparing the reports, and more.

Inspectors need to understand the various inspection requirements. There are several different types of inspection that can be required for a structure. Some inspections are visual and conducted from a distance, while others are primarily tactile (hands-on) and conducted within the arm's reach of each structure member. Some inspections are conducted every few years, while others may be required every few months. Inspectors need to know which type of inspection is appropriate or required.

Before going out to the field, inspectors should properly plan an inspection. This includes reviewing available data, arranging for qualified personnel and appropriate equipment, scheduling traffic control, and so on.

In the field, good inspectors are meticulous and pay great attention to details. Inspectors need the experience to know what to look for, the knowledge to understand what they see, and the skills to accurately document what is significant. After the inspection is complete, inspectors need to know how to prepare and submit the inspection results to the proper authority.

A structural inspection involves a series of tasks that require dedicated, well-trained inspectors to fulfill them. The purpose of this chapter is to explain the fundamental background that an inspector needs to do the job well.

### 1.4.2 Duties of Inspectors

#### 1.4.2.1 General Responsibilities

The structure inspector's job is one of great importance. In performing their daily duties, structure inspectors ensure the safety of the traveling public in a tangible way. Few other transportation jobs offer this opportunity. This opportunity comes with several key responsibilities.

The five general responsibilities of a structure inspector are as follows:

1. Maintain public safety and confidence.
2. Protect the public's investment.



3. Provide bridge inspection program support.
4. Maintain accurate bridge records.
5. Fulfill legal responsibilities.

#### **Maintain Public Safety and Confidence**

The primary responsibility of the structure inspector is to ensure public safety and confidence. The people and businesses of Wisconsin depend on safe transportation facilities to carry the commercial traffic that fuels our economy as well as the public traffic of daily life. The traveling public has zero tolerance for structure failures. Failures result in property damage, traffic congestion, lost investment in infrastructure, and the potential loss of life. When a structure fails, the public loses confidence in the safety of the transportation network. To alleviate the potential for a structure failure, it is the responsibility of the structure inspector to provide the following:

1. Thorough inspections identifying structure conditions and defects.
2. Condition reports documenting the deficiencies and providing recommendations for remediation.

Structure inspectors often work within the sight of the public and may be under close scrutiny. Inspectors should always exercise responsible behavior. It reflects well on the inspector and Wisconsin Department of Transportation (WisDOT) when inspectors behave professionally. If approached by a curious bystander, the inspector should always be courteous and professional. This helps to reinforce the public's confidence in the work that inspectors do. However, the inspector should not discuss inspection findings unless authorized to release such information by the owner of the structure.

#### **Protect the Public's Investment**

Structure failures can and have happened in Wisconsin. In 1989, the Tayco Street drawbridge in Menasha collapsed blocking roadway traffic and navigation between Lake Winnebago and the Fox River's downstream locks. Nobody was hurt, but a large pleasure boat was only fifty feet away from the bridge and moving toward it when the south bascule span came crashing down into the water. The span collapsed because a pin that connected the end of the span to a massive counter weight system failed. It cost several million dollars to replace the bridge. The channel that served as a busy weekend artery for pleasure boaters was closed for several days. Businesses near both ends of the bridge were negatively affected because employees and patrons had to take a longer, alternate route across the river to reach them. The bottom line is that, when a bridge fails, the economic impact is very real and often immediate. The inspector has a duty to detect and report serious defects before they cause failures. Early detection of serious defects can help to ensure public safety and helps to prevent the economic hardships associated with catastrophic structure failures. Had the pin problem on the Tayco Street drawbridge been detected earlier, maintenance and repair action could have been taken. The cost of the maintenance required would have been significantly less than the resulting costs of the failure. Since funding for bridgework comes from tax dollars, it is important that inspectors do their part to minimize the cost to the public. Thorough and regular inspection practices, coupled with timely and consistent maintenance, will save the public money and help to

prevent any loss of property or life. It is also the responsibility of the inspector to detect minor problems in order to correct them early on and prevent more costly repairs in the future.



Figure 1.4.2.1-1: Failed Tayco Street Bascule Bridge, Menasha.



Figure 1.4.2.1-2: Failed Pin, South Bascule Span of Tayco Street Bridge.



#### **Provide Bridge Inspection Program Support**

Experienced inspectors should be able to look at a structure and identify elements that are critical and elements that are failure prone. Once the suspect elements are identified, the inspector needs to recognize which of those elements are in need of maintenance, repair or replacement. The knowledge required to make such judgments comes from experience and training. Therefore, it is important that all inspectors meet or exceed the minimum qualification requirements set forth in this manual. All elements in need of maintenance should be identified, located, described, and recorded in sufficient detail to create a reasonable estimate for repair materials and cost. Inspectors need to evaluate the general condition, safety level, and serviceability of each bridge and structure with certainty. No element of the structure should be overlooked during an inspection. At the time of the inspection, the inspector should make recommendations for the maintenance or repair of any problems and deficiencies. The Inspection Team Leader and the Region inspection Program Manager or county inspection Program Manager should review the inspector's recommendations and consider what the most efficient course of action is before implementing the final recommendations. Efficient maintenance and repairs will help to maintain the safety of the structure in the most cost effective manner.

The bridge inspection program is funded through public dollars, therefore the inspector is financially responsible to the public.

The National Bridge Inspection Standards (NBIS) requires all state agencies to create and maintain a bridge inspection program. An inspector is a valued asset within that program that allows it to work efficiently to appropriate funds accordingly through the inspector's diligence in the field.

The inspector is obligated to maintain this work ethic for the public good.

#### **Maintain Accurate Structure Records**

The inspector is responsible for providing accurate bridge dimensions and element quantities on the inspection form. The inspector is also responsible for documenting structural deficiencies and maintenance or repair items that are identified in the field. The inspector is also responsible for noting any functional deficiencies. Documentation should be thorough enough that a program manager, load rating engineer or other qualified individual who has not seen the structure can get a good understanding of the condition of the structure. The inspector needs to prepare neat and legible notes and sign the inspection forms. When necessary, the inspection form should be supplemented with additional notes and photographs.

The inspector shall:

1. Verify that all data is correct on the inspection form.
2. Verify that elements are correctly identified and quantified on the form.
3. Spot-check structure dimensions in the field to verify that the dimensions are correct.



### Fulfill Legal Responsibilities

The inspection report is a legal document, and proper, standard language needs to be used. The inspector should not use vague adjectives. Concise descriptions that “paint” a picture of the structure should be used. The description should also express the specific location and quantity of the condition. All information will be entered into the WisDOT Highway Structure Information System (HSIS).

A completed inspection report becomes a legal document/record when it is signed by a qualified Inspection Team Leader. By signing an inspection report, the Team Leader is attesting to having been at the structure site and having taken an active part in the inspection of the structure. The Team Leader’s signature also certifies that the information in the inspection report is accurate. Federal and state laws, as well as organizational policies, define the qualifications and duties of the Inspection Team Leader. Anyone who signs an inspection report without meeting those qualifications, or signs a report without being at the structure site and participating in the inspection as defined in the American Association of State Transportation and Highway Officials (AASHTO) *The Manual for Bridge Evaluation* may be subject to prosecution for forgery or fraud under Wisconsin Statutes §§943.38 and 943.39 or other applicable state or federal laws.

### Disciplinary Actions

Structure inspection ensures the safety of the public and helps to maintain the public’s investments. It is a privilege for an individual to carry out this work, and it is expected that all conduct their work in a professional manner.

Unfortunately, there may be some occurrences where an ulterior motive takes precedence over professional judgment. These occurrences may be prohibited to protect the interests of the Program. Occurrences may be any event that conflicts with state and/or federal requirements, or one where reasonable professional expectations of the individual (such as using a reasonable level of professional judgment when inspecting or providing recommendations) are questioned. Occurrences may range from acts of fraud (e.g., recommendations solely based on personal interests) to failure to maintain required training requirements. Other examples of fraud may include untrained inspectors, ultra-conservative ratings to promote future work, and ratings based on the directions of owners to reduce sufficiency rating.

#### Definition of Status

**Active:** Individual meets all requirements and is in good standing.

**Inactive:** Individual is in good standing, but does not meet all requirements.

**Disqualified:** Individual is not in good standing.

#### Disciplinary Process

Specifics are located in the Quality Assurance (QA) section of Part 1 Chapter 2 of this manual.



Findings may be forwarded to the Wisconsin Department of Regulation and Licensing, the Wisconsin Department of Justice or the U.S. Department of Justice, if deemed appropriate.

### 1.4.2.2 Basic Duties

The structure inspector has the following basic duties:

1. Planning the inspection
2. Preparing for the inspection
3. Performing the inspection
4. Preparing the inspection report
5. Identifying safety concerns and items in need of repair or maintenance
6. Recommending re-rating, load posting, or structure closure (follow-up for critical findings)

#### **Planning the Inspection**

The goal of the inspector is to be safe, efficient and systematic. One way to accomplish this goal is through proper planning. Planning includes developing an element inspection sequence; establishing personnel requirements and an estimated time frame for the inspection; formatting of field notes; anticipating traffic control, material testing, and bridge access equipment needs; and determining other measures to ensure productive use of time in the field. The previously documented inspection procedures are an excellent place to start with the planning of an inspection.

#### **Preparing for the Inspection**

Preparations for a field inspection should include reviewing the most recent inspection report for the structure, reviewing the structure plans, and mapping a route to the work site. All of the necessary inspection equipment and tools should be inventoried and prepared for the field. Good preparation saves the inspector time and saves the owner time and money. A well-prepared inspector can focus on the task of inspecting without worrying about organizational issues.

#### **Performing the Inspection**

The inspector should perform such examination, testing, and observation of the structure as required to evaluate its condition, safety, and serviceability. In order to accomplish this goal, the inspector should strictly adhere to the proper element level inspection procedures and NBIS Condition Rating procedures laid out in this Manual.

The inspector should maintain the proper structure orientation and element numbering system and follow the inspection sequence plan. Inspectors should maintain proper traffic control, when required, and adhere to the appropriate safety and fall protection guidelines. The inspector should record enough information to ensure proper recommendations can be made in a comprehensive report.



**Preparing the Inspection Report**

The report form should be completed in its entirety at the bridge site. It is important that the inspection report be prepared in a style that is easy to read and understand. All writing needs to be legible and appropriate pictures should be labeled, dated, and inserted to clarify the documentation. All photographs not used in the report should be labeled, dated, and kept in the project folder. It is a good quality control practice to have a third party review the form for errors and omissions before submittal. Any mistakes should be crossed out, initialed, and dated. The inspector should never erase any written information on a written inspection form.

**Identifying Safety Concerns and Items In Need of Repair or Maintenance**

The inspector has a duty to identify safety issues and structure elements in need of repair or maintenance. When a defective element is identified, the inspector should document the defect, locate it on the structure, quantify it, and list the recommended remedial actions on the inspection form. Items requiring immediate attention should be reported to the Region Structure Maintenance Engineer. This helps to ensure public safety and maximize the life of the structure. See Part 1, Chapter 7 (Emergency Notification and Follow-Up Documentation) for structure defects that require prompt action to maintain public safety.

**Recommending Re-rating, Load Posting or Structure Closure**

The final duty of the inspector may be to recommend a re-rating, load posting, or closure of a structure. This recommendation is based on the findings of the inspection and the experience of the inspector. For a re-rating or load posting, the inspector may need to get the professional opinion of a structural engineer, materials engineer, etc. or request an engineering analysis of the structure be performed. In Wisconsin, structure inspectors (*i.e.*, Program Managers and Team Leaders) have the authority to close a structure that poses an immediate danger to the public or shows signs of imminent failure. When a structure inspector finds a defect or damage to a structure that warrants a structure closure, the inspector should close the structure first and secure the location to ensure that nobody gets injured. The inspector may want to enlist the help of the state highway patrol, county sheriff, or local law enforcement to assist in restricting public access to the structure. Once the structure location is secure, the inspector should follow the appropriate emergency actions as described in Part 1, Chapter 7 of this manual.

**1.4.3 Inspection Preparation**

The inspection team should develop an inspection plan. Good preparation is an important part of any inspection. Important steps that will help in accomplishing a successful inspection are: planning, scheduling, equipment, personnel requirements, and field inspection procedures.

**1.4.3.1 Historical Plan and Structure Review**

It is critical to gather all of the historical information that is available. Information that may be available includes:

1. Original design plans



2. “As-built” plans
3. Original shop drawings
4. Construction history
5. Maintenance history
6. Rehabilitation history
7. Bridge inspection reports and photographs
8. Log of openings (for movable bridges)

This information should be reviewed by the Inspection Team Leader (ITL) prior to performing the inspection in order to determine the fatigue prone, failure prone, and fracture critical members or member components. It is strongly recommended that original plans and documents remain in the office of the owner and that only copies are taken to the field.

#### 1.4.3.2 Required Permits and Safety Training

In some instances, it may be necessary to obtain permits or special training prior to doing field inspection work. A good example would be inspection work above or adjacent to an active railway corridor. Railways typically have a significant amount of right-of-way, so most of the space underneath a railway bridge is typically railroad property. Most rail lines are privately owned and inspectors that wish to work in an active railway corridor need to obtain permission from the railway owner first. Failure to obtain permission is considered trespassing and can have serious consequences. Railway owners can levy stiff fines and, at worst, an accident could lead to serious injury or death. In some cases, railway owners may require that inspectors receive special safety training before permission will be granted. Railways may elect to send a railway flagman to the site to direct and caution railroad traffic during the time the inspector is working in the railway corridor. Railroads may pass the cost of the flagman onto the agency that ordered the inspection (*i.e.*, the structure owner). Railroads also have restrictions on the proximity of people and equipment to the actual railroad tracks. All of these details need to be worked out and understood prior to the field inspection.

Many of the permit and safety requirements that apply to inspections over railroads also apply when inspecting bridges over navigable waterways. The U.S. Coast Guard (USCG) must be notified if an inspection may reduce navigable clearances (*i.e.*, snooper truck platform or arm under bridge). The USCG oversees Wisconsin from two district offices as illustrated on their website (<http://www.navcen.uscg.gov/?pageName=InmMain>). The inspection team leader should coordinate with the appropriate local USCG Marine Safety Office (MSO)/Dispatch (MSO Milwaukee, WI (414) 747-7161, MSO Sturgeon Bay, WI (920) 743-9448, MSO Duluth, MN (218) 720-5286, MSD St. Paul, MN (651) 290-3991) as well as notify the USCG District Office (Western Rivers: USCG District 8, [d8marineinfo@d8.uscg.mil](mailto:d8marineinfo@d8.uscg.mil) Phone: (504) 589-6277; Great Lakes: USCG District 9, [thomas.c.perez@d9.uscg.mil](mailto:thomas.c.perez@d9.uscg.mil) Phone: (216) 902-6073) so that a “notice to mariners” can be published.



**Figure 1.4.3.2-1:** Inspectors Working Next to a Live Railway.

Inspectors should be aware of the rules and policies pertaining to confined space entry. The Occupational Safety and Health Administration (OSHA) definition of a confined space is as follows:

"Confined space" means a space that:

- (1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- (2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- (3) Is not designed for continuous employee occupancy.

Inspectors should be aware of confined spaces. Inspection of the following structures can involve confined space entry:

1. Steel or concrete box girders
2. Steel arch rings
3. Arch tie girders



4. Cellular concrete structures
5. Long culverts

Three main issues must be addressed when inspecting inside of a confined space.

1. **Lack of oxygen** (human beings require an oxygen content above 19% to remain conscious)
2. **Toxic gasses** (paint fumes, exhaust, pollutants, smoke, carbon monoxide)
3. **Explosive gasses** (natural gas, methane, petroleum fumes)

When a confined space must be entered, the following safety precautions should be heeded:

1. Test the air in the space for oxygen content and toxic gasses before entering. Continue to test the air at fifteen-minute intervals while the space is being occupied.
2. If necessary, properly ventilate the space before and during occupancy
3. Adequate lighting and lifeline equipment should be used.
4. One inspector should remain outside of the space and remain in contact with the inspector inside. The inspector outside the space should never attempt to rescue the inspector inside. The outside attendant should call the fire department or 911 in the case of an emergency.
5. Keep running vehicles and exhaust creating machinery downwind of the space to avoid filling the space with carbon monoxide or other harmful exhaust fumes.

Inspectors should determine whether the structures they need to inspect have confined spaces. If yes, the inspector needs to contact the owner of the structure or space and determine what requirements and policies exist regarding entry of confined spaces. The inspector should also meet with their employer to discuss what requirements and policies the employer has regarding confined spaces. OSHA has strict requirements regarding confined space entry and these requirements are the minimum acceptable standard for confined space entry. The OSHA standard for “Permit-required Confined Spaces” can be found in Chapter 29 of the Code of Federal Regulations, Part 1910.146. It is in the inspector’s best interest to follow all of the pertinent rules and policies regarding entry of confined spaces. These spaces can be deadly if an inspector does not follow the proper procedures.



**Figure 1.4.3.2-2:** A View Inside of a Steel Box Girder.

### 1.4.3.3 Identification of Critical Details

#### **Identification of Fatigue Prone Details**

Fatigue failure of a material is due to the formation and propagation of cracks resulting from the cyclic application of loads. Fatigue cracks initiate from points of stress concentrations in structural members or details. Stress concentrations can result from:

1. Material flaws
2. Type of connection detail
3. Out-of-plane distortions

It is absolutely necessary for inspectors to understand the causes and effects of fatigue and be knowledgeable on all fatigue prone details. If left unchecked, a fatigue crack can propagate to a size where it may trigger a fracture in a structural member.

#### Material Flaws

Metal structures, particularly those that are welded, can contain flaws. Flaws can vary in size from undetectable non-metallic inclusions to large inherent cracks. Material flaws may exist



as external flaws such as pits or internal flaws such as nonmetallic inclusions or lamellar tears.

#### *Fabrication Flaws*

Fabrication flaws can also be introduced. Fabrication flaws can include:

1. Damage at the edges of drilled or punched holes
2. Gouges/notches from flame cutting
3. Gouges/notches from grinding operations
4. Sharp corners at coped or blocked details

Fabrication flaws due to welding are also common and include such phenomenon as:

1. Incomplete fusion
2. Slag inclusions
3. Porosities
4. Blow holes
5. Undercuts
6. Intersecting welds
7. Craters
8. Hot and cold cracks
9. Back-up bars or tack welds left in place
10. Plug welds in misaligned bolt holes
11. Arc strikes

Careless material handling during transportation or erection can create flaws such as:

1. Nicks
2. Notches
3. Indentations
4. Chain marks



### *Service Flaws*

Flaws can be created while a structure is in service, as well. Vehicle impacts to the tension flange of a steel girder can induce tears or grooves into the steel. Corrosion can cause severe pitting.

The structure inspector should be aware of these types of flaws and note the existence of any such flaws found in the field. The inspector should also pay close attention to such flaws in tension zones of members and note any cracks that form at these locations.

### Type of Connection Detail

“Type of detail” refers to the stress condition in a member or connection. Various details have different fatigue strengths associated with them. Typical details have been grouped into a number of categories (A through E’) based on their respective fatigue strengths. See Part 2 Appendix D, Fatigue Prone Details for more detailed information. Members or details should be inspected in order of fatigue susceptibility (*i.e.*, E’ details first and A details last). Type D, E, and E’ details are the most susceptible to fatigue cracks and should be examined carefully. The location and condition of these members and details should be thoroughly documented on the inspection report form. The following are the most common fatigue prone details and should be closely inspected during In-Depth and Fracture Critical Inspections:

- Groove Welds
  1. Older structures with web or flange groove welds made prior to nondestructive evaluation during fabrication.
  2. Longitudinal stiffeners on girder webs.
  3. Groove welds between intersecting longitudinal stiffeners and members.
- Ends of welded cover plates on tension flanges
  1. Cover plates with end welds: Cracking can develop at the toe or throat of the weld and most likely at mid width of the flange
  2. Cover plates without end welds: Cracking can develop at the end of the longitudinal weld and the flange tip.
- Ends of attachment plates welded to girder flanges/webs or truss members
  1. Welded splices or lateral gusset plates (details similar to cover plates)
  2. Perpendicular attachments welded to the member: These are more fatigue resistant than cover plate-like details.
- Diaphragm Connections
  1. Ends of diaphragm connections that are not welded to the flange: Cracking may develop at the cope in the web-to-flange weld or near the top of the connection plate.



2. Ends of riveted angles attached to girder webs: Cracks may develop horizontal in the web near the flanges or vertically in the angle.
- End Connections of Floor Beams
    1. Copes and blocked ends of floor beams: Cracks may occur at the re-entrant angle of the cope or blocked flange, especially when the re-entrant angle is flame cut, with re-entrant notches.
  - Floor Beam Brackets
    1. Bracket connections to girder webs: These have similar details to diaphragm connections
  - Stringer to floor beam connection
    1. Cracking may occur in the coping
    2. Cracking may occur in the connections.
  - Top and Bottom Lateral Bracing Connections
    1. Gusset plates welded to girder web or flange: Cracking may occur in the web gap at the toe of the weld.
    2. Gusset plate to diaphragm connection plate welds: Areas of intersecting welds create high restraint which increases probability of fatigue cracking.
  - Transverse stiffeners
    1. Not diaphragm or floor beam connections. These details are fairly resistant to fatigue. Cracking may occur at ends of cut short stiffeners. Excessive web vibrations may result in cracking. For fitted stiffeners, movement can be depicted from observing the paint film.
  - Truss bridge floor beams
    1. Connections to verticals: Cracks may develop in connection angles or at rivet/bolt heads.
    2. Connection to lateral bracing: Cracks may occur in horizontal gusset plates connecting the laterals to the floor beam flanges, often near the bearings
  - Truss bridge verticals and diagonals
    1. Verticals near bridge ends: Cracking may occur at first vertical member at the top near the gusset plate (typically starting at a rivet hole). Cracks may also occur at the floor beam connection.
    2. Eye-bar members: Cracks may develop at pin holes where a lap forge exists. Cracking may also occur at the shank to head transition.



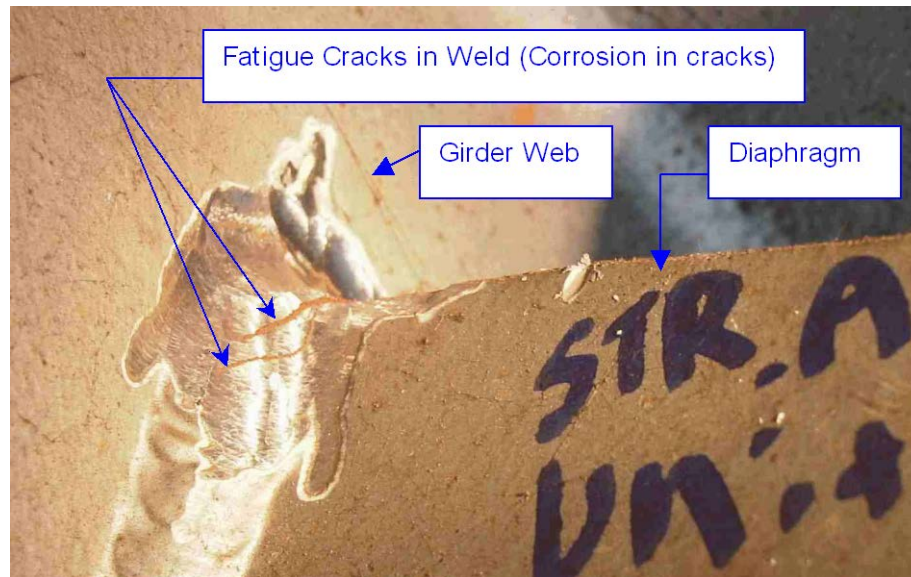


- Pin-connected links or hangers
  1. Eye-bar links: Cracking may occur at the ends of pin holes, at the width transition or the end of the bar.
  2. Hanger plates: Cracking may occur at pin holes or at edge of plate. Special attention is needed when corrosion and fixity are apparent due to in-plane bending
- Tack Welds
  1. Welds between main structural components or gusset plates are common sources of fatigue.
- Plug welds
- Burn Holes
- Attachments (with welded connections)

### Out-of-Plane Distortions

The majority of fatigue cracks result from out-of-plane distortion across a small gap, usually a segment of a girder web. The problem of distortion-induced fatigue cracking has been observed in the following types of bridges:

1. Trusses
2. Suspension bridges (floor system)
3. Two-girder bridges
4. Multi-beam and multi-girder bridges
5. Tied arch bridges
6. Box girder bridges



**Figure 1.4.3.3-1:** Fatigue Cracks in Weld Due to Out-of-Plane Distortion.

### Identification of Failure Prone Members and Details

Certain members are more prone to failure than others are. The following are examples of members that are failure prone or members where failure would lead to accelerated deterioration of the overall structure:

#### Expansion Joints

There are two key failure modes for expansion joints: leaking and seizing. Leaking occurs when joints allow water to pass through the deck and spill onto the superstructure and substructure units. This can result in accelerated deterioration of the superstructure and substructure units near joints. Seizing occurs when joints fill up with non-compressible debris and can no longer facilitate expansion. The debris resists expansion, which results in the development of high stresses in the superstructure and at bearings. The resulting damage may include joints breaking out of back walls or decks, bearing failures or misalignments, or pier or abutment seat cracks.

#### Bearings

Bearing failure can have several consequences. A failed high-rocker bearing can kick out and result in the bridge superstructure dropping several inches. Frozen bearings can result in restricted thermal expansion forces, which are transformed into stresses. These stresses are typically very large and could result in overstress of members and accelerated deterioration of superstructure and substructure elements.



**Figure 1.4.3.3-2:** Failed Bearing at Pier.



**Figure 1.4.3.3-3:** Damage Resulting From Failed Joint.

### **Identification of Fracture Critical Members**

Fracture Critical Members (FCMs) and member components should be identified and shown on the structure plans or a sketch of the structure to be submitted with the Fracture Critical Inspection forms. See Section 2.4.2.4 for a more complete description of Fracture Critical Members.

FCMs have all or part of their cross-sections in tension. Frequently, cracking is a result of fatigue occurring near a weld, a material flaw, and/or changes in member cross-section. See Part 2 Appendix B for a review of typical fatigue prone details.



After the crack occurs, failure of the member could be sudden and lead to collapse of the bridge. For this reason, steel bridges with the following structural characteristics or components should be reviewed for a Fracture Critical Inspection.

1. Overhead two-truss bridges
2. Low two-truss bridges (pony trusses)
3. Deck two-truss bridges
4. Thru-girder bridges
5. Two-girder bridges
6. Tied arch bridges
7. Movable bridges
8. Steel pier caps and cross-girders
9. Pin and hanger system on two-girder systems

See Part 2 Appendix D for examples of fracture critical bridges, components, bending definitions, typical crack locations, and typical pin and hanger parts.

#### 1.4.3.4 Inspection Plan

The inspection plan is the final step in preparation for the field inspection. From the information gathered, a plan needs to be organized for the field inspection. A pre-inspection visit to the site may be required to develop or finalize the inspection plan.

Visual inspection is intended to be the primary examination method. For Fracture Critical, In-Depth, and Damage Inspections, it is required that each critical member or member component needing inspection be inspected hands-on, from a maximum distance of one arm's length for the entire length of the member and/or member component. Non-destructive evaluation techniques should be used to identify internal defects or hard to see external defects in critical members.

An inspection plan may include some or all of the following and should be prepared prior to the field inspection:

1. A brief historical fact statement.
2. Essential plans that would help with field inspection.
3. Identification of fatigue prone, failure prone and/or fracture critical members and/or member components along with tension members on inspection form or attached plan.
4. Access equipment and personnel needed to perform the field inspection.



5. Inspection tools and safety equipment needed to perform the field inspection.
6. Summary of required non-destructive evaluation equipment.
7. Traffic control requirements.
8. Estimate of inspection time.
9. Coordination with and notification of owner and other agencies.

To meet the minimum requirements, all of the required information should be noted in appropriate locations of the applicable bridge inspection report forms. On larger or more complex structures, it may be necessary to create individual sections for each of the required areas of the inspection plan, which can be attached to the bridge inspection report form.

#### 1.4.3.5 Special Considerations

The Inspection Team Leader has many things to consider when planning an inspection. Several key considerations are listed below:

##### **Peak travel times**

In urban areas, an inspection that requires traffic lane closures may be restricted to certain hours of low traffic volume. Some days, such as holiday weekends, may be banned from any traffic restrictions. In either case, it may not be possible to accomplish a forty-hour inspection workweek. The Inspection Team Leader should be aware of this and plan the inspection work accordingly.

##### **Setup time**

Setup time can be significant and needs to be considered when planning an inspection. For example, actions such as rigging can take several days to complete before the inspectors arrive on site. Traffic control setup may take an hour or so each day before inspection work can start. Equipment, such as manlifts or compressors, may need to be setup and torn down or stowed daily. Time should be allotted for these things in the inspection plan.

##### **Access**

Access requirements must be considered when planning an inspection project. If access equipment is needed, the Inspection Team Leader will need to decide which kind of equipment would be most effective and determine whether that equipment is available. The Inspection Team Leader should estimate the number of days or weeks the equipment will be needed. Keep in mind that although structure elements may appear similar, it may require more effort and time to access some versus others. Simple obstacles such as utility lines, fences, adjacent buildings, and cross bracing can make access more difficult.

##### **Overall Condition**

It takes longer to document and inspect an element that is deteriorated. Making the necessary sketches, taking photographs and measurements, etc. is time consuming. The



inspector should use old inspection reports to determine the overall condition of the structure and estimate the time required for inspection and reporting accordingly.

**Weather**

Unexpected weather conditions can adversely affect structure inspection work. Rain and wind can make structures slippery or make manlift operation unsafe. Snow and fog can make traffic restrictions impractical and unsafe. Commonly, structures in low lying, wet areas will have fog cover until mid-morning. Any host of adverse weather conditions can potentially slow or halt a structure inspection. Depending upon the structure location, time of year, and local weather patterns; the inspector should try to anticipate what types of weather could potentially slow inspection work and provide a contingency plan to compensate.

**Permits**

Inspection of structures that pass over or through railroad right-of-way, structures that span navigable waterways, and structures with confined spaces may require permits. The Inspection Team Leader is responsible for determining whether or not a permit is required, obtaining the necessary permits, and following all rules or regulations stipulated by the permitting agency.

**1.4.4 Field Inspection Procedures**

Field inspection procedures are the implementation of the inspection plan and are documented on the inspection report. Good preparation will increase the quality of the field inspection and ensure that all needed tools, safety devices, and operational procedures are available to effectively and efficiently complete the task. It is critical that the Inspection Team Leader (ITL) guide the field inspection process to assure that each inspection is done safely and to the desired level of quality.

A certain degree of uniformity in inspection techniques and recording is required for efficiency and completeness. No element of the structure should be overlooked and the time spent on each element should be in direct proportion to the importance of the element. The inspector should systematically record all observations that may affect the structure “today” or cause concern in the future.

**1.4.4.1 Historical Review**

The construction history, along with any rehabilitation and maintenance history, should be reviewed at the bridge site prior to performing an inspection. This will be helpful in possibly defining deficiencies that may be found during the inspection. It also is advantageous to know the age of possible deficiencies to determine how critical they are when making final recommendations.

**1.4.4.2 Critical Member Plan Review**

The critical members that have been identified on the inspection plan should be reviewed prior to performing the inspection. Critical members are fatigue prone, failure prone or fracture critical members, member components, or details. The inspector should look at the existing bridge member and member connection details to determine whether any of those



details are known to result in specific problems or deterioration. In addition, the inspector should determine if any repairs to or rehabilitation of the structure might have influenced the deterioration of other parts of the structure. Locations where the potential for member cracking exists should be identified and highlighted on the inspection plan.

Bridge orientation should be evaluated to determine the location of critical members. The location of panel points in relation to bridge orientation should be determined.

#### 1.4.4.3 Element Inspection Sequence

It is paramount that an inspector be thorough. When elements go unseen for extended periods, the structure is subject to localized failures. An easy way to ensure that no element is overlooked is to develop an element inspection sequence map. Structure plans are a great place to start. Identify all of the elements on the structure and formulate a logical sequence for inspection. Check members off on the plan as they are inspected.

The cardinal directions are north and east. Abutments and piers should be numbered from lowest to highest going from the south increasing to the north or from the west increasing to the east. Pier columns and longitudinal superstructure elements such as girders or stringers should be numbered from left to right on a bridge cross section when looking north or east.

If the structure elements are already identified and numbered on a set of structure plans, repair plans, or in a previous report, that same identification and numbering system should be used for continuity. The inspector should document an abnormal numbering system.

#### 1.4.4.4 Traffic Control

Traffic control requirements should be reviewed prior to performing an inspection to assure safety of the inspection team and the traveling public (see Section 1.4.7). The Inspection Team should review the traffic control requirements with the people setting up the traffic control, if they are not part of the Inspection Team. The traffic control requirements should be documented on the inspection report form. Any unsafe traffic control conditions should be corrected before performing the inspection.

#### 1.4.4.5 Access Equipment and Procedures

The inspector should anticipate the need for access equipment. For typical Routine Inspections, access equipment may not be required. If access equipment is needed, it needs to be evaluated to determine if it can provide the required visual “hands-on” inspection and non-destructive testing of all critical members and/or components.

Typical methods of access include but are not limited to:

1. Deck-parked, under-bridge inspection vehicles
2. Ground-parked aerial lifts (manlift, etc.)
3. Scaffolding and staging
4. Boats

5. Ladders
6. Climbing



**Figure 1.4.4.5-1: Access Equipment.**

Access equipment, safety features, and procedures need to be evaluated prior to inspection. The safety sheet provided with the equipment, including emergency evacuation procedures, should be reviewed and understood.

The Wisconsin Department of Transportation (WisDOT) owns and operates three under-bridge inspection units. Only trained WisDOT personnel are authorized to operate the units. These units may be used upon mutual agreement between the Region Program Manager (RPM) and the Statewide Program Manager (SPM). See Section 1.4.7 for a more complete description of equipment available from WisDOT.

#### 1.4.4.6 Personal Safety

All personal safety equipment needed for an inspection should be identified and checked for condition. Such equipment may include, but is not limited to, high visibility clothing, body harnesses, hard hats, safety shoes, eye protection, ear protection, respiratory protection, and protection from hazardous paint or other materials.

Safety of the inspector is essential in providing a quality inspection. Providing for all safety requirements is paramount to maintain the confidence of the inspector and to ensure a quality inspection.





**Figure 1.4.4.6-1: Body Harness/Tie-Off.**

#### 1.4.4.7 Inspection Tools

A review of the structure and its condition should be performed to determine what tools may be required to perform a thorough visual, “hands on” inspection and any needed nondestructive evaluation (NDE).

For a more detailed list of typical equipment for all types of inspection, see Section 1.4.5.

#### 1.4.4.8 Field Inspection

For a Routine Inspection, all members can be inspected from the ground or a suitable work platform as long as the inspector has a good enough view to determine with certainty that all structure members are functioning properly. Members should not be cracked or sufficiently deteriorated to adversely affect the serviceability of the structure. For inspections other than Routine Visual, all critical pertinent members and components which require hands-on inspections need to be identified. For In-Depth, Damage, and Interim Inspections, members and components may need to be inspected hands-on. For Fracture Critical Inspections, the inspector shall inspect the critical pertinent members and components hands-on. All members and/or components should be cleaned, as necessary, so that all extraneous material is removed to provide a clear view of the underlying member.

The condition of each member and/or component needs to be determined, including any deficiencies such as section loss, cracks, impact damage, unspecified welds, field welds, tack welds, sharp bends or kinks, and other unspecified damage.



Non-destructive evaluation (NDE) may be required to further analyze defects. An inspector needs to meet the qualifications established in Part 1, Chapter 2 in order to perform an official NDE investigation. The following nondestructive evaluation procedures may be required as directed in Section 1.3.5 and Section 1.3.6:

1. Ultrasound for analysis of pins, welds, and cracks
2. Dye penetrant for surface flaw analysis
3. Magnetic particle for surface flaw analysis
4. Ultrasound thickness gauge for section loss analysis
5. Resistograph for timber elements with internal defects
6. Thermal Imaging Camera for shallow delamination in concrete elements

Deficiencies that require emergency repairs or action should be reported immediately by using the emergency notification procedures provided in Part 1, Chapter 7. If the ITL has doubts about the load-carrying capacity of a bridge when such deficiencies are found, they should take action to close the bridge and use the emergency notification procedures detailed in Part 1, Chapter 7 of this manual. ITLs do have the authority to close a bridge when, in their judgment, it is unsafe for continued usage. Local law enforcement or the State Patrol may be called to assist in bridge closure. The SPM or RPM have the authority to reopen a bridge. All bridge inspection reports should be signed and dated by the ITL.

#### **1.4.5 Photograph Procedure**

Photographs are an extremely useful tool for the inspector. Photographs are foremost a window to view a bridge component or a portion thereof as it was during a previous inspection. This is a powerful comparative tool that can indicate to the inspector whether the deterioration is worsening and requires a more thorough inspection, or little to nothing has changed and the rating of the element can remain as is.

##### 1.4.5.1 Photograph Policy

All bridge files shall have a minimum of two photographs depicting the structure

- Roadway or approach view
- Elevation or side view

The inspector is responsible to ensure these photographs are within the HSI system. The direction the photo is looking is at the inspector's discretion but must be clearly noted in the photo description when uploading to HSI. These two required photos are for comparative purposes. The photos allow the inspector to observe any changes that may have occurred on or around the structure since the previous inspection. Moreover, one of these two photos shall be chosen by the inspector as the cover photo for the inspection report.



The inspector is not required to keep up to date cover photos (roadway or elevation photos) with every inspection, however, it is highly recommended. Photographs are a useful visual tool in allowing the inspector to compare the state of the current structure and its surroundings to the past inspections.

#### 1.4.5.2 Element Level Photograph Policy

Elements with defects in Condition State 3 or 4 shall have an associated photo taken and included within the inspection report. Each defect in Condition State 3 only requires a general photo. Note this is for *each* defect in Condition State 3. All areas exhibiting Condition State 4 defects shall have an associated photo. The photo should be taken as close to the defect as possible. Larger areas exhibiting Condition State 4 defects should be broken up and appropriately labeled for reference.

Photographs of Condition State 3 and 4 defects shall be taken every inspection and uploaded to the HSI system.

#### **1.4.6 Inspection Equipment**

An inspector needs the correct tools to do their job effectively and efficiently. The information provided in this section should help guide inspectors to select the correct equipment for their work in the field. Most of the tools that the inspector will use can be grouped into the following eight basic groups:

1. Personal Safety Gear
2. Cleaning Tools
3. Measuring Tools
4. Visual Aid Tools
5. Inspection Tools
6. Documentation Materials
7. Access Equipment and Methods
8. Specialty Inspection Equipment

##### 1.4.6.1 Personal Safety Gear

1. Hard Hat
2. Steel-toed/steel shank shoes or boots
3. Work gloves
4. Reflective safety vest-Be sure the vest conforms to current OSHA and MUTCD standards.



5. Safety glasses – when working near flying particles (*i.e.*, using a wire brush, grinding).
6. Safety harness and up to two lanyards – when working over water or traffic, or when working at heights over 6 feet, a harness and lanyard should be worn and the lanyard must be tied to a stationary object such as a safety line or a solid structural member.
7. Life jacket – when working near water.
8. Safety boat – when working over water for long periods.
9. Hip boots or waders – when working in relatively shallow, slow moving waterways
10. First aid kit
11. 2-way radio or cell phone – for emergency communication
12. Flashing light / beacon – on the inspection vehicle to warn the public of inspector's presence
13. Dust mask
14. Respirator – when required
15. Sun screen
16. Insect repellent

#### 1.4.6.2 Cleaning Tools

1. Whisk broom
2. Shovel – for removing large amounts of debris
3. 2" Scraper – for removing corrosion or plant/fungus growth
4. Steel wire brush – to remove light corrosion, for use on steel only
5. Brass wire brush – for use on non-steel
6. Spray primer – the inspector should prime steel that he scraped or brushed the paint off of
7. Flathead screwdriver – for scraping or probing

#### 1.4.6.3 Measuring Tools

1. 100-foot tape
2. 6-foot rule
3. 4-foot level – for measuring cross slopes and approach settlement



4. 2-foot level – to check for plumbness
5. Calipers or D-meter
6. Micrometer
7. Feeler gauges
8. Optical crack gauge
9. Plumb bob – use with a rule to measure vertical alignment
10. Telescoping vertical clearance rod or electronic distance measuring device
11. Thermometer

#### 1.4.6.4 Visual Aid Tools

1. Binoculars
2. 5x or 10x magnifying glass
3. Flashlight
4. Telescoping, hinged inspection mirror – to see inside box members or to see around corners

#### 1.4.6.5 Inspection Tools

1. Geologist's hammer
2. Sounding chains – to check a horizontal reinforced concrete surface for delaminations ( or thermal imaging camera)
3. Pocketknife
4. Ice pick – to probe wood for rot
5. Incremental borer – used to take core samples of wood elements
6. Tool belt
7. Probing rod –to check streambed for scour holes
8. Protractor – use with plumb bob to determine tilt angles; use to determine skew angles

#### 1.4.6.6 Documentation Materials

1. Inspection forms



2. Extra paper
3. Clip board
4. Straight edge – to keep notes and drawings neat
5. Laptop computer or Tablet computer– for field data entry or report writing
6. Pencil/pen
7. Permanent marker
8. Paint stick/marker – for marking on the structure
9. Lumber crayon – for marking on the structure
10. Camera (Required with elements/defects in Condition State 3 or worse)

#### 1.4.6.7 Access Equipment and Methods

1. Extension ladder
2. Man lift
3. Bucket truck
4. Truck mounted, moveable, under-bridge work platform
5. Rigging –structure mounted cables and platforms; used where lifts are impractical
6. Scaffolding
7. Boats, rafts or barges
8. Climbers or spiders – mobile inspection platforms that “climb” steel cables; well suited for tall vertical surfaces
9. Boatswain chair – one-man chair suspended by a rope and raised/lowered from above with a block and tackle system
10. Free climbing – some structures can be free-climbed by inspectors who have experience with the appropriate climbing procedures, ropes, and equipment. This method should be used only upon approval of the structure owner.

#### 1.4.6.8 Specialty Inspection Equipment

1. **Non-Destructive Evaluation Equipment:** Refer to Part 5.
2. **Underwater Inspection Equipment:** Refer to Sections 1.3.7 and 1.3.8.
3. **Paint Inspection Equipment**



- a. Cutting tool (for X or cross cuts; e.g., pocketknife)
  - b. Magnetic paint thickness gauge
  - c. Cross cutting template & pressure sensitive tape
  - d. Tooke Gauge
4. **Access or Lift Equipment**
5. **Confined Space Entry Equipment:** Consult Safety Directives and consult Occupational Safety and Health Administration (OSHA) policy.
6. **Fall Protection Equipment:** Consult Safety Directives and consult OSHA policy
7. **Survey Equipment:** Survey equipment may be required in special cases when movement in a structure needs to be measured in relation to a reference point. Use of transits, levels, etc. may be required.
8. **Mechanical/Electrical Inspection Equipment:** Refer to Part 3.

#### 1.4.7 Methods of Access

Gaining access to structures can be challenging. The proximity of a structure to live traffic, a navigable waterway, an active rail line, overhead utilities, etc. can make inspection access difficult. The inspector should always use good judgment and be safe. All non-participating inspection vehicles and equipment should be parked off the roadway. Ideally, a driveway, parking lot or even a large gore area can be safer than parking along the roadway. If no such suitable area exists near the structure, then park on a nearby roadway with the least traffic or the widest shoulders. Be certain not to park in front of any signage that may reduce or block visibility for the travelling public. If other means are impractical and appropriate traffic control exists, inspection vehicles or equipment can be parked inside the safe work zone.

Access fence along freeways may be gated somewhere near a bridge. Most access gates are locked with Wisconsin Department of Transportation (WisDOT) locks. Inspectors may get keys to these locks upon request from the Region Structure Maintenance Engineer.

Crossing a live roadway is dangerous, especially on well-traveled roads. Exercise common sense and be safe. When working in or around active railroad corridors or navigable waterways, make sure to contact the railroad company or coast guard and follow all required safety and access requirements. This may include obtaining special permits. Information that should be documented in the structure inspection procedures.

The WisDOT currently has three under-bridge access vehicles available for use out of the Bureau of Structures (BOS) Maintenance Section. This equipment is scheduled for use by regional offices, counties, and locals for use in structure inspection work. Typically, counties and local government units will make scheduling requests to their regional office. The region will compile all of the requests and forward them to the WisDOT BOS Maintenance Section. The objective of the WisDOT BOS is to keep this equipment scheduled and utilized for as much of each calendar year as possible, depending on the weather. The annual operations schedule are developed by the WisDOT BOS Maintenance Section personnel from requests



received by February 1 of that year. The final equipment schedule is posted on the DOTNET. Changes to the schedule can be and are made as needed throughout the year. Each inspection vehicle needs to be properly staffed with an experienced crew.

Each WisDOT under-bridge access unit shall be operated by a minimum of two trained people. For safety reasons, one person should be in the under-bridge basket and one person should be on the bridge deck or in the cab of the truck at all times. The person on the bridge or in the truck cab and the person in the bucket shall be trained to operate the vehicle. The WisDOT BOS Maintenance Section has staff trained to operate these vehicles. Regions and local government units should arrange to have their own inspector on the vehicle crew to work as a Team Member/Leader with WisDOT BOS Maintenance Section personnel. The region will arrange through the county or others to provide personnel, proper lane closure, traffic control equipment, a blocking truck, and communication for bridge vehicle operations. The region will also arrange press releases when appropriate, to alert local motorists to the presence of on-going bridge inspection work that may impede traffic.

WisDOT region offices may also schedule and provide traffic control through the counties for consultant structure inspectors.

#### **1.4.8 Safety Practices**

The safety of the public and of structure inspection personnel is paramount. Accidents can cause injury, suffering, family hardship, and even death. Accidents also cost money in terms of lost equipment, lost production, medical expenses, and possible litigation costs. Therefore, inspectors should always strive to create and maintain a safe working environment.

##### **1.4.8.1 Inspection Team Safety**

In order to minimize the chance of an inspector becoming injured, all inspectors in the field should adopt the following work habits:

1. Never work alone, when possible.
2. Be well-rested and alert.
3. Stay in good health and maintain a level of good physical conditioning.
4. Be familiar with and use the proper tools.
5. Keep work areas neat and uncluttered.

Inspectors ideally should operate in groups of two or more when performing any inspection fieldwork. It is good practice for inspectors to carry a mobile phone or a radio for use in case of an emergency. Inspection personnel should also have basic first aid training. It is recommended inspectors be familiar with cardiopulmonary resuscitation (CPR). The American Red Cross and American Heart Association (AHA) offer training for CPR. To minimize the risk of a traffic accident, proper procedures for traffic control should be followed at all times. See Section 1.4.8.





Inspectors should be familiar with federal (Occupational Safety and Health Administration (OSHA)) and local safety standards and requirements. OSHA requirements are minimum standards and should be followed. Requirements that are more stringent may exist, depending on the activity, structure owner, etc. The inspector is responsible for knowing this information and adhering to the applicable requirements and standards. OSHA requirements and standards can be found at:

<https://www.osha.gov/>

Appropriate personal protective clothing should be worn at all times including vests, safety glasses, hardhats (where needed), and appropriate footwear. Proper hand, hearing, sight, breathing, and face protection should be used whenever appropriate. For instance, many of these protection devices are needed when scraping paint and corrosion and brushing bird droppings from any inspection area or during the use of any manual or power tools. All equipment, safety devices, and machinery should be kept in good operating condition.

Inspection vehicles, under-bridge access equipment, trucks, and vans should be operated in accordance with the operating manuals provided by the manufacturer. Personnel should be trained in the safe use of the vehicles and emergency procedures in the event of an equipment failure. These inspection vehicles need to be inspected and maintained in accordance with the manufacturer's recommendations.

Lanyards, safety harnesses, life jackets, and other personal safety equipment should be used in accordance with applicable standards. All safety equipment should be inspected regularly and in good working order. Worn or damaged equipment should be discarded. In addition, inspection personnel should be cautioned to keep safety equipment clean and away from potentially harmful chemicals such as gasoline, dye penetrant, and/or oil.

Proper safety precautions and confined space entry procedures should be employed when entering the interior of a box girder, vaulted abutment, long culvert, etc. Air quality monitoring, air exchanges, and/or the use of portable air packs may be required. The OSHA standard for "Permit-required Confined Spaces" can be found in Chapter 29 of the Code of Federal Regulations, Part 1910.146. It is in the inspector's best interest to follow all of the pertinent rules and policies regarding entry of confined spaces. These spaces can be deadly if an inspector doesn't follow the proper procedures.

There is no safety guideline that can replace common sense and good judgment. Each structure site is unique. If unusual working conditions exist, specialized safety precautions may be required and shall be documented in the structure inspection procedures.

#### 1.4.8.2 Public Safety During an Inspection

To minimize the chance of the public becoming injured, all inspectors in the field should do the following:

1. Use appropriate traffic control for vehicles and pedestrians when required.
2. Maintain the traffic control (watch for tipped or moved cones, signs, etc. and replace/realign them as needed).



3. When working at heights, make sure all tools and equipment are secure and cannot fall onto people or traffic below. A tool pouch, belt, or bucket is a good way to secure tools and items. Hardhat chinstraps are also recommended to prevent hardhats from falling.
4. When inspecting members, make certain not to push or drop debris (loose concrete, paint chips, pack rust, etc.) onto people or traffic below.

Inspectors should be aware of the traffic and pedestrian traveled ways when performing any inspection fieldwork. If one inspector is performing aerial work (in a manlift, free climbing, etc.), it is good practice to have another inspector on the ground. The ground inspector should observe vehicle and pedestrian traffic and relay pertinent information, such as stray vehicles or pedestrians in the work zone, to the aerial inspector. The ground inspector can also take notes for the aerial inspector and guide him around the structure. By following this procedure, the aerial inspector can concentrate on inspecting, and the ground inspector can protect the public near the work zone. The aerial and ground inspectors should have radios in order to communicate. It is a good practice for at least one of the crewmembers to carry a mobile phone or a radio for use in case of an emergency.

Inspection vehicles such as under-bridge access units, trucks, and vans should be kept away from live traffic. Manlifts, etc. should not be extended over live lanes of traffic. Manlifts should not be operated directly adjacent to live traffic (*i.e.*, on a narrow shoulder) without providing appropriate traffic control. Lanes should be closed if access to structure members over live traffic lanes is necessary. Trucks and vans should be parked away from live traffic. Good places to park include on the edge of or off the shoulder, in the wide part of a large gore area on an adjacent low volume roadway.

Most importantly, should an inspector discover any defect in a structure that would make imminent failure of the structure likely or pose a danger to the public, the inspector has the authority to close the structure. Closing a structure would apply to structures like bridges and culverts that are integral to traveled roadways. When light poles, sound walls, retaining walls, or highway sign bridges are found to be in dangerous conditions, the inspector should assess the danger level and respond appropriately to prevent any injury or property damage. The state police or local sheriff's department can provide assistance in road closures or cordoning off dangerous areas. If any structure is closed, the Inspection Program Manager needs to be contacted immediately after securing the area.

#### **1.4.9 Traffic Control**

##### **1.4.9.1 Introduction**

Inspection operations that obstruct traveled ways can create unexpected and unusual situations for motorists. Effective traffic control eliminates surprises and routes traffic safely around any hazards, inspection personnel, or equipment. Wisconsin has amended the federal *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) in the Wisconsin Department of Transportation (WisDOT) Facilities Development Manual (FDM). The FDM contains the standards for traffic control procedures and equipment in Wisconsin. The FDM is available from the WisDOT Bureau of Highway Operations and the federal MUTCD is available on the Internet at <http://mutcd.fhwa.dot.gov/>. The FDM dictates the minimum traffic control requirements and the proper use of standard traffic control devices

for various applications. The FDM also contains plan sheets with plan views of traffic control layouts for typical applications. These plan views detail the types of signs or message boards to use, the geometry of channelization devices, flagger requirements, etc.



**Figure 1.4.8.1-1:** Barrels Channel Traffic Away From Work Zone.

#### 1.4.9.2 Traffic Control Plan

Traffic control plans are required for any inspection work that will adversely affect the smooth flow of traffic through the work zone. A traffic control plan should be designed by the Inspection Team Leader (ITL), Inspection Program Manager (IPM), or a qualified employee of a traffic control subcontractor. A traffic control plan is a plan view drawing of the proposed work zone that shows where traffic control devices will be placed, what devices will be used, and how they will be oriented. All parties that will be operating in the work zone should review and be familiar with the traffic control plan. If the traffic control plan changes, the changes need to be approved by the ITL or IPM and all affected parties should become familiar with the changes prior to working in the field.

#### 1.4.9.3 Fundamentals of Traffic Control

Traffic control should be designed and implemented to accomplish the four following goals:

1. **Inform the motorist** of changing conditions or hazards ahead.
2. **Control the motorist** and reduce traffic speed in the work zone.
3. **Provide a clearly marked path** to create a smooth traffic flow through the work zone.
4. **Use positive protection** such as crash trucks and attenuators to protect the work zone.



**Figure 1.4.8.3-1:** Truck Mounted Crash Attenuator.

### **Inform the Motorist**

There should not be any surprises. Proper use of signs can keep the motorist informed of unexpected conditions. Several types of signs are used. They are as follows:

1. **Regulatory Signs:** speed limit, do not pass, etc.
2. **Warning Signs:** this lane ends, work zone ahead, etc.
3. **Guide Signs:** these show motorists the direction they are supposed to travel and tell them how to reach their destination. These signs are only used when a detour is involved.

### **Control the Motorist**

The same safety principles used to design roadways should be applied in the design of traffic control. The geometry, signs, and lights used for traffic control should resemble the unobstructed roadway conditions as closely as possible. This minimizes the confusion for the driver. Channelizing devices are used to guide drivers safely through a work zone. They also warn drivers of hazards ahead in the roadway or just off the roadway. Channelizing devices include but are not limited to traffic cones, barrels, barricades, and wands. Wind and traffic can misalign or knock over channelization devices. Therefore, channelization devices need to be monitored to ensure that they are in place, according to plan, and functional. Speed limit signs can be used to slow traffic in the work zone and increase work zone safety.



**Figure 1.4.8.3-2:** Directional Arrow Board and Channelizing Barrels.

### **Provide a Clearly Marked Path**

Channelization devices should be used properly to define a clear definite path for drivers to follow. It should be obvious to the driver where he is supposed to go. There should be no confusion. Channelization devices should also provide drivers with a smooth, gradual transition from one lane to another, onto a bypass or a detour or through the narrowing of a traveled lane or shoulder. Abrupt changes in traffic direction and abrupt constriction of the traveled way should be avoided. Warning signs are also used to inform the motorist of unusual or changing conditions. All traffic control devices should be promptly removed once they are no longer needed.

#### 1.4.9.4 Typical Traffic Control Plans

See the WisDOT FDM for typical traffic control plans and traffic control requirements.

### **1.4.10 Lane Closure System (LCS)**

To aid in traffic control on the Wisconsin Highway System, the WisDOT's Statewide Traffic Operations Center (STOC) implemented the Lane Closure System in April 2008. The STOC's mission is to manage congestion and improve transportation safety, mobility, and efficiency on state highways. The LCS is an important and required tool for agencies and engineers requiring access to highly trafficked bridges on the highway system.

The LCS is a web-based system used to track closures and restrictions on Wisconsin state highways. The data accumulated through the LCS is used for traffic analysis and patterning. The LCS data is incorporated into 511 Traveler Information, Inconvenience Maps for public use, and Oversize/Overweight (OSOW) permitting. Finally, the LCS fully integrates historical traffic flow and capacity information which is used to determine available lane closures and the appropriate time at which they can occur to create as little impact on the travelling public as possible.



The LCS coordinates activities throughout the state to prevent back-ups and potential conflicts such as lane closures during special events or conflicting lane closures on the same highway.

As an inspector, lane closures for inspections are common place. However these closures must be accurate and approved with enough time to notify the traveling public. Lane closures involving any planned maintenance on Interstate, state or major state highways, or an emergency closure are required to be entered into the LCS.

Notification requirements to the LCS depend on the roadway system type. The following list indicates when the LCS should be notified for each type:

- 7 days      Project start, full roadway closure, or restriction of width, height or weight
- 7 days      System ramp closure
- 3 days      Lane and service ramp closure

Acceptance of a requested closure depends on the roadway system the closure is on. All freeway and expressway closures are required to be accepted by a WisDOT Regional Traffic Supervisor (RTS).

The LCS is accessed via the internet. Therefore users outside of the WisDOT can log on with a username and password. For more information on and access to the LCS refer to the following URL:

<http://transportal.cee.wisc.edu/closures/>

The Traffic Operations and Safety Laboratory also provides LCS training. Refer to the following URL to request user privileges and access the training.

<https://transportal.cee.wisc.edu/training/applications/WisLCS/>