# Chapter 4: Inspection Types

The scope, intensity, and frequency of bridge safety inspections are discussed here to provide a better understanding of the purpose and use of each inspection type and to assist in the development of scope of inspection work for individual inspections. An inspection event, particularly for large, complex, or deficient structures, often requires that a variety of inspection types be performed, using a variety of methodologies. For example, a fracture critical bridge may also require an underwater inspection and a routine inspection.

### *Frequency*

All bridges greater than or equal to 10-feet clear span shall receive an <u>annual</u> inspection with no inspection outside of 18-months. Structures that are Fracture Critical shall receive a hands-on arms-length inspection of the Fracture Critical Members not to exceed (NTE) 24 months. Structures with substructure units in water unfit for regular probing or visual inspection (often deeper than 5-feet at the substructure unit) shall receive Underwater Inspections not to exceed 60-months. In-Depth inspections are typically scheduled for Major Bridges and Complex Bridges on a five year cycle. Damage Inspections are unscheduled inspections to assess structural damage resulting from environmental factors or human actions (i.e. barge-clip, overheight hit, earthquake).

Criteria for increasing the frequency or level of inspection beyond the minimum statutory or policy requirements shall be at the discretion of the Control Authority or Program Manager. Often the discretion is based on a rapid or unforeseen change from the results of a previous inspection. Rationale for scheduling increased frequencies for an In-Depth, Special or increased frequency Routine, Fracture Critical or Underwater Inspection should consider: age, traffic volume, size, susceptibility to collision, extent of deterioration, performance history of the bridge type, load rating, location, recent failures of similar structure or material type, structural damage, scour and erosion, drift, streambed movement, ice loading or navigation traffic collision national defense designation, detour length and social and economic impacts due to the bridge being out of service.

| Inspection Type | Frequency |
|---|---|
| Initial | Infrequent, performed and inventoried before the bridge is first opened to traffic or there is a change or update in inspection responsibility. |
| Routine | Annual, performed at least once each calendar year per ORC Not To Exceed (NTE) 18-months. |
| In-Depth | As-needed, generally performed for Major or Complex bridges often on a 60-month cycle or less per Control Authority or inspection and maintenance procedure. Additionally this inspection type is recommended when the routine inspection does not provide a condition evaluation to ascertain the safe live load capacity at the discretion of the Team Leader or Program Manager. |
| Damage | As-needed, performed in-frequently and not part of a normally scheduled inspection, i.e. someone else notifies inspectors of the damage. |
| *Flood* | As-needed, performed in-frequently and not part of a normally scheduled inspection. |
| Fracture Critical | Not to exceed 24-months for structures that fit the rigid definition. Fracture Critical Inspections require an inspection procedure. |
| Underwater | Not to exceed 60-months. For structures that cannot be probed or inspected due to the water depth, turbidity or unsafe conditions during routine inspections shall receive an Underwater Dive Inspection. Dive Inspections require an inspection procedure. |
| *Cross Channel Profile* | As-needed, performed on structures over waterways at the discretion of the Control Authority. Usually performed on bridges over waterways that exhibit aggressive stream migration, sloughing or undercutting. |
| *Scour Susceptibility Inspection & Eval* | As-needed, performed on structures in order to evaluate risk from scour and scour potential |
| Special/Interim | As-needed, performed at an interval more frequently than the routine inspection in order to check on one area or one location. The localized inspection may only focus on and update one or a small number of inspection or inventory data. |
| Safety (Cursory) | Annual, at least once each calendar year not to exceed 18-months, on structures or portions of structures that are primarily inspected by another entity. |
| Quality Assurance | A rolling sample set of field and office visits performed regularly by FHWA, ODOT Central Office, CEAO or initiated by any Control Authority or NBIS Program Manager to verify quality inspections. |
| Complex | Annual routine, with often a 60-month in-depth inspection cycle. These structures require an inspection procedure. |

Table 31 - Inspection Type and Frequency

### *Initial Inspections*

An Initial Inspection is the first inspection of a new structure, a structure that has changed ownership or a reconstructed structure. It is a close-up hands on inspection of the structure to document its baseline condition.

*Purpose of Initial Inspections*

The purpose of the Initial Inspection is to verify the safety of the bridge, in accordance with the NBIS and Department standards, before it is put into service. It also serves to provide required inventory information of the as-built structure type, size, and to document its structural and functional conditions by:

- Providing all Structure Inventory & Appraisal (SI&A) data required by Federal regulations along with all other data required by Department standards.
- Determining baseline structural conditions and eliminate deficiencies recorded under previous structural assessments.
- Clearance envelopes (for features carried and those intersected) and bridge waterway openings are to be documented at this time.
- Identifying maintenance needs, including preventative maintenance activities.
- Noting the existence of elements or members requiring special attention, such as fracture critical members, fatigue-prone details, and underwater members.
- Verify construction/rehabilitation contracts.
- Documents, including but not limited to, photographs, drawings (design, as-built and shop drawings), scour analysis, foundation information, hydrologic and hydraulic data are to be inserted into the bridge file. Selected construction records (e.g. pile driving records, field changes, etc.) may also be of great use in the future and should be included.
- Unexpected problems with a small number of newly constructed bridges have demonstrated that safety inspections may be needed even for new bridges to ascertain their initial and long-term safety.
- Uncompleted non-bridge maintenance items (e.g. roadway drainage, channel debris, etc.) have caused significant bridge damage in several incidences. The inspection cycle is needed for effective planning and programming of bridge maintenance activities, especially on-demand repairs and preventative maintenance items. In addition, new asset management analysis tools

for bridges and other assets require high quality bridge condition and needs data collected at regular intervals to provide good decision-making tools for bridge owners.

In the event that responsibility of a bridge changes, a letter notifying the Central Office, Office of Structural Engineering, shall be written by the Control Authority retiring the structure. The letter shall inform all parties of their inspection and maintenance responsibilities. The SFN will remain the same however the program responsibilities will change.

*Scope and Frequency of Initial Inspections*

The level of effort required to perform an Initial Inspection will vary according to the structure's type, size, design complexity, and location. An Initial Inspection is to be a close-up, hands-on inspection of all members of the structure to document the baseline conditions. Traffic control and special access equipment may be required.

Initial Inspections are performed for each structure after construction is essentially complete and before the bridge is put into service (or returned to service for bridges that have had a major reconstruction). Bridges open to traffic during construction operations are required to be inspected. Anytime ownership changes, a bridge is newly constructed or receiving a major rehab, the bridge shall receive an initial inspection.

### *Routine Inspections*

Routine Inspections provide documentation of the existing physical and functional conditions of the structure. All changes to the inventory that have occurred since the previous inspection are also to be documented and updated. The written report will include appropriate photographs and recommendations for major improvements, maintenance needs (preservation, preventative maintenance or on-demand repairs), and follow-up inspections. Load capacity analyses are re-evaluated only if changes in structural conditions or pertinent site conditions have occurred since the previous analyses.

*Purpose of Routine Inspections*

A Routine Inspection shall satisfy the requirements of the NBIS and Department standards. Routine Inspections serve to document sufficient field observations/measurements and load ratings needed to:

- Determine the physical and functional condition of the structure.

- Determine the need for establishing or revising a weight restriction on the bridge.
- Determine improvement and maintenance needs.
- Ensure that the structure continues to satisfy present service and safety requirements.
- Identifying and listing concerns of future conditions.
- Identify any inventory changes from the previous inspection.

*Scope and Frequency of Routine Inspections*

Routine Inspections are regularly scheduled inspections performed **once each calendar year**. No routine inspection shall occur outside of an 18 month interval since the previous inspection. The interval for Routine Inspections should be reduced from the maximum calendar year inspection when the engineer determines that the bridge conditions have deteriorated to the point where additional scrutiny is warranted to ensure public safety. This reduced frequency inspection would be called a special interim inspection.

The level of scrutiny and effort required to perform a Routine Inspection will vary according to the structure's type, size, design complexity, existing conditions, and location. Generally, every element in a bridge does not require a hands-on inspection during each Routine Inspection to provide an acceptable level of assurance of the bridge's ongoing safety. The difficulty is that the areas not needing close-up scrutiny cannot always be determined until after the entire bridge has been inspected and non-critical areas identified. To provide a reasonable level of confidence in the safety of the bridge, knowledge of the structure and good engineering judgment are necessary when considering those portions that will not receive the close-up scrutiny with each inspection. **Areas that may be more difficult to access but warrant a hands-on inspection in each Routine (or Special) Inspection, include, but are not limited to:**

- Those areas explicitly determined by previous inspections
- Load carrying members in Poor condition, critical sections of controlling members on posted bridges
- Scour critical substructure units
- Areas determined by the Program Manager, for example:
    - End regions of steel girders or beams under deck joints
    - Cantilever portions of concrete piers or bents
    - Ends of Prestressed concrete beams at continuity diaphragms
    - Pin and Hanger / Hinge assemblies
    - Redundancy retrofit systems

- Vertical Clearance restrictions on state routes
- New product testing for maintenance application
- Reoccurring maintenance needs that pose structural or safety concerns

During Routine Inspections, particular attention should be given to scour, erosion, (new rock fields, debris) and overall stability of the substructure.

Routine Inspections are generally conducted from the deck, ground and/or water levels, ladders and from permanent work platforms or walkways, if present. Inspection of underwater members of the substructure is generally limited to observations during periods of low flow and/or probing/sounding for evidence of local scour.

The application of these inspection guidelines do not relieve the Control Authority or Program Manager in charge of the inspection from the responsibility to perform other In-Depth Inspection tasks and/or tests needed to ascertain the condition of the bridge and assure the safety of the traveling public. **Increased intervals or level of inspection are at the discretion of the Control Authority or Program Manager.**

### *In-Depth Inspections*

An In-Depth Inspection is a close-up, hands-on inspection of one or more members and a close visual of all members above or below the water level to identify any deficiency not readily detectable using Routine Inspection procedures. An In-Depth Inspection may be limited to certain elements, span group(s), or structural units of a structure, and need not involve the entire structure. Conversely, In-Depth Inspections may include all elements of a structure. In-Depth Inspections can be conducted by itself or as part of a Routine or other type of inspection.

*Purpose of In-Depth Inspections*

In-Depth Inspections serve to collect and document data to a sufficient detail needed to quantify the physical condition of a bridge. This data is more detailed than data collected during a Routine Inspection.

In-Depth Inspections should be routinely scheduled for selected bridges based on their size, complexity and/or condition. Major or complex bridges represent large capital investments and warrant closer scrutiny to ensure that maintenance work is identified and completed in a timely manner. These bridges tend to be more critical to local and area transportation because of the usual lack of suitable detours. It may be more difficult to provide a complete snapshot of the bridge conditions when access difficulties limit the scope of Routine Inspections.

*Scope and Frequency of In-Depth Inspections*

The level of effort required to perform an In-Depth Inspection will vary according to the structure's type, size, design complexity, existing conditions, and location. Traffic control and special equipment, such as

**Figure 32 - In-depth Inspection of Suspension Cable**

under-bridge cranes, rigging, or staging may be needed for In-Depth Inspections. Personnel with special skills such as divers and riggers may be required. Non-destructive field tests and/or material tests may be performed to fully ascertain the existence of or the extent of any deficiency. On small bridges, the In-Depth Inspection, if warranted, should include all critical elements of the structure.

For large or complex structures, these inspections may be data driven or scheduled separately for defined segments of the bridge or for designated groups of elements, connections or details that can be efficiently addressed by the same or similar inspection techniques. If the latter option is chosen, each defined bridge segment and/or each designated group of elements, connections or details should be clearly identified as a matter of record and should be assigned a frequency for re-inspection. The activities, procedures, and findings of In-Depth Inspections shall be completely and carefully documented more than those of Routine Inspections. Stated differently, In-Depth Inspection reports will generally be detailed documents unique to each structure that exceed the documentation of routine inspection forms.

A structural analysis for load carrying capacity may be required with an In-Depth inspection to fully evaluate the effect of the more detailed scrutiny of the structure condition.

An In-Depth Inspection can be scheduled in addition to a Routine Inspection, though generally at a longer interval, or it may be a follow-up to a previous inspection. An In-Depth Inspection that includes all elements of the structure will satisfy the requirements of the NBIS and take the place of the Routine Inspection for that cycle.

In-Depth Inspections do not reduce the level of scrutiny for Routine Inspections. Program Managers shall schedule In-Depth Inspection based upon condition and importance. **Increased intervals are up to the discretion of the Control Authority or Program Manager.**

### *Damage Inspections*

Damage Inspections are performed following extreme weather-related events, earthquakes vandalism and vehicular/marine traffic crashes. When major damage has occurred, the Inspectors will need to evaluate fractured or failed members, determine the amount of section loss, take detailed measurements for misalignment of members, check for any loss of foundation support, etc.


**Figure 33 - Damage inspection**

*Purpose of Damage Inspections*

Damage Inspections serve to determine the nature, severity, and extent of structural damage following extreme weather-related events and vehicular and marine traffic collisions/accidents for use in designing needed repairs. Damage Inspection findings shall be used to determine the immediate need to place an emergency restriction on a bridge (e.g. weight restriction or closure) for vehicular traffic. If a bridge is closed to vehicular traffic, the need to close it to pedestrian traffic shall also be determined.

The findings of a Damage Inspection may be used to re-coup the costs of inspection and needed repairs or reconstruction from involved parties or other governmental agencies. Accordingly, documentation of the inspection may be critical in these efforts. For Department bridges, the extent of damage and estimated costs of repair should be reported to the District damage coordinator. Photographs, videos and sketches can be extremely helpful. See Appendix. Over-Height Steel Beam Bridge Strike Form for additional information regarding reporting ODOT District bridge emergencies in accordance with SAC4SR7 emergency funds.

*Scope and Frequency of Damage Inspections*

A Damage Inspection is an unscheduled inspection to assess the structural damage resulting from environmental factors or human actions. Damage Inspections are performed on an as-needed basis.

The amount of effort expended on this type of inspection will vary significantly depending upon the extent of the damage, the volume of traffic encountered, the location of the damage on the structure, and documentation needs. The scope of a Damage Inspection must be sufficient to determine the need for emergency load restrictions or closure of the bridge to traffic, and to estimate the level of effort necessary to accomplish repairs. The capability to make an on-site determination of the need to establish emergency load restrictions may be necessary.

*Flood Inspections*

To combat the loss of structures from the transportation system and protect our valued infrastructure, Program Managers should assess and prioritize bridge‘s vulnerability to scour so that critical bridges can be identified for closer monitoring and possible implementation of scour countermeasures.

See Appendi. Scour Critical Plan of Action (POA) and Appendix. Scour Critical Assessment Checklist for support to help determine the Scour Susceptibility.

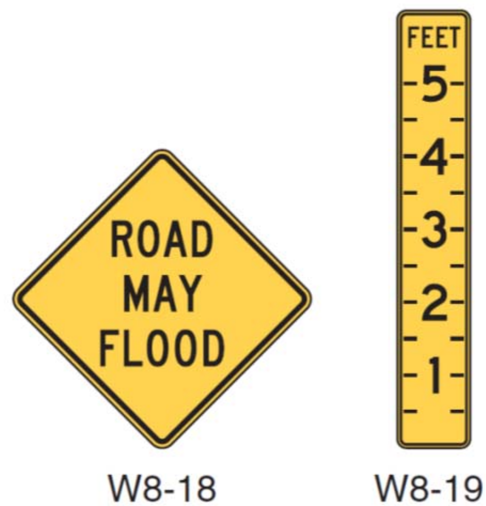



Figure 34 - Flood Inspection Signage

The Program Manager is to establish an internal procedure to monitor bridges that are vulnerable to scour during or immediately after periods of high water. The following elements are recommended for consideration as part of the procedures:

- A list and map of bridges that are to be monitored during periods of high water. Bridges vulnerable to scour include scour critical bridges, those that may have scoured previously or that may have a history or be susceptible to degradation and aggradation.
- Because high stream flows can be localized and information about its severity and extent may not be immediately available, a method of reporting the occurrence and extent of high water is

needed. Many times the first responders are maintenance forces; they can be trained to report high water events to the program manager. This method is useful for prioritizing structures to be checked by bridge Inspectors.

- Local benchmarks established at bridges can enable non-bridge Inspectors to record and report the height of water. The list of bridges should also indicate the location of the benchmarks and the water heights at which scour inspections are warranted. In addition, the benchmarks enable Inspectors to quickly gauge the progress of scour at a substructure.

## Fracture Critical Inspections

### *Description of Fracture Critical Inspections*

Fracture critical bridges must carry public vehicular traffic and have at least one Fracture Critical Member (FCM) in order to be considered a Fracture Critical bridge. A FC Member must meet all of the following:

- Must be steel
- Must be in partial (ex. Bottom flange of a flexure member) or total tension (ex. Axial)
- The loss of the FCM would result in a partial or total loss of the structure. In other words, the bridge is unable to safely carry some level of traffic (Live Load) in its damaged condition. Conservatively in Ohio that is less than four (4) load paths i.e. three (3)or less. In addition to **Load Path Redundancy** there are sub-categories of redundancy that are helpful in categorizing and refining FC bridges:
  - **Structural Redundancy** – The internal spans on continuous bridges are structurally redundant.
  - **Internal Redundancy** – Mechanically fastened connections or more than 3 internal load paths per member.
  - **System Redundancy** –Experimental and analytical research has shown that members once deemed FC based on conservative consideration alone actually may provide redundancy by 3-dimensional system behavior and lateral load redistribution.

### *Scope and Frequency of Fracture Critical Inspections*

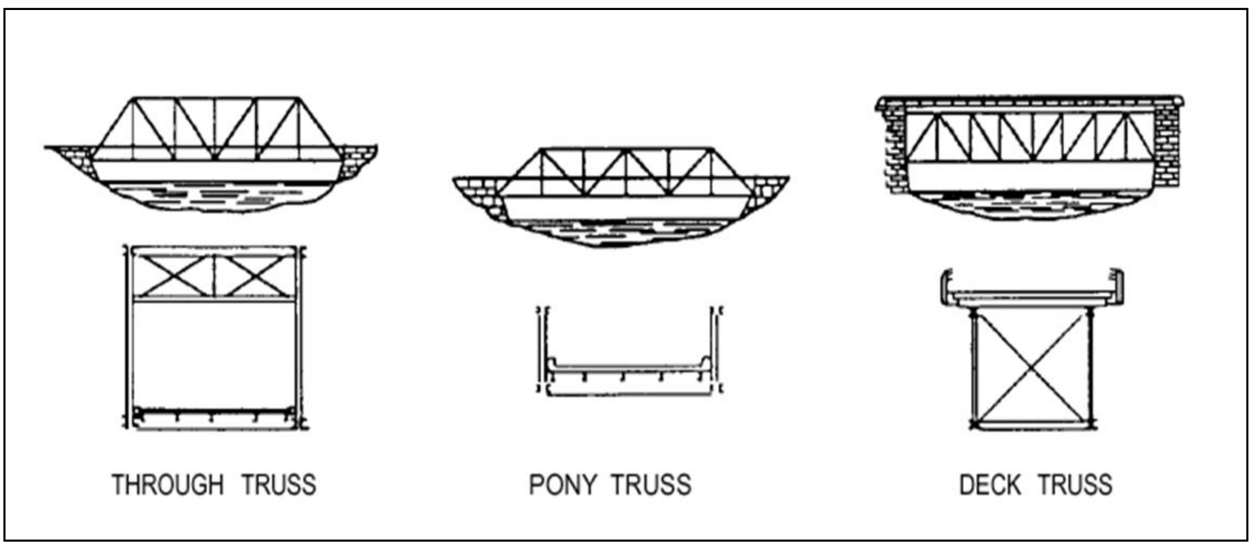
Fracture Critical Members must be inspected within a 24 month frequency at an arm's-length distance, 18"-35", so inspectors are able to find initiated small cracks in the steel faces in the tension zone(s).

Structures that do not carry highway traffic do not necessitate a FCM inspection. **It is desirable for inspectors performing FCM inspection to have successfully passed the 3-day NHI Fracture Critical Inspection Techniques for Steel Bridges (FHWA 130078).**

*Common Fracture Critical Bridge and Member Types*

Examples of structure types with FCM's include the following.

Figure 35 - Deck Truss with Fracture Critical Members




The following bridge types **always** have Fracture Critical members:

1. *Steel Truss* -The primary members are made of steel that carry axial tension and they often have two primary load paths (two truss-lines).
2. *Steel through Girder* - The primary members are made of steel, have non-redundant (two load paths) primary load carrying members with tension zones and are therefore fracture critical.

The following bridge types **usually** have Fracture Critical members:

1. *Steel Beam or Steel Girder* – when non-redundant load paths exist
2. *Steel Box Girders* – when conditions are met

The following bridge members are Fracture Critical when any one of the following **criteria** are met:

1. *Steel Floorbeams are FCM when any one of the four criteria are met:*
    a. Hinged connection (including the hinge, i.e. U-bolt) to the support girders or
    b. Spacing (from floorbeam to floorbeam) greater than 14’-0” or
    c. Floorbeams without stringers or
    d. Stringers are configured as simple beams

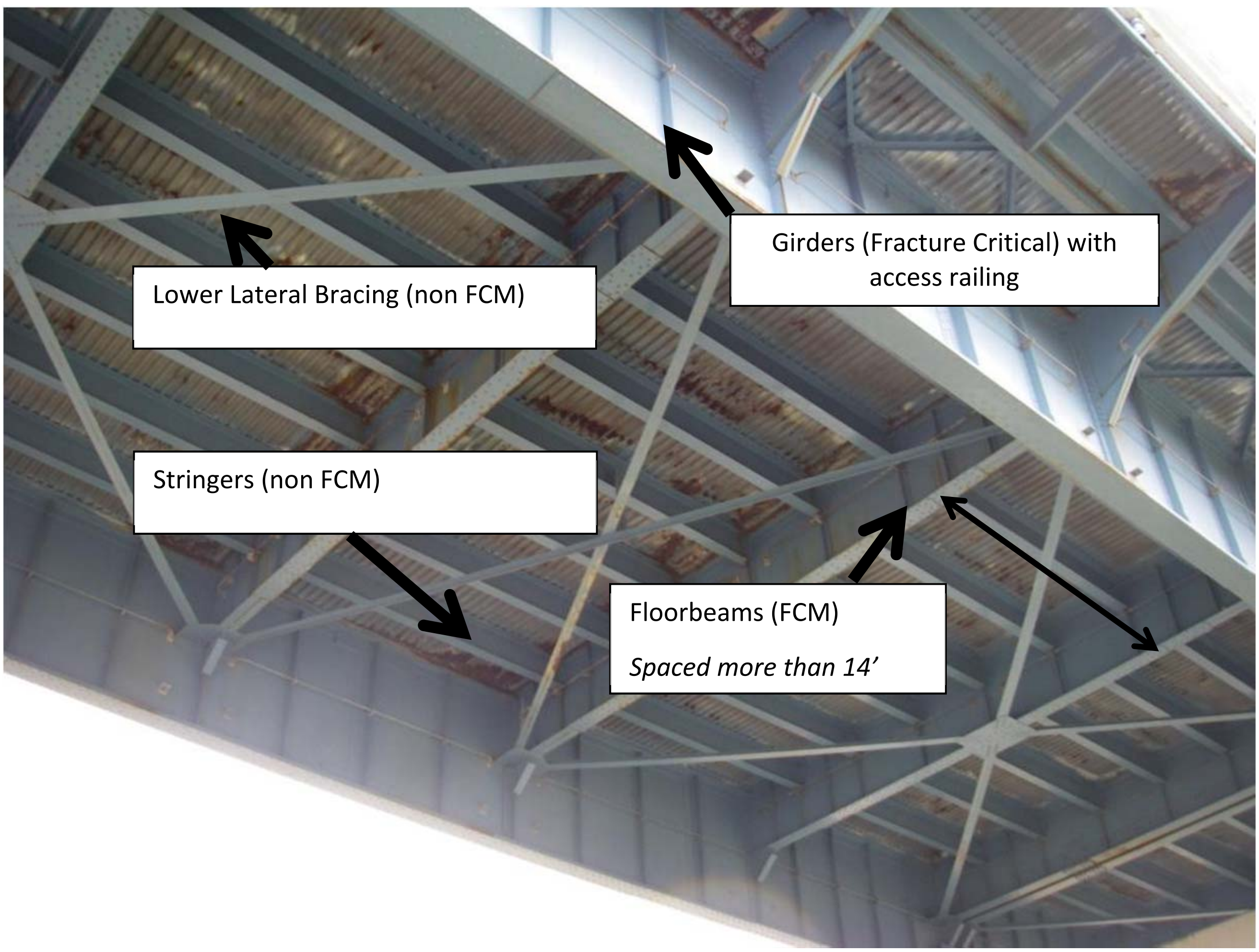



**Figure 36 - Fracture Critical Girder and Floorbeam**

2. *Hangers at the Pin and Hanger Assembly* – when 3 or fewer beam-lines exist
3. *Arch Ties* Tension hangers supporting the roadway

4. *Steel Pier Caps or Cross-Girders-* When only 2 supports (bents or columns) exist per cap

**Figure 37 - Fracture Critical Steel Pier Cap with Confined Space Entry**

5. *Any Other Member Qualifying as Fracture Critical (Steel, Tension & Partial/Total Collapse)*

*Fracture Critical Inspection Procedures*

Bridges with FCM's must have written inspection procedures which clearly identify the location of all FCMs, specify the frequency of inspection (if less than 24 months), describe any specific risk factors unique to the bridge, and clearly detail inspection methods and equipment to be employed. Acceptable written procedures are those that communicate to the inspection team leader what is necessary to insure a successful inspection. The prior inspection report is valuable to review for inspection findings but most often do not serve the same purpose as inspection procedures. The inspection report records what an inspector actually did, what was looked at, and what was found. Procedures lay out what <u>should</u> be done, looked at, etc. The Fracture Critical Plan in Appendix, when completely filled out, will fulfill the intent of the required procedures. The procedures should be incorporated into SMS in the inspection report under the "Review" Tab. These inspections must be planned and prepared for, taking into account special circumstances or conditions that the inspector needs to be aware of.

A procedure will require three primary components:

1. Identified Fracture Critical Members on framing plan or sketch
2. Table or location of important structural details
3. Risk Factors
    - *Risk Factors (Structural)-* FCMs must be inspected according to the written inspection procedures for the bridge, which should contribute to thorough inspections yielding accurate condition assessments. Specific risk factors include, but are not limited to:

• fatigue and fracture prone details, notably the E & E' details

• Material specific factors, including welded:

- T1 steel
- ASTM A514
- Grade 100 Steel
- Quenched & Tempered (Q&T) Steel
- High-Strength Steel
- Heat-Treated Steel
- Combinations of the above or any above used with the adjective "alloy"

- poor welding techniques
- potential out-of-plane distortion details
- previous cracking or repairs
- source of prior cracking

• cold service temperatures

• load posted

• superstructure condition code of 4 or less

• subject to overloads or impact damage

• older service life

• high ADTT (can be taken as ADTT>5,000 but may be less depending on the # of fatigue cycles)

Knowledge of the source of prior cracking, such as load induced, distortion induced, constraint induced (pop-in fracture), or fabrication flaws (hydrogen, weld defect, other), can be important for determining proper inspection procedures. Load induced is typically the most predictable, whereas

Figure 38 - Plug Weld

the others are less predictable (with more inherent risk). Knowing the lowest anticipated service temperature is an important factor in determining susceptibility to cracking.

Bridges posted because of a controlling FCM, which may or may not include deterioration, also warrant special attention. In general, evaluate the appropriateness of the prescribed procedures for any identified risk factors.

Gusset Plates that have structural bowing require documented and quantitatively repeatable procedures for measuring bowing change within a tolerance of 1/16”.
The non-redundant nature of FCMs, especially when coupled with risk factors, leads to a heightened concern for the performance of these members. By identifying these conditions or risk factors, the inspectors of FCMs can appropriately prepare for, and perform, a thorough inspection.

- *Risk Factors (Inspector Access)* The procedure should also identify risk factors or unique circumstances or conditions at the site. The proper development of good inspection procedures, and concerted attention to follow those procedures, will mitigate most risks. Items to consider should include:
  - clearly detail any inspection methods (include specifically what needs looked at and what the inspector is looking for)
  - needed access (snooper, manlift, climbing, consider including contact for property owners, driveway location, key location, etc.)
  - scheduling for equipment rental, bridge maintenance, RR or river traffic under bridge
  - maintenance of traffic
  - detour of traffic or closure of bridge necessary
  - unique inspection methods and frequencies if within the minimum 24 months
  - are there time periods of high water preventing access to floor beams
  - specific inspection devices or safety equipment utilized
  - permits/permission required for access, from landowner, agency governing land/water
  - necessity to clean or open access hatches prior to the inspection
  - confined space needs

## Underwater Inspections

The purpose of underwater inspections is to provide information on underwater portions of a bridge to evaluate their overall degradation, safety and, to assess the risk of failure due to scour. The levels of Underwater Inspection are as follows:

- Routine Visual, Wading and/or Probing Inspection
- Underwater Dive Inspection
  - Level – Visual, tactile inspection
  - Level II – Detailed inspection with partial cleaning
  - Level III – Highly detailed inspection with Non-Destructive Testing (NDT) or Partially Destructive Testing (PDT)

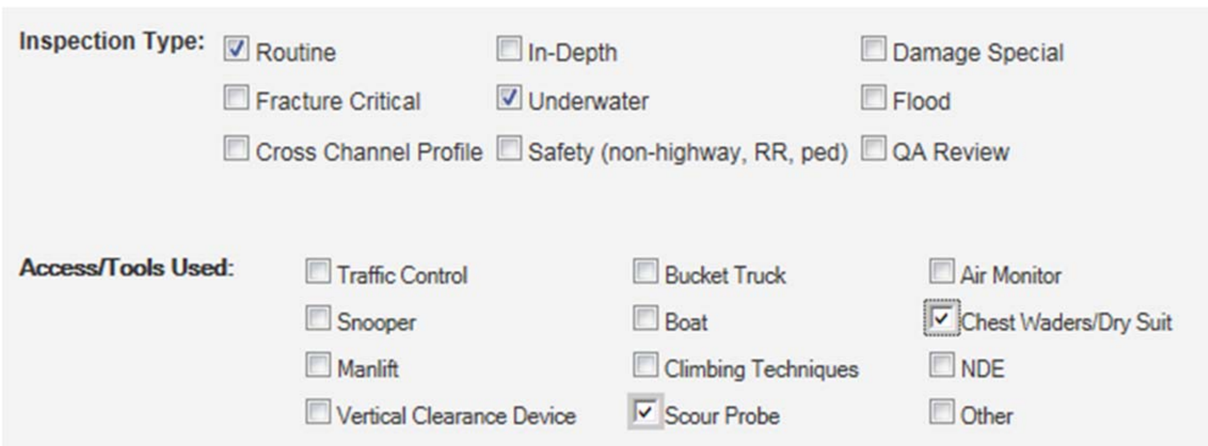



Figure 39 - SMS Screen-Shot of an In-Progress Inspection > Review Tab

*Routine Wading or Probing Inspection*

Visual combined with probing substructure units should be performed at every routine inspection. Structures which cannot be inspected visually at low water by wading or probing, will require diving techniques. Active scouring and undermining or substructure deterioration below the water level must be regularly monitored.

*Dive Inspection*

Structures which cannot be inspected visually at low water by wading or probing, will require diving techniques. Typically the threshold is for those substructure units in water deeper than 5-ft but depending on access, tools available, visibility and safety this may need to be adjusted.

Various factors influence the underwater bridge inspection selection criteria. All structures receive routine underwater inspections at intervals not to exceed 60 months. This is the maximum interval permitted between underwater inspections for bridges which are in excellent underwater condition and which are located in passive, nonthreatening environments. The control authority determines the inspection interval that is appropriate for each individual bridge. This is generally considered to be a water depth that prevents an inspector from safely probing around the culvert, pier or abutment.

Factors to consider in establishing the inspection frequency and levels of inspection include:

Inspector Access
Inspector Safety
Age of Structure & Substructure
Traffic volume
Size of Structure
Susceptibility to collision
Extent of deterioration
Performance history of bridge type
Load rating
Location
National defense designation
Detour length
Social and economic impacts due to the bridge being out of service
Type of construction materials
Environment
Scour characteristics
Condition ratings from past inspections
Known deficiencies

Non-destructive technology, including ground sensing radar, ultrasonic techniques, remote video recorders, and others are useful aids to supplement, but not replace, underwater inspections of substructure foundations.

Key information to be determined in every underwater dive inspection is the top of streambed relative to the elevation of the substructure foundations. Because scour can vary significantly from one end of a footing to the other, a single probing reading is not sufficient. Baseline streambed conditions should be established by waterway opening cross sections and by a grid pattern of probing readings around the face of a substructure unit. This baseline information is essential for future monitoring and assessment. The current streambed conditions and changes since the last inspection are critical inputs to the bridge scour assessment.

Each bridge should have a local reference point established near each substructure unit to enable Inspectors to quickly and accurately determine the depth of adjacent scour. These can be as simple as a painted line or PK nail driven into the wall in a place visible during high water. The location of these scour-monitoring benchmarks should be referenced in the inspection records and bridge file. Use previously established benchmarks when possible to provide a long-term record of scour conditions. If new benchmarks need to be established, provide conversion from new to old datum.

Underwater inspections are intended to investigate two critical issues regarding the condition of bridge substructures located in water:

- The condition of structural components (including pier shaft, abutment walls, footings, etc.) under water.
- The integrity of the substructure foundation (including underlying soil, piles, caissons, etc.) against scour at each substructure unit in water.

The inspection of the foundation of a substructure unit and the determination of its ongoing resistance to scour is critical for the overall safety of the bridge. Because the integrity of the foundation against scour can suddenly and dramatically change in a relatively short time (as compared to physical condition of the structure components), shorter intervals for inspection of the foundation should be established when warranted.

*Scope for an Underwater Dive Inspection*

A regularly scheduled Underwater Dive Inspection normally includes a 100% Level I inspection and a 10% Level II inspection. It may also include additional Level II inspections and Level III inspection if necessary to determine the structural condition of the submerged substructure elements with certainty

*Level I Underwater Dive Bridge Inspection* includes a close visual examination of the entire submerged portions of a bridge. They should include, but are not limited to the following:

- Written Inspection Procedures specific to the bridge
- Steel, concrete, stone & timber abutments, piers, fenders, and dolphins
- Identify and describe any scour adjacent to the above mentioned items.
- Identify and describe any damage to substructure items as may have been caused by collision (ice, debris, vessels, vehicles, etc).
- Identify and describe any footings or support elements which may be exposed.
- If bottoms of footings are exposed, include measurements describing the sizes of voids under the footings. In addition, describe the condition of any piling exposed in the void area.

- Identify and describe the condition of all piling of pile supported structures from the waterline to channel bottom, and identify and describe the condition of any pile protection.
- Identify and describe any cracks, scaling, tilting, or spalling of concrete or masonry piers and abutments.
- Probing of the soil adjacent to any substructure unit is required
- Cross Channel Profile (if applicable): Discussed later in this chapter.
- Scour Susceptibility Inspection and Evaluation (if applicable): Discussed later in this chapter.

*Level II Underwater Dive Bridge Inspection* may be required whenever serious deterioration is found during a Level I Inspection. A level II shall include field measurements and substructure cleaning below the waterline to document the extent of unsatisfactory structural condition. The inspector must report in full detail giving all dimensions of size, shape, and exact location. Effective methods for testing and measuring sound or unsound concrete; sound or unsound timber; section loss of steel, sound or unsound masonry; in piers, piles, bents, cribs, or other types of substructure construction; presence of scour, alteration, or other conditions; and/or any other conditions that may affect the integrity of substructure units. For example if concrete encased steel piles of a bridge bent were in water, and they were found to have areas of advanced section loss. A Level-2 Inspection would involve cleaning a representative number of piles and taking measurements of the steel shell thickness.

*Level III Underwater Dive Bridge Inspection* Is a highly detailed inspection of a critical structure or structural element or a member where extensive repair or possible replacement is contemplated. The purpose is to detect hidden or interior damage or loss in cross sectional area and to evaluate the material. It includes extensive cleaning, detailed measurements and selected nondestructive and partially destructive techniques: ultrasonic, sample coring or boring, physical material sampling and in situ hardness testing. The use of testing techniques is generally limited to key structural areas, suspect areas or areas which may be representative of the entire underwater structure.

### *Underwater Dive Inspection Procedures*

Acceptable written procedures are those that communicate to the inspection team leader what is necessary to insure a successful inspection. Each bridge with elements requiring underwater diving inspection must have written inspection procedures specific to each bridge which address items unique to that bridge. The prior inspection report, by itself, does not suffice for the required procedures. It is valuable to review for previous inspection findings, but does not serve the same purpose as the inspection procedures. The inspection report records what an inspector actually did, what was looked at, and what was found. Procedures lay out what should be done, looked at, etc. The procedure checklist in Appendix is a framework to satisfy the intent of the FHWA requirements. The procedures can be incorporated into the inspection report in SMS "Review" tab.

The underwater inspections must be planned and prepared for, taking into account:

- identified underwater elements
- physical scour countermeasures
- needed access (consider including contact for property owners, driveway location etc)
- inspection equipment necessary
- structural details
- hydraulic features and characteristics
- unique inspection methods and frequencies if within 60 months
- the qualifications of inspecting personnel if more advanced than the minimum NBIS
- Other items that may be addressed, if applicable, are: special contracting procedures prior to inspection (Coast Guard, etc.), scheduling considerations (lake draw down, canal dry time, etc.)
- Risk factors
  - The procedure should identify risk factors or unique circumstances or conditions at each site. The proper development of good inspection procedures, and concerted attention to follow those procedures, will mitigate most risks. In addition, the risk of scour for scour critical bridges, or bridges with unknown foundations, is mitigated by development and implementation of a scour plan of action (POA) for each bridge. Specific risk factors include waterway features such as rapid stream flows, significant debris accumulation, constricted waterway openings, soft or unstable streambeds, meandering channels, etc., which may promote scour and undermining of substructure elements. Water conditions which may affect the inspection such as: black water, or rapid stream flows should also be identified and accounted for in the inspection methods. Water environment and structural systems or materials which may combine for accelerated deterioration of the bridge elements should be identified such as highly corrosive water, unprotected steel members, timber piling in the presence of teredos or limnoria, etc. By identifying these conditions or risk factors, the underwater inspectors can appropriately prepare for, and perform, a

thorough inspection. The underwater inspection procedures developed for the bridge should adequately address these items, and also whether the inspection reports adequately address them, as appropriate.

*Cross Channel Profile*

Cross channel profile measurements are taken on bridges over waterways to track the rate-of-change of stream alignment and scour. Soundings of the channel bottom are usually done along the bridge centerline (to depict any areas of scour). Soundings will be made at a maximum interval (ex. 10'spacing) and the channel bottom elevations shall be compared with pier or abutment elevations. Additional

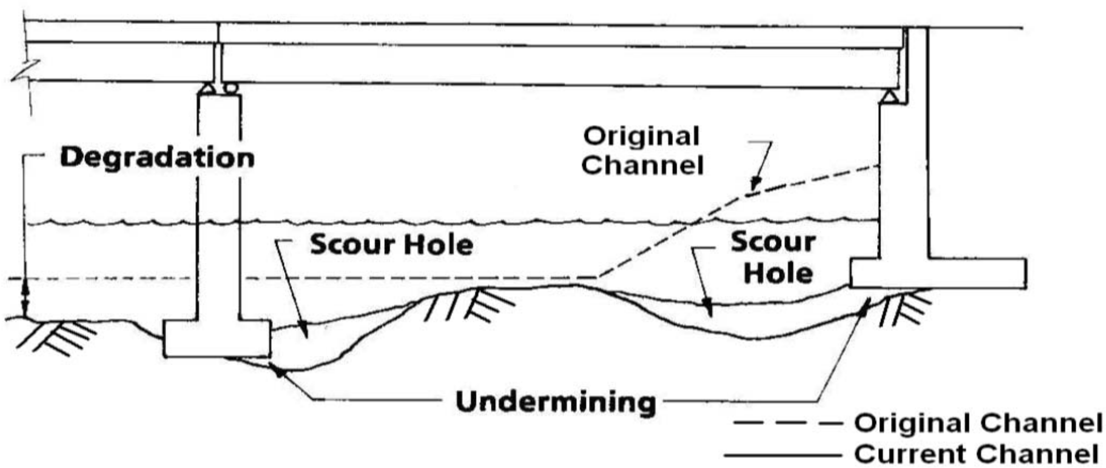



Figure 40 - Cross Channel Profile

soundings around piers and abutments, both up and downstream should be taken as necessary to accurately depict any areas of scour. River current direction should be shown on the sounding diagram. Additional resources should be assigned to complete cross channel profiles, see Appendix. Cross Channel Profile Measurements and the SMS Cross Channel Form in order to chart the rate of change of scour and channel embankments.

*Scour Susceptibility Inspection and Evaluation*

Scour Susceptibility Inspection and Analysis evaluations are performed to determine the level of risk associated with hydraulic events. A full Evaluation includes a Data Review, a Field Inspection and an Engineering Evaluation. The level of effort at each site will depend on the availability of information collected.

- *Data Review*: Plans, Assessment Checklist, FEMA Flood Insurance Studies, Bridge Evaluation Survey & Underwater Inspection Reports, Foundation Reports, Pile Driving, and Boring Logs and Existing Hydraulic Calculations (if applicable).
- *Field Inspection:* The investigation should include, but is not limited to:
  - Completing the Assessment checklist, Visual observations, verification or collection of the required information. The appropriate Sections of HEC-18 and HEC-20 (titled "Stream Stability at Highway Structures") can be utilized for guidance in the evaluation of existing conditions.
  - Photographic documentation of the bridge elevation, and the general configuration of the substructure elements and the upstream and downstream channel and any existing scour related conditions
  - Cross Channel Profile: As part of the evaluation of the distribution of flood flows at the site, cross sections at the bridge and at the upstream and downstream channels.
  - Evaluation of waterway and channel characteristics, including the evaluation of channel and overbank roughness coefficients and the location of additional waterway cross sections as required.
  - Collection of soil samples adjacent to the footings at any bridge substructure unit that is being evaluated and in the stream channel. The samples shall be collected using augers or other hand excavation methods.
- *Engineering Evaluation and Calculations*
  - Calculate the depth of scour and plot stream cross sections showing the scour depth at the bridge site in accordance with the procedures documented in the current FHWA publication HEC-18 titled Evaluating Scour at Bridges. The analysis includes an assessment of the effects of long-term changes in the streambed. In accordance with the FHWA Publication, HEC-18, this effort should include the evaluation of long-term bed elevation changes and the determination of the proper scour analysis method. Computations should be performed for the magnitude of: contraction scour; local scour at pier(s), if required; and local scour at the abutments.
  - Calculations performed should include contraction and local scour values for discharge events per the StreamStats a USGS web based application. Based upon the results of the calculations and evaluations, scour depth cross-sections should be developed for each discharge event which illustrate: the general configuration of the bridge; the location

and depth of the bridge foundations; and the depths of the various scour components (long term, contraction, local) Based upon these cross-sections, the existing substructure units can be evaluated/analyzed for horizontal and vertical stability. The depths of scour should be evaluated/analyzed for reasonableness based upon actual records for storms and/or scour holes and the potential effect of lateral stability of the waterway.

### *Special/Interim/Miscellaneous Inspections*

Special (or Interim) Inspections are scheduled by the bridge Owner to examine bridges or portions of bridges with known or suspected deficiencies. Special Inspections tend to focus on specific areas of a bridge where problems were previously reported or to investigate areas where problems are suspected. Special Inspections are conducted until corrective actions remove critical deficiencies or until the risk is diminished.

#### *Purpose of Special/Interim Inspections*

Special Inspections are used to monitor particular known or suspected critical deficiencies, fulfill the need for interim inspections (i.e. reduced inspection interval for posted bridges, repairs), and to investigate bridge conditions following a natural disaster or manmade emergency.

#### *Scope and Frequency of Special/Interim Inspections*

The Program Manager defines the scope and frequency of the Special Inspections. The personnel performing a Special Inspection should be carefully instructed regarding the nature of the known deficiency and its functional relationship to satisfactory bridge performance. Guidelines and procedures on what to observe and/or measure must be provided.

The determination of an appropriate scope and frequency for a Special Inspection frequency should consider the nature, severity and extent of the known deficiency, as well as age, traffic characteristics, public importance, and maintenance history. Special Inspections are typically at intervals shorter than 12 months.

### *Safety (Cursory) Inspection*

Safety inspections are similar to routine inspections but are more cursory in nature. They are secondary inspections performed by entities that do not have primary inspection responsibility per State regulation but that have a vested interest in the safety of the traveling public on or under the structures.

*Non-Highway bridges over a highway*: Those entities with right-of-way underneath the bridge should be inventory and annually inspect such structures to ensure such structures do not pose an unacceptable safety risk. Such inspections should only consist of those portions of the structure which would directly affect the right-of-way underneath the structure. Any problems requiring immediate attention should be relayed to the responsible authorities.

**Figure 41 - Overhead Conveyer Structure**

*Closed bridges*: When a public road bridge is closed to vehicular traffic but not removed from the site, continued cursory inspections are required on an annual basis to assure adequate safety to the public having access on or beneath the structure, and that necessary barricades for vehicles and/or pedestrians are in place.

If a bridge remains on the inventory of public roads, it must be inspected in accordance with NBIS and Department standards. Although a bridge is closed, the inspection must be current. Federal-aid funding eligibility is not maintained without current inspection records (note: the Operational Status on the report must be coded “X” or “K” to indicate the structure is closed).

**Figure 42 - Overhead Pedestrian Non-Highway Structure**

*Coordination with Railroad Bridges over a Public Highway*:

Railroad track owners are responsible for an annual inspection per Federal Regulation (49 CFR part 237 eff. July 15, 2010). Not performing inspections may result in tickets or fines, anywhere between $650 to $25,000, from FRA inspectors. ORC requires that annual inspection reports are submitted to:

- Public Utility Commission of Ohio (PUCO) and
- The public authority with jurisdiction of the highway (ORC 4907.44), when dangerous conditions exist

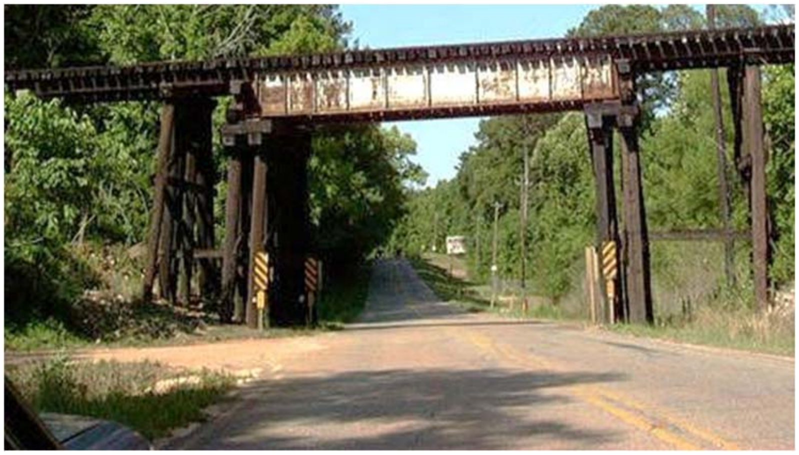


Table 32 - Railroad Bridge Over Highway ROW

In the event reports are not submitted to the public authority a request may be filed with the track owner in order to receive such reports. Safety (or Cursory) inspections should be performed by the public authority with jurisdiction of the highway to ensure the safety of the traveling public. This includes an inventory of the portion of the structure in the right-of-way.

Track owners are responsible not only for inspecting but for performing maintenance (ORC 5523.17 eff. 9/28/1973, ORC 4955.20 eff. 10/1/1953). Track-owners are required to report to the Public Utility Commission (PUCO) unsafe structures that require speed reductions (ORC 4907.45 eff. 10/1/1953) and annual inspection reports (ORC 4907.44 eff. 6/11/1968). Additionally, if the obstruction or properties present an immediate and serious threat to the safety of the traveling public, the ODOT director may remove or relocate the obstruction or properties without prior notice (ORC 5515.02 eff. 4/5/2001).

### *Quality Assurance (QA) Review Inspection*

Established QA Inspections are regularly performed on bridges by representatives from FHWA, CEAO or ODOT central office to promote accuracy and consistency and to ensure NBIS Compliance. The Control Authority of each entity is encouraged to perform sample inspections in addition to the independent field reviews prescribed in Metric 20.

*Complex Bridge Inspections*

Figure 43 - Complex Inspection 1

Complex Bridges include structures with suspension bridges, movable bridges and cable stayed bridges. These unique or special features necessitate additional inspection requirements and inspector duties.

The inspection of a Complex bridge must be in accordance with this Manual of Bridge Inspection, the FHWA Bridge Inspectors Reference Manual (BIRM). Additionally every complex bridge should have its own Operating and Maintenance Manual and Field Inspection Plan. If there is no Operating and Maintenance Manual, then sound judgment should be used in establishing a thorough Field Inspection Plan where specific conditions are encountered that are not covered by this manual or the BIRM.

Due to the size and/or complexity of the bridge, a good field inspection plan is necessary to ensure historical continuity, track deficiencies and communicate nomenclature. A good inspection plan should include most of the following:

- The type of Inspection(s) to be completed
- A brief historical fact statement about the bridge type and condition
- Confirmation that the bridge has been properly cleaned for the type of inspection planned
- Copies of essential plans
- A mapped route to the site
- Keys for any locked access points
- Specialized inspection procedures which clearly identify the complex features
- Frequency of inspection of those features
- Describe any specific risk factors unique to the bridge

- Clearly detail inspection methods and equipment to be employed.
- Identification of tension members and fatigue-prone details, failure prone details and fracture critical members or member components
- Identification of access equipment and arrangements for them to be on-site
- Identification of required nondestructive testing (NDT) equipment and arrangements for it to be on-site
- Identification of traffic control requirements and arrangements for on-site implementation
- Press releases, if necessary
- Inspection time estimate
- Coordination with the owner and other agencies as required

On larger bridges it may be necessary to create individual sections for each of the required areas of the inspection plan.

In addition to an operation and maintenance manual and a field inspection plan, the inspection team leader will have additional qualifications. The NBIS Team Leader who leads the field inspection must meet the following requirements:

Figure 44 - Complex Bridge Inspection 2

- NBIS Team Leader
- Familiarity with the type of complex bridge to be inspected
- Understanding of how the bridge functions and where possible defects might occur
- Must be current on issues with the type of bridges being inspected
- Understanding and ability to perform testing or recommend advanced testing procedures at problem areas
- Familiar with the Operating and Maintenance Manual for the bridge inspected and in charge with developing and implementing the Field Inspection Plan.

- Successfully passing training related to the type of complex bridge within the last ten years. For example, the FHWA-NHI-130078, Fracture Critical Inspection Techniques for Steel Bridges, Non Destructive Testing training etc.

*Description: Complex Bridges*

Complex bridges include the following:

- Any Bridge Designated by the Program Manager
- Suspension Bridges - Bridges in which the floor systems are supported by catenary cables that are supported upon towers and are anchored at their extreme ends (BIRM 12.1)
- Cable Stayed Bridges - Bridges in which the superstructures are directly supported by cables, or stays, passing over or attached to towers located at the main piers (BIRM 12.1)
- Movable Bridges - Bridges having one or more spans capable of being raised, turned, lifted, or slid from their normal service location to provide a clear navigation passage (BIRM 12.2)

*Scope and Frequency of Complex Bridge Inspections*

**Figure 45 - Inspector Rappelling the Cable Stay**

The inspection frequency of complex bridges varies depending on the type and condition of each individual component of the bridge. At a minimum each bridge needs a routine inspection every year, a fracture critical inspection (when applicable) every 24 months, an underwater inspection (when applicable) every 60 months and a special inspection to monitor known deficiencies at the discretion of the Program Manager. In depth inspections are recommended for Complex Bridges on a 5-year cycle or in accordance with the inspection and maintenance manual.