INDOT BRIDGE INSPECTION MANUAL

PART 1

ADMINISTRATION

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INTRODUCTION

Part 1 of the Bridge Inspection Manual contains the following chapters:

1. Program Overview
2. Types of Inspections
3. Reporting Systems
4. Emergency Notifications / Critical Findings

These chapters define the qualifications required to become a team leader and the procedures that the team leader must follow. The performance expectations and responsibilities are provided in part 1 of this manual. While other portions of the manual provide recommendations and guidance for the inspector, Part 1 provides the regulatory guidance and outlines the requirements that must be performed in order to provide the documents in the format and timely manner necessary for INDOT to fulfill the requirements of the National Bridge Inspection Standards.

1-1.0 PROGRAM OVERVIEW

1-1.01 Program Summary

It is important for the safety of the driving public that qualified personnel inspect Indiana's bridges and large culverts. The Bridge Inspector is required to render judgment on a daily basis pertaining to the safety and integrity of the structures inspected.

The individuals involved in the State Bridge Inspection Program have critical input on many issues, including the allocation of scarce rehabilitation funds and the decision to close major bridges. It is important that the Inspector is highly trained and proficient; he/she must understand the mechanics, behavior trends, and economics of a wide range of bridge types.

Indiana's State Bridge Inspection Program operates under the directives of the Federal Highway Administration (FHWA) and the Indiana Department of Transportation (INDOT). The mission of the program is as noted below:

1. Ensure public safety.
2. Provide for the efficient use of resources in maintaining the serviceability of Indiana's bridges and large culverts.
3. Comply with all federal and state laws, rules, and policies.
4. The State is given the responsibility to accurately inventory and inspect all highway bridges on public roads. The State shall inspect the bridges on its highways and delegates this responsibility to the counties to accurately inventory and inspect their bridges on public roads.
5. The failure of a county to perform these responsibilities may cause a loss of funding. The State shall have the authority to take the appropriate action to assure bridge safety. These assurances will include that the bridge has been inspected at the proper frequency, that if necessary the bridge is posted, and that the posting in done in a timely manner. The State shall have the authority to close unsafe bridges.

1-1.02 Inspection Program

The State Bridge Inspection Program is federally mandated and has been in effect since 1971. The program policies are based on the National Bridge Inspection Standards (NBIS). Bridge inspection reports are stored in BIAS (Bridge Inspection Application System) and records are kept in ERMS (Electronic Records Management System) the required bridge data is forwarded to the FHWA on an annual basis.

NBIS define a bridge as a structure, including supports, erected over a depression or an obstruction, such as water, highway, or railway. It has a track or passage way for carrying traffic or other moving loads, and has an opening measured along the center of the roadway of more than twenty feet between under copings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes. It may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.

This manual will address all bridges meeting this definition, as well as large culverts spanning between 4 and 20 feet. Refer to Figures 1:1-1 and 1:1-2 for the defining bridge measurements.

1-1.03 Organization

The State Program Manager (SPM) is charged with administering the State Bridge Inspection Program. The INDOT Bridge Inspection Engineers (BIE), State/Toll Road/County/Local Bridge Inspection Consultants report to the State Program Manager. Inspection Team Leaders report to the appropriate INDOT Bridge Inspection Engineer, the Toll Road Operating Engineer, or Bridge Inspection Consultant. Inspection Team Members report to their Inspection Team Leaders.

The Assistant State Program Manager (ASPM) is charged with the overall responsibility for load rating and posting of bridges.

The organization of the State Bridge Inspection Program is shown in Figure 1:1-3 and described in detail later in this section. The review and quality assurance/quality control procedure is discussed in Part 2, Quality Assurance/Quality Control.

1-1.04 Qualifications And Responsibilities

1-1.04(01) State Program Manager (SPM)

The SPM is responsible for setting all bridge inspection policies and procedures, and for all bridge inspections and related reporting in the state.

SPM Minimum Qualifications

The SPM must meet the following minimum qualifications:

1. Capable of overseeing the INDOT Bridge Inspection Engineers (BIE), all Bridge Inspection Consultants (BIC)
2. Sound background in bridge inspection
3. Specialized knowledge and skills in bridge design, construction, soils, construction materials, and emergency repair techniques

4. Successful completion of the Safety Inspection of In-Service Bridges (FHWA-NHI-130055) course or Safety Inspection of In-Service Bridges for Professional Engineers (FHWA-NHI-130056
5. Successful completion of the Fracture Critical Inspection Techniques for Steel Bridges (FHWA-NHI-130078) course
6. Registered Professional Engineer (PE) in the state of Indiana.

SPM Responsibilities

As a part of the responsibilities of this position, the SPM shall:

1. Oversee the INDOT BIE, all Inspection Consultants
2. Manage the statewide bridge inspection and inventory programs.
3. Ensure all bridges in the state are inspected at a frequency and by a method consistent with the NBIS and state law.
4. Ensure that bridge inspection data is uploaded to BIAS within mandated time frames and that all required files have been uploaded into ERMS.
5. Ensure load ratings are completed in accordance with all federal requirements.
6. Oversee quality assurance and quality control of all bridge inspection programs.
7. Coordinate with federal, state, toll road, county, and local governmental agencies.
8. Formulate and monitor in-depth inspection programs for bridges with fracture critical members, underwater components, or unique or special features requiring additional attention during inspection to assure the safety of such structures.
9. Conduct annual inspections of state border bridges in company with respective states' personnel and district offices to determine required actions and lead the effort to accomplish Indiana's portion of any required actions.
10. Notify FHWA of all critical findings.
11. Ensure proper signage is in place for bridges that require load posting or other restrictions.
12. Ensure a system is in place that will notify INDOT BIE and BIC of required inspections and their due dates.
13. Ensure a system is in place to upload all approved inspection data.
14. Formulate and administer programs and policies.
15. Develop, implement, and evaluate inspection and preservation policies, standards, procedures, and programs.

16. Analyze federal and state legislation, administrative rules, and national and industry standards for incorporation in programs and policies.
17. Recommend the revision of legislation and participate in new legislation development.
18. Lead prompt, decisive, and effective responses to emergencies such as floods, earthquakes, and major bridge damage.
19. Train bridge inspection personnel.
20. Develop, monitor, and update training programs for state and consultant inspectors.
21. Arrange or conduct inspection training programs and refresher programs throughout the state.
22. Provide training on proper access, equipment operation, and safety procedures.
23. Review and approve Inspection Team Leader and Inspection Team Member qualifications. The SPM will have the final say on all questions of qualifications.
24. Maintain a list of all qualified Inspection Team Leaders and Inspection Team Members in Indiana. The list will identify training required to keep the qualifications up to date.
25. Evaluate Inspection Team Leaders and Inspection Team Members and require additional training as necessary.
26. Advise on technical issues concerning problems or deficiencies discovered during inspections.
27. Act as an Inspection Team Leader as needed.
28. Monitor inspections and develop a good, general knowledge of all bridges in the state and their inspection records.
29. Review all inspection reports for complex bridges performed on Indiana bridges.
30. Manage state bridge inspection personnel and consultants to meet the needs of the State Bridge Inspection Program.
31. Manage state-owned underbridge access equipment to assist in the inspection of bridges statewide.

1-1.04(02) Assistant State Program Manager (ASPM)

The ASPM must meet the following minimum qualifications:

1. Capable of overseeing the load rating and posting of all public bridges in the state.
2. Registered Professional Engineer (PE) in the state of Indiana.

ASPM Responsibilities

The Assistant State Program Manager (ASPM) is charged with the overall responsibility for load rating and posting of bridges in the state.

1-1.04(03) Bridge Inspection Area Engineer (BIAE)

The BIAE is responsible for assisting the SPM as directed, for setting all bridge inspection policies and procedures, and for all bridge inspections and related reporting in the state.

INDOT BIAE Minimum Qualifications

The BIAE will meet the following minimum qualifications:

1. Capable of overseeing the INDOT BIE
2. Sound background in bridge inspection
3. Specialized knowledge and skills in bridge design, construction, soils, construction materials, and emergency repair techniques
4. Successful completion of FHWA-NHI-130055, Safety Inspection of In-Service Bridges or FHWA-NHI-130056, Safety Inspection of In-Service Bridges for Professional Engineers
5. Successful completion of FHWA-NHI-130078, Fracture Critical Inspection Techniques for Steel Bridges
6. Registered PE in the state of Indiana

BIAE Responsibilities

As a part of the responsibilities of this position, the BIAE shall:

1. Oversee INDOT BIE.
2. Assist the SPM in managing the state bridge posting and restriction program.
3. Ensure proper signage is in place for bridges that require load posting or other restrictions.
4. Ensure a system is in place that will notify INDOT BIE and BIC of required inspections and their due dates.
5. Ensure a system is in place to upload all approved inspection data.
6. Assist in the formulation and administration of programs and policies.
7. Develop, implement, and evaluate inspection and preservation policies, standards, procedures, and programs.
8. Analyze federal and state legislation, administrative rules, and national and industry standards for incorporation in programs and policies.

9. Recommend the revision of legislation and participate in new legislation development.
10. Lead prompt, decisive, and effective responses to emergencies such as floods, earthquakes, and major bridge damage.
11. Train bridge inspection personnel.
12. Develop, monitor, and update training programs for state and consultant inspectors.
13. Arrange or conduct inspection training programs and refresher programs throughout the state.
14. Provide training on proper access, equipment operation, and safety procedures.
15. Assist in maintaining a list of all qualified Inspection Team Leaders and Inspection Team Members in Indiana. The list will identify training required to keep the qualifications up to date.
16. Assist in the evaluation of Inspection Team Leaders and Inspection Team Members and require additional training as necessary.
17. Advise on technical issues concerning problems or deficiencies discovered during inspections.
18. Act as an Inspection Team Leader as needed.
19. Monitor inspections and develop a good, general knowledge of all bridges in the state and their inspection records.
20. Review all inspection reports for complex bridges performed on Indiana bridges.

1-1.04(04) INDOT Bridge Inspection Engineer (BIE)

The INDOT BIE is responsible for the inspection and reporting for all assigned state-owned bridges.

INDOT BIE Minimum Qualifications

The INDOT BIE must meet the following qualifications:

1. Successful completion of FHWA-NHI-130055, Safety Inspection of In-Service Bridges or FHWA-NHI-130056 Safety Inspection of In-Service Bridges for Professional Engineers
2. Qualified as a Bridge Inspection Team Leader in the state of Indiana
3. Registered PE in the state of Indiana with appropriate training and experience
4. Capable of overseeing Inspection Team Leaders and Inspection Team Members
5. Successful completion of FHWA-NHI-130078, Fracture Critical Inspection Techniques for Steel Bridges

6. Demonstrate a strong background in such areas as structural engineering, structural behavior trends, and bridge rehabilitation techniques
7. Demonstrate management abilities
8. Demonstrate thorough familiarity with NBIS, this manual, and applicable INDOT guidelines
9. Good eye sight and the ability to walk and climb over uneven surfaces and be comfortable working at heights, near water, in confined spaces, and close to live traffic

<u>BIE Responsibilities</u>

As a part of the responsibilities of this position, the INDOT BIE shall:

1. Coordinate inspections to ensure that all inspections are completed in compliance with this manual.
2. Oversee Inspection Team Leaders and Inspection Team Members.
3. Ensure that all assigned state-owned bridge inspection results are approved and uploaded to BIAS within 30 days of the date of the inspection and within seven days for all closures and emergency inspections.
4. Notify the SPM of all critical findings in accordance with Section 4.02.
5. Act as an Inspection Team Leader as needed.

1-1.04(05) Bridge Inspection Consultant (BIC)

The BIC is the individual in a prequalified consulting firm who is responsible for all contracted inspections.

<u>BIC Minimum Qualifications</u>

The BIC must meet the following minimum qualifications:

1. Registered PE in the state of Indiana with appropriate training and experience
2. Qualified as an Inspection Team Leader in the state of Indiana.
3. Successful completion of FHWA-NHI-130055, Safety Inspection of In-Service Bridges or FHWA-NHI-130056, Safety Inspection of In-Service Bridges for Professional Engineers
4. Successful completion of FHWA-NHI-130078, Fracture Critical Inspection Techniques for Steel Bridges
5. Capable of overseeing ATL and ATM

<u>BIC Responsibilities</u>

As a part of the responsibilities of this position, the BIC shall:

1. Oversee ATL and ATM.
2. Accept responsibility for all contracted inspections.
3. Inspect or ensure that qualified inspectors inspect all bridges and large culverts included in their contracts in compliance with this manual.
4. Ensure that all inspection results are approved and uploaded to BIAS within 60 days of the of the inspection date and within seven days for all closures and emergency inspections.
5. Ensure that all quality control and quality assurance procedures are met for all team leaders.
6. Fulfill requests for information from the SPM in an efficient and timely manner.
7. Recommend load posting, restrictions, or bridge closings and ensure the related signage is in compliance with the applicable requirements.
8. Notify the SPM of all critical findings in accordance with Section 4.02.
9. Assist the hiring agency in maintaining a perpetual inventory of all bridges and large culverts in BIAS.
10. Recommend a bridge repair and construction program to the agency.
11. Ensure all ATL, ATM, LRE, and General User active profiles are maintained in good standing in BIAS. The list shall include the following:
    a. Name
    b. Company Name
    c. Address
    d. Email Address
    e. Phone Number
    f. Training Course Certificates
    g. Professional Engineering License
    h. Other Pertinent Certifications; SPRAT, Commercial Diver, Confined Space, etc.

1-1.04(06) Inspection Team Leader (ATL)

The ATL is the person responsible for the field inspection work. Preferably, the inspection team should consist of two persons: an ATL and an Inspection Team Member (ATM).

ATL Minimum Requirements

The ATL must meet the following requirements to be considered qualified:

1. Be responsible for field work and be on site during the inspection

2. Demonstrate a strong background in such areas as structural engineering, structural behavior trends, and bridge rehabilitation techniques
3. Demonstrate management abilities
4. Thorough familiarity with all NBIS, this manual, and applicable INDOT guidelines
5. Good eye sight, the ability to walk and climb over uneven surfaces, and the ability to work at heights, near water, in confined spaces, and close to live traffic
6. Meet one of the following scenarios:
   a. Successful completion of FHWA-NHI-130055, Safety Inspection of In-Service Bridges, or FHWA-NHI-130056 Safety Inspection of In-Service Bridges for Professional Engineers **and** Registered PE in the state of Indiana
   b. Successful completion of FHWA-NHI-130055 and Bachelor degree in Engineering from a college or university accredited by the Accreditation Board for Engineering and Technology or a substantially equivalent organization, **and** successful completion of the National Council of Examiners for Engineering and Surveying Fundamentals of Engineering exam, **and** two years of bridge inspection experience in a responsible capacity under the direction and supervision of a qualified ATL
   c. Successful completion of FHWA-NHI-130055 **and** five years of Bridge Inspection Experience in a responsible capacity under the direction and supervision of a qualified ATL.
   d. Successful completion of FHWA-NHI-130055 **and** Certified Level III or IV NICET Bridge Inspector.
   e. Successful completion of FHWA-NHI-130055 **and** Associate's degree in Engineering or Engineering Technology from a college or university accredited by the Accreditation Board for Engineering and Technology or by a substantially equivalent organization, **and** four years of bridge inspection experience in a responsible capacity, as determined by the SPM, under the direction and supervision of a qualified ATL.

A request for Inspection Team Leader status shall be submitted on the Record of Qualifications form. The Inspection Team Leader form can be found online at: Http://www.in.gov/dot/contracts/standards/bridge/ Under Qualifying Form

To remain qualified, all Inspection Team Leaders:

1. Must successfully complete Bridge Inspection Refresher Training (FHWA-NHI-130053) or FHWA-NHI-130055/130056 at least once every 10 years.

2. Must have conducted a bridge inspection, where he/she has fully participated in the field inspection work and signed his/her name on the report in the last five years. Inspection Team Leaders who do not meet this requirement must successfully complete FHWA-NHI-130053 - Bridge Inspection Refresher Training to become re-qualified.

3. Maintain a current S-BRITE Bridge Inspection certification. The requirements to acquire and maintain the bridge inspection certification from the Purdue University Steel Bridge Research, Inspection, Training, and Engineering Center will be published in Bridge Inspection Memorandums and may also be found at the S-BRITE link : https://engineering.purdue.edu/CAI/SBRITE/Training .

The Inspection Team Leader who does not meet the ongoing qualifications outlined may conduct field inspections during an emergency such as a flood, post-earthquake, or after a collision. He/she must be instructed by, and under the supervision of, a qualified Inspection Team Leader. The inspections should be limited and should not involve changing any NBI data without having their data reviewed by a qualified Inspection Team Leader.

1-1.04(07) Complex Bridge Inspection Team Leader

Inspection Team Leader for the inspection of a complex bridge is not a separate team leader classification. A complex bridge inspection is not a separate type of bridge inspection. A complex bridge inspection will follow the instructions outlined in the inspection plan. The inspection plan will outline the experience and skills necessary to perform the complex bridge inspection. The selection of a complex team leader will be based on experience and specific engineering qualifications for the specific complex bridge. A complex bridge may require engineering expertise in areas such as structural, mechanical, and electrical. The specific requirements will be listed in the design level three requirements of contract documents if contracted and the inspection plan. The team leader managing the multidisciplinary engineering specialties must meet the following requirements:

1. Qualified Inspection Team Leader
2. Successful completion of FHWA-NHI-130078, Fracture Critical Inspection Techniques for Steel Bridges.
3. Licensed Professional Engineer in the state of Indiana and have specific experience on the type of complex bridge being inspected and have qualified team members to cover all necessary engineering disciplines to inspect all components of the complex structure.
4. Current certification from Purdue University Steel Bridge Research, Inspection, Training and Engineering Center.
5. The credentials must be approved by the SPM.

1-1.04(08) Fracture Critical Inspection Team Leader (ATL-F)

ATL-F Minimum Requirements

Inspection Team Leaders for the inspection of a fracture critical bridge must meet the following requirements:

1. Qualified Inspection Team Leader
2. Successful completion of FHWA-NHI-130078.
3. Licensed Professional Engineer in the state of Indiana, or have 2 additional years of bridge inspection experience as a team leader.
4. Current certification from Purdue University Steel Bridge Research, Inspection, Training and Engineering Center.
5. The credentials must be approved by the SPM.

1-1.04(08) Underwater Inspection Team Leader (ATL-U)

ATL-U Minimum Requirements

An Inspection Team Leader for an Underwater Inspection will meet the following requirements:

1. Qualified Inspection Team Leader
2. Divers must meet the requirements listed in Section 1.04(11)
3. Registered PE licensed in the State of Indiana
4. Experienced in Underwater and In-Water Bridge inspections
5. Experienced in stream bed profiles and cross sections
6. Experienced in underwater nondestructive testing techniques
7. Responsible for the inspection, data integrity, and report preparation for bridge inspection projects in the last five years

ATL-U Responsibilities

The Inspection Team Leader shall:

1. Lead the inspection team in actively planning, preparing, and performing bridge inspections. The ATL-U must be at the bridge at all times during the inspection.
2. Be on site leading in the inspection of each bridge and participating in all in-water activities.

3. Ensure worksite safety compliance, including traffic control, Inspection Team Members' safety procedures, equipment, and the proper use of access equipment.
4. Sign each bridge inspection report and take full responsibility for all data and comments contained in the report.
5. Approve all data in BIAS.
6. Train Inspection Team Members working under his/her supervision, and provide opportunities to further his/her knowledge and professionalism in this field.
7. Report any condition which is dangerous to persons or property, or any structural condition that would likely increase the potential for structure or member failure, to the SPM and the INDOT BIE or BIC as soon as possible.
8. Report any Critical findings to the appropriate individuals and agencies identified in 1- 4.02.
9. Recommend load posting calculations be completed as needed.
10. Recommend restrictions or bridge closings and ensure the related signage is in compliance with all applicable requirements.
11. Duties and responsibilities of the Inspection Team Leader are described in 1 - 1.04(05).

1-1.04(10) Inspection Team Member (ATM)

ATM Minimum Requirements

An ATM shall meet, as a minimum, all of the qualifications listed below:

1. High School Degree or equivalent
2. Familiarity with NBIS
3. Familiarity with the FHWA Recording and Coding Guide
4. Familiarity with appropriate parts of this manual

The Inspection Team Member is encouraged to take FHWA-NHI-130055, Safety Inspection of In-Service Bridges.

ATM Responsibilities

The Inspection Team Member is responsible for the following:

1. Following all Inspection Team Leader instructions in a safe manner
2. Assisting the Inspection Team Leader in the field
3. Documenting his/her participation and experience
4. Keeping a personal log of bridge inspection and related bridge experience

5. Acting in a professional manner

1-1.04(11) Nondestructive Testing Specialists

Individuals contracted to perform nondestructive testing (NDT) shall be qualified in accordance with American Society for Nondestructive Testing (ASNT) Level II or III. For all NDT work, other than dye penetrate, the NDT personnel must work hand-in-hand with a professional engineer, licensed in Indiana, who is qualified as a Bridge Inspection Team Leader.

1-1.04(12) Divers

Diving operations shall be conducted in accordance with all applicable federal and state regulations. Each member of the team should be trained in accordance with Occupational Safety and Health Administration (OSHA) standards.

All divers shall have completed training accredited by the Association of Commercial Diving Educators to the appropriate level or documented evidence that the divers training meets the requirements specified by the national consensus standard published by the American National Standards Institute (ANSI) and the Association of Commercial Diving Educators (ACDE) (i.e. ANSI / ACDE-01-2015, American National Standard for Divers – Commercial Diver Training – Minimum Standard).

All divers shall have certification proving successful completion of the Underwater Bridge Inspection course (FHWA-NHI-130091). All proof of training and certifications must be on file with the INDOT Bridge Inspection Unit.

1-1.04(13) Load Rating Engineer (LRE)

Routine load ratings of state-owned bridges are generally performed and maintained by INDOT's Bridge Load Rating Engineer in the Division of Bridges. The load rating of toll road, county, and local bridges is generally done by the BIC of record for owner.

LRE Minimum Qualifications

The LRE must meet the qualifications listed below:

1. Have experience calculating load ratings and knowledge of load capacity rating computer programs and posting policies in Indiana
2. Registered PE licensed in the state of Indiana, qualified to oversee, review, and certify all load capacity ratings performed under his/her supervision
3. It is preferred, but not required, that the LRE successfully complete FHWA-NHI-130055, Safety Inspection of In-Service Bridges.

LRE Responsibilities

The LRE must:

1. Provide engineering judgment to those performing the load ratings.
2. Be actively involved in reviewing the quality and accuracy of all load ratings.

1-1.05 Bridge Inspection Database

INDOT's Bridge Inspection Database is called BIAS (Bridge Inspection Application System). This application is used to create the annual file submitted to Federal Highway.

All inspection data shall be entered into BIAS and approved by the Inspection Team Leader.

These materials include the following:

1. Structure Inventory and Appraisal information
2. Field inspection information including sketches and photographs showing typical and deteriorated conditions. This requirement includes a brief narrative to justify a change in condition rating. A NBI item rated below 5 or condition state 3 requires a picture or sketch in additional to narrative descriptions of the deteriorated condition. A plan of action is to be included if required.
3. Critical Findings in accordance with Section 1-4.02
4. Waterway information in accordance with Section 1-2.10
5. Other Inspection Procedures. These items will include other required reports such as fracture critical and underwater. These reports will be in accordance with Section 1-2.0 of this manual.
6. Load Rating. A dated load rating along with identification of the analysis to determine capacity. Results must be included which clearly identify the loads and methodology used in the analysis. Identify controlling members. Include any updates that reflect changes in the condition of structural members. If calculations cannot be provided due to lack of information, provide documentation for justification of determined load rating.
7. Posting Documentation. In accordance with 3-9.02(02)
8. Scour Assessment. Document the assessment conducted to determine the scour vulnerability of the bridge.

For additional information on BIAS and ERMS requirements see section 1-3.0 Reporting Systems

1-2.0 TYPES OF INSPECTIONS

1-2.01 Introduction

There are numerous types of inspections, each designed to obtain specific information. For example, an Initial Inspection is performed after a bridge is constructed to document the as-built conditions, whereas Routine Inspections are used to monitor the condition of a bridge at regular intervals. Damage Inspections are used to assess damage resulting from events such as impacts, fires, or floods. These inspections help create a complete picture of a bridge's condition and are described in detail in this chapter.

Visual inspection is the primary examination method for all inspections. Nondestructive testing (NDT) techniques may be required to identify internal flaws or hard-to-see external defects in critical members. NDT is detailed in Part 5 of this manual.

See Figure 1-2.1 for an example of an arch bridge.

1-2.02 Inspection Types

The Federal Highway Administration (FHWA) and the state of Indiana dictate the type of inspection each bridge requires, and the maximum interval between inspections. Figure 1-2.2: Bridge Inspection Types and Maximum Intervals gives an overview of the types of inspections, the maximum interval between inspections, and the governmental unit responsible for the inspection policy.

1-2.03 Initial Inspections

1-2.03(01) Purpose

An Initial Inspection is the baseline inspection that should be completed on every new bridge, after a major rehabilitation, or when the configuration or geometry of a bridge changes (e.g., when a bridge is widened). An Initial Inspection is a fully documented inspection using the bridge plans to determine basic data for entry into BIAS. Initial Inspections are also used when a bridge is discovered that has not been previously inventoried. In this case, the bridge plans may not be available. As part of the Initial Inspection, inspectors evaluate the bridge and decide what other foreseeable inspections will be required throughout its life, including Fracture Critical, Special, or Underwater Inspections.

See Figure 1-2.3 for an example of an inspector performing an initial inspection.

1-2.03(02) Precision

The Initial Inspection should be a fully documented investigation. Inspectors must be able to identify any deficiencies and verify the geometric data. All observed deficiencies, cracks, construction errors, and alignment problems should be documented.

An Initial Inspection should include:

1. Record all Structure Inventory and Appraisal (SI&A) data required by federal and state regulations.
2. Complete an inspection and evaluation of all required data identified in the Indiana Coding Guide in accordance with relevant chapters of this manual.
3. Complete a Basic Channel Survey, in accordance with Section 1-3.10 of this chapter.
4. Complete a Scour Evaluation for a bridge with substructure units in water in accordance with 4-2.01 and the BIRM (Bridge Inspection Reference Manual).
5. Note that an underwater inspection may be required if a dry period of the year cannot be found to probe the substructure units in water and the substructure units cannot be probed from a boat. The need for an underwater inspection should be verified at the first routine inspection.
6. Gather relevant information required to maintain an accurate bridge file.
7. Determine and evaluate the baseline structural condition.
8. Assess scour susceptibility.
9. Identify the location and condition of any fracture critical members or details.
10. Identify the location and condition of any details that may require a Special Inspection.
11. Verify that all clearances and geometric dimensions are correct in BIAS.
12. Verify that any protection required to shield the bridge from traffic on navigable waters is in place.
13. Identify any critical findings and notify the appropriate individuals and agencies identified in 1-4.02

All inspection results should be fully documented in the BIAS

1-2.03(03) Repairs

Rehabilitation repairs are permanent repairs that are intended to improve the structural condition of a member and/or component. Access to the repair plans is needed to determine if and to what extent rehabilitation improves any specific rating number.

Bridges used to maintain traffic during construction must be inspected in the month the Routine inspection is due.

1-2.03(04) Frequency

For state-owned bridges, an Initial Inspection should be completed before the new construction or rehabilitation construction contract is finalized and the bridge is open to traffic. These inspections are often performed in conjunction with the construction department's Pre-Final Inspection. Approved Initial Inspection data, including the SI&A data, must be entered into BIAS within 90 days of the completion of the construction.

For toll road, county, and local agency bridges, Initial Inspections should be completed as soon as reasonable. Approved Initial Inspection data, including the SI&A data, must be entered into BIAS within 90 days of the opening of the bridge.

A bridge not previously documented in BIAS shall receive an Initial Inspection within 90 days of the discovery of the bridge. The data must be entered into BIAS within 90 days of the discovery of the bridge.

See Figure 1-2.4: Steel Girder Bridge for an example of a steel girder bridge.

1-2.04 Routine Inspection

1-2.04(01) Purpose

Routine Inspections are regularly scheduled inspections consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, and to identify any changes from previously recorded conditions. The Routine Inspection also ensures that the bridge continues to satisfy present service requirements.

1-2.04(02) Precision

Routine Inspections will follow a Plan of Action, documented in the BIAS if the bridge has unique issues such as difficult access, polluted water, requires access equipment or traffic control.

Routine Inspections are generally conducted from the deck, ground, water-level, or from permanent work platforms and walkways, if present. A complete walk-around visual inspection of all components of the structure, channel, and adjacent roadway is required.

If the water is not safe for wading access, the inspection team should return when the flow conditions allow safe access. The inspection team may probe the underwater portion of the bridge using a boat. If the bridge cannot be inspected using these options then an Underwater Inspection (92B) is necessary. The conditions that mandate an Underwater Inspection are listed in Section 1 - 2.06. The Inspection Team Leader must send a written request to the State Program Manager to add, modify, or remove a bridge from the list of bridges needing an Underwater Inspection.

A Routine Inspection should include the following:

1. Complete an inspection and evaluation of all required data identified in this manual in accordance with this manual.
2. Complete a Basic Channel Survey for bridges with substructure units in water every 72 months in accordance with Section 1-2.10 of this chapter.
3. Complete a Basic Channel Survey for bridges with substructure units in water in accordance with Section 1 - 2.10 of this chapter if required by the Scour Plan of Action, or if probing indicates a changed condition in the stream bed.
4. Verify SI&A data.
5. Gather other relevant information required to maintain an accurate bridge file.
6. Note any existing problems or components.
7. Note the condition of fracture critical members or details.
8. Identify the location and condition of details that may require a Special Inspection.
9. Note signs of bats and cliff swallows at state-owned bridges.
10. Report significant debris or drift to the bridge owner.
11. Take alignment photos from both ends of the bridge. Closing, posting, and/or restriction signs should be visible and legible in the photos.
12. Take elevation photos, preferably for both sides of the bridge, as a minimum on one side of the bridge. If only one elevation photo is taken, a picture of an important detail must be taken.
13. Take photos of all bridge National Bridge Inventory (NBI) Items with a condition rating of 4 or less.
14. If needed to complete the bridge file, take one clear photo under each superstructure type, clearly showing details.
15. If needed to complete the bridge file, take one clear photo of each substructure unit in the water.
16. If needed to complete the bridge file, take one photo looking at the upstream channel.
17. If needed to complete the bridge file, take one photo looking at the downstream channel.
18. If needed to complete the bridge file, take one photo of any fracture critical member or details.

19. If needed to complete the bridge file, take one photo of any detail that requires a Special Inspection.
20. Take photos of significant collision damage.
21. Note if a new load rating is warranted.
22. Verify that the protection required to shield the bridge from traffic on navigable waters is in place.
23. Identify any Critical Findings and notify the appropriate individuals and agencies identified in Part 1-4.02.

1-2.04(03) Inspection Frequency

Bridges must receive a Routine Inspection every 24 months unless widespread deterioration dictates more frequent inspections. If only a portion of a bridge needs more frequent inspections, a Special Inspection is required.

Bridges with a rating of 4 or less for the deck, superstructure, substructure, or culvert rating shall have a reduced interval between Routine Inspections. *A maximum inspection interval of 12 months will be used*.

1-2.05 Fracture Critical Inspections

1-2.05(01) Purpose

Fracture Critical Inspections (92A) are regularly scheduled inspections to examine the fracture critical members or member components of a bridge. Fracture critical members are steel tension members or steel tension components of members, whose failure would probably cause all, or a portion of, the bridge to collapse. Fracture critical members require more thorough and detailed inspections than the members of non-fracture critical bridges. Fracture Critical Inspections are explained in detail in 4-4.0 and the BIRM (Bridge Inspection Reference Manual).

1-2.05(02) Precision

Every Fracture Critical Inspection must follow a Plan of Action. The Plan of Action must include:

1. A time table for conducting the inspection.
2. The personnel requirements for the inspection.
3. A list detailing what is required to be inspected.
4. The required access equipment.

5. The required traffic control.
6. A sketch showing the location of all fracture critical members.
7. A table listing the locations of the fracture critical members and connections with comments regarding the condition of the member.

A Fracture Critical Inspection is a hands-on inspection. “Hands-on” means a visual/manual inspection made at a distance no greater than arm’s length of the entire member or member component surface, including gusset plates. The observations and measurements are used to determine the structural capacity of the member or member component, identify critical findings, identify any changes from previous inspections, and ensure that the bridge continues to satisfy present safety and service requirements. Under-bridge access equipment may be required to move the inspector within arm’s length of the critical members. There may be permanent work platforms and walkways available on some larger bridges to aid in inspection work or the members may be reached by climbing

Critical findings shall be reported to the appropriate individuals and agencies identified in 1-4.02.

All inspection results should be fully documented in BIAS.

If a bridge is scheduled for a Fracture Critical Inspection, but the road is closed to traffic, the inspection team should follow the steps outlined in 1-2.12 of this chapter.

1-2.05(03) Frequency

A Fracture Critical Inspection is required at regular intervals not to exceed 24 months. A fracture critical member with a rating of 4 or less shall have the frequency of inspection reduced to no greater than 12 months.

1-2.06 Underwater Inspections

Underwater Inspections are a necessary part of an effective State Bridge Management Program, and are mandated by the FHWA on routine intervals for bridges with substructure units in water that cannot be waded or probed.

See Figure 1-2.5 for an example of an inspector conducting a wading inspection.

1-2.06(01) Purpose

Because most problems that occur under water do not become visible from the surface until they are critical, bridges with substructure units in water must be inspected to ensure they are sound.

Underwater Inspections are called for if scour and the condition of elements below water cannot be assessed because:

1. The substructure unit is in deep water during the entire year. Inspectors are expected to visit the site at various times to find a time when the water level and current are low enough to safely gather the necessary data as a part of the Routine Inspection; and,
2. At the lowest flow during the year, the water is too deep. Generally, if the velocity times depth is equal to or greater than 10, inspectors should not attempt wading,
3. The channel bottom is too soft for safe wading, or
4. Hazardous water quality exists.
5. At the lowest flow during the year, the water is too deep for probing from a boat.

1-2.06(02) Precision

Every Underwater Inspection must follow a Plan of Action. The Plan of Action must include:

1. A time table for conducting the inspection.
2. The personnel requirements for each portion of the inspection.
3. A list detailing what is required to be inspected.
4. The required access equipment.
5. The required traffic control.

An Initial Underwater Inspection should include the items listed above. Subsequent inspections may be modified based on field conditions. For example, the number of cross sections may be reduced if the inspector is confident that the stream is stable.

1. A detailed listing of the divers participating in the inspection complete with duties performed and a complete listing of credentials. This will include diving credentials and

Bridge Inspection Team Leader and Team Member numbers issued by the Bridge Program Manager (SPM). This information must be placed on the first section of the inspection report.

2. A detailed Channel Survey as described in 1-2.10 of this chapter, including channel soundings and waterline elevations.
3. Photographs including:
   a. Overall views of the Bridge.
   b. General views of each substructure unit (both sides and noses).
   c. Significant defects.
   d. Typical material condition at the water line.
4. Sketches showing:
   a. The substructure layout, including overall bridge length and each substructure unit length and width.
   b. The shoreline limits upstream and downstream of the bridge.
   c. A north arrow.
   d. The width of the channel at the bridge.
5. A record of the water velocity at the deepest point in the channel.
6. A record of the channel bottom material adjacent to all submerged substructure units.
7. A record of the shoreline conditions and material.
8. A check of the foundation type to ensure it has been correctly coded in Item 113.
9. Complete pre-dive and post-dive checklists.
10. A record of defects, noting section loss and dimensions.
11. Notifying of the owner of any significant deficiencies.
12. Reviewing available plans against the current condition for changes.
13. Making preliminary recommendations if needed.

All inspection results should be fully documented in the BIAS. Critical findings shall be reported to the appropriate individuals and agencies identified in 1- 4.02.

See Figure 1-2.6 for an example of a diver at a pier.

Due to limited underwater visibility, the inherent access restrictions of the underwater environment, and the presence of marine growth, the required underwater inspection precision depends on the level of effort. Three underwater diving inspection levels of effort are defined by the FHWA. A standard Underwater Inspection in Indiana requires a Level I effort on 100 percent of all underwater elements. A Level II or III effort shall be conducted only if defects or advance deterioration are found or suspected, and then only at the direction of the SPM.

A summary of the Inspection Levels and typical detectable defects is provided in Figure 1-2.7. A narrative description of each level follows.

Level I Effort

A Level I Inspection is a visual or tactile examination using large sweeping motions of the hands where visibility is limited. A Level I effort must be detailed enough to detect obvious major damage or deterioration due to overstress or other severe deterioration. It should confirm the full-length continuity of all members and detect undermining or exposure of normally buried elements. A Level I effort also includes limited probing of the substructure and adjacent channel bottom.

Level II Effort

The Level II effort is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling. A Level II inspection requires marine growth to be removed from portions of the bridge. The thoroughness of cleaning should be governed by what is necessary to discern about the condition of the underlying material. A detailed inspection of a representative sample of the components is required. For piles, a 12-inch high band should be cleaned at designated elevations, generally near the waterline, at the mudline, and midway between the waterline and the mudline. On an H-pile, marine growth should be removed from both flanges and the web. On a rectangular pile, the marine growth removal should include at least three sides; on an octagonal pile, at least six sides; and on a round pile, at least three-fourths of the perimeter. On piles with a diameter of three feet or greater, one-foot squares should be cleaned at four locations spaced approximately equally around the perimeter, at each designated elevation. On large, solid-faced elements such as pier shafts, one-foot squares should be cleaned at four random locations, at each designated elevation. The Level II effort should also focus on typical areas of weakness such as attachment points and welds. Figure 1-2.8 shows a view of a typical Level II effort.

Level III Effort

The Level III effort is generally limited to key structural areas which are suspect or areas which may be representative of the underwater structure. A Level III Inspection typically involves NDT or partially-destructive testing (PDT) to detect hidden or interior damage, or to evaluate material homogeneity. Testing techniques typically include the use of ultrasonic, coring or boring, and in-situ hardness testing. Refer to Part 6 of this manual for additional information on NDT and PDT. Refer to Figures 1 -2.9 and 1-2.10 for views of inspectors conducting Level III efforts.

The SPM will be notified of all Critical Findings identified in this inspection, as detailed in Part 1-4.02 of this manual. Critical Findings will be submitted in BIAS for all bridges.

All inspection results should be fully documented in BIAS.

1-2.06(03) Frequency

The standard interval for Underwater Inspections is 60 months. This interval is for bridges that are in good condition underwater, located in passive, nonthreatening environments, and have not had any significant changes in the submerged substructure units or channel bottom since the previous Underwater Inspection. If warranted due to deficiencies or deterioration, the inspection interval may be reduced to less than 60 months.

A frequency of 48 months is to be used when there have been changes in the submerged substructure units or channel bottom since the previous inspection that are serious enough to warrant tighter scrutiny, but not serious enough to require corrective action.

A 36-month frequency is to be used when there have been substantial changes in the submerged substructure units or channel bottom since the previous inspection, or problems have developed that require corrective action.

A 24-month frequency is to be used when serious submerged substructure unit deterioration or scour/channel problems exist. The deficiencies should be immediately addressed, or the bridge should be rehabilitated or replaced in the very near future.

A 12-month frequency is to be used when very critical submerged substructure unit deterioration or scour/channel problems exist. The deficiencies should be immediately addressed or the bridge should be rehabilitated or replaced in the very near future.

The investigation into the need for an Underwater Inspection may begin at the initial inspection. Follow the guidelines of 1-2.06(01) to verify the need for an underwater inspection. Addition of an underwater inspection require the concurrence of the SPM. When the current frequency is out of compliance to the frequencies outlined above, the Inspection Team Leader shall write the SPM requesting a change in frequency citing the reasons as listed above.

Increasing frequency: The inspection frequency may be increased from a reduced frequency if the situation that required the reduced frequency has been properly addressed or if it has been observed over several inspections the situation has stabilized. The increase in frequency will be made in writing and must have the approval from the SPM.

1-2.07 Special Inspections

1-2.07(01) Purpose

Special Inspections (92C) are scheduled to examine a portion of a bridge in more detail or at a greater or lesser frequency than is standard for Routine Inspections. Special Inspections may provide follow-up after a Routine, Damage, or Initial Inspection. The Special Inspection mandates the component being inspected is at arm's length, and NDE methods utilized when necessary to complement visual evaluations.

Details and bridges that may require a Special Inspection include the following:

1. Fatigue category E and E' details (includes: welded cover plates, if not determined by analysis to have an infinite fatigue life, or retro-fitted and gusset plates with lateral bracing).
2. Hangers of all types
3. Hinge or pin connections
4. Known defects, significant section loss/deterioration, or damage severe enough to warrant extra scrutiny
5. Unique or problematic details as determined by the SPM

Complex Bridges that require a Special Inspection include the following:

1. Bridges designated by the SPM
2. Cable-stayed bridges
3. Movable bridges
4. Suspension bridges

Figure 1-2.11 shows an example of a cantilevered bearing bridge.

1-2.07(02) Precision

Special Inspections may include a Plan of Action, if required. The Plan of Action may include:

1. A time table for conducting each inspection.
2. The personnel requirements for each portion of each inspection.
3. A list detailing what is required to be inspected under each inspection.
4. The required access equipment needed for each inspection.
5. The required traffic control for each inspection.

For bridges that require a Special Inspection because of unique or problematic details, the inspector must make sufficient measurements and observations to quantify the deficiencies to allow for future monitoring. Inspectors should document:

1. The physical and functional conditions of the known or suspected deficiency.
2. Any developing problems such as deterioration, foundation settlement, scour or erosion of the slopes, scour at the supports, ice damage, or other problems that, if left unchecked, would degrade the load-carrying capacity of the bridge.
3. Signage is in place and visible for load-posted or restricted bridges.
4. The ability of the bridge to satisfy its present service requirements.

Inspection results must be recorded in BIAS. The date of the inspection and a list of the deficiencies investigated must be included. If any deficiency has become more severe, it may be necessary to notify the owner and re-evaluate the bridge load rating. Critical findings shall be reported to the appropriate individuals and agencies identified in 1-4.02.

Some Special Inspection tasks need not be performed with an Inspection Team Leader on site. Inspection Team Members can be sent out to perform specific inspection or measurement tasks under the direction of an Inspection Team Leader. Such tasks might include measuring a crack, photographing a weld, or measuring section loss on specific members. These tasks must be clearly documented in the Special Inspection Plan of Action. The Inspection Team Leader is still required to review and sign off on all inspection data entered into BIAS.

For state-owned complex bridges that require a Special Inspection, a lead Inspection Team Leader is assigned by the State Program Manager. The Plan of Action will be developed and modified by the lead Inspection Team Leader in consultation with the State Program Manager.

The lead Inspection Team Leader for state-owned complex bridges may or may not be the Inspection Team Leader for any individual inspection performed as a part of the Special Inspection. The Inspection Team Leader for each individual inspection will approve the inspection results entered in BIAS for that inspection. The lead Inspection Team Leader must review all individual inspections performed as a part of the Special Inspection, as well as generate/approve a summary of the Special Inspection. This summary must be entered in BIAS.

Inspection teams for state-owned complex bridges may consist of state personnel, consultants, or a combination. The lead Inspection Team Leader will ensure that each team is working within the scope of its professional ability.

For toll road, county, and local agency complex bridges that require a Special Inspection, a lead Inspection Team Leader may be assigned by the Inspection Consultant but must be approved by the SPM.

The Plan of Action will be developed and modified by the lead Inspection Team Leader in consultation with the State Program Manager.

The lead Inspection Team Leader must review all individual inspections performed as a part of the Special Inspection, as well as generate/approve a summary of the Special Inspection. This summary must be entered into BIAS.

Depending on the extent of the damage or deterioration, a Special Inspection may include a recommendation for a load rating to assess the capacity of damaged or deteriorated members. Nondestructive tests and/or other material tests may be needed to assist in determining the safe load-carrying capacity.

Critical findings shall be reported to the appropriate individuals and agencies identified in 1-4.02

All inspection results should be fully documented in the BIAS.

Figure 1-2.12 shows an example of a Load-Posted Truss Bridge

1-2.07(03) Frequency

Special Inspections for unique and problematic details are completed in addition to Routine Inspections. The maximum inspection interval for a Special Inspection is 60 months. A problematic detail that is performing well on a structure can have an inspection interval of 60 months. A structure with a problematic detail that has a rating of 4 or less shall be inspected on a 12 month interval.

A written request should be sent to the SPM requesting the Special Inspection be removed if the detail has been retrofitted or rehabilitated.

The inspection frequency of each component inspection of a Special Inspection for a complex bridge may be identified in the Plan of Action. It may be most efficient to conduct all of the inspections at one time, using the same inspectors. However, it may not be practical to schedule inspections requiring different types of traffic control, access equipment, or NDT at the same time.

Figure 1-2.13 shows Inspectors performing a special inspection.

1-2.08 In-Depth Inspection

1-2.08(01) Purpose

An In-Depth Inspection is a close-up inspection that allows for the detection of deficiencies that aren't readily identifiable during a routine inspection. The term close-up is used which indicates this is not a hands-on inspection but is still well within visual range so that defects can be seen.

An In-Depth Inspection is a scheduled inspection which is scheduled at a maximum 96 month interval for structures that meet the following criteria:

1. The structure is of the type that does not require a scheduled hands on inspection
2. The structure contains elements not easily inspected during a routine inspection
3. The structure has been selected by the Program Manager

1-2.08(02) Precision

The scope of an In-Depth Inspection should be to inspect the entire structure close-up. This is a relatively infrequent inspection scheduled for structures that typically do not require a scheduled inspection beyond the routine inspection. This inspection will give the inspector the opportunity to make sure that all of the components of the structure are performing as intended.

1-2.08(03) Frequency

The maximum frequency of an in-depth inspection is 96 months.

1-2.09 Damage Inspections

1-2.09(01) Purpose

A Damage Inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions. Flood damage, fire damage, barge impact, and vehicle impact are examples of events that may call for a Damage Inspection.

Figure 1-2.14 shows impact damage to a concrete girder bridge.

1-2.09(02) Precision

The scope of a Damage Inspection should be sufficient to determine whether there is a need for emergency load restriction, or closure of part or all of the bridge to traffic. Inspectors of state-owned bridges should also assess the level of effort necessary to repair the damage. The amount of effort expended on this type of inspection may vary significantly and depends on the extent of the damage. If major damage has occurred, the inspector shall document the damage, including measuring section loss or misalignment, and any loss of foundation support.

Inspection data and pictures shall be entered into BIAS as soon as possible, and no more than seven days after the inspection. This inspection may be supplemented by a timely Special Inspection to more fully document the extent of damage and the urgency and scope of repairs. A more refined analysis, to establish or adjust interim load restrictions, may also be required as follow-up for a Damage Inspection. A structural engineer may need to be consulted for the inspection or analysis. If the inspection identifies a Critical finding, the inspector must follow the notification procedures outlined in 1-2.04.

A damage inspection is required for all bridges in which the event has left permanent physical evidence. The damage inspection data and pictures shall be entered into BIAS as soon as possible and no more than seven days after the inspection.

The Inspector of state-owned bridges should gather data on the vehicles and drivers involved and any police report after a crash. This information will be used to bill the appropriate insurance company for damages.

1-2.09(03) Frequency

A Damage Inspection is an unscheduled inspection that is performed to determine if significant damage has been done to the bridge. Based on the findings of the damage inspection, the inspector will determine if the damage warrants placing the structure on a special detail inspection. Pictures of any damage will be uploaded into BIAS with a complete description of the event. Generally, a law enforcement officer on the site of an accident involving a bridge will notify the owner who will request a Damage Inspection be performed to determine if the bridge should be closed. Damage Inspections may be needed after flooding or earthquakes.

1-2.10 Channel Surveys

1-2.10(01) Purpose

Scour is the movement of channel bed material by the action of moving water. This movement may result in degradation (i.e., erosion of material), as well as aggradation (i.e., accumulation of material). These changes in the channel bed may lead to bridge instability and are generally identified by profiling the channel bottom. Comparison of previous profiles is typically needed to detect and assess scour. Plotting the underwater measurements of the stream bottom and probing bridge foundations are two of the most important aspects of inspecting a bridge for scour.

Channel cross section data is used to evaluate trends in channel bottom movement and to compare channel bottom elevations to footing elevations. Indiana has two levels of Channel Survey: basic and in-depth.

1-2.10(02) Precision

For all Channel Surveys, the elevation of the waterline must be determined and referenced to a known elevation on the bridge.

For a basic Channel Survey, bottom elevations are required:

1. At the upstream fascia, locate enough points between substructure units to identify any problems or deficiencies. Typically the elevations are taken at locations spaced between 10 and 25 feet depending on the contours of the channel. The notes of how to layout the survey must be kept in BIAS. Once the survey method and points are determined, the process can be repeated when a change in the stream profile. Create a profile sketch and plot the profile on the sketch. Future profile data can be added in BIAS.

For an in-depth Channel Survey, bottom elevations are required:

1. Around each substructure unit in the water at enough points to identify any problems or deficiencies.
2. Between substructure units along the centerline of the bridge, or between twin bridges at enough points between substructure units to identify any problems or deficiencies. A minimum of three points between each substructure and one point at each substructure is required.
3. At the upstream fascia, at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.
4. At the downstream fascia at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.
5. 100 feet upstream at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.
6. 200 feet upstream at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.

7. 100 feet downstream at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.
8. 200 feet downstream at enough points between substructure units to identify any problems or deficiencies. A minimum of one point at each substructure and three points between each substructure is required.
9. At additional locations, if required, to adequately determine the thalweg of the waterway.
10. As needed when an unusual change in the channel has been identified.

Where the bridge length is less than 100 feet, the upstream and downstream profiles should be taken at locations equal to the bridge length and twice the bridge length.

Every in-depth Channel Survey Inspection will follow a Plan of Action. The Plan of Action must include:

1. A time table for conducting the survey.
2. The personnel requirements for the survey.
3. A list detailing what is required to be surveyed.
4. The required access equipment.
5. The required traffic control.

Water depth measurements should be recorded to the nearest tenth of a foot. Scour evaluations are typically based on changes in elevations greater than 0.5 foot since most channel bottoms are irregular surfaces with random cobbles, debris, and sand ripples.

The water surface elevation should be referenced to a known elevation or reference point on or near the bridge.

The individuals taking the profiles need not be bridge inspectors. However, the profiles must be reviewed and compared to known substructure elevations and past profiles by the Inspection Team Leader.

1-2.10(03) Frequency

Channel Surveys are performed concurrently with many of the required inspections of a bridge over water. After the initial basic Channel Survey is completed, additional Channel Surveys shall be performed after large flood events or when channel changes have occurred. A basic Channel Survey is required for all Initial Inspections, all Underwater Inspections, and as required in the Scour Plan of Action for Scour Critical Bridges.

Figure 1-2.15 shows an example of aggradation and vegetation in a channel.

1-2.11 Large Culvert Inspection

Large culverts are culverts (structures) with spans greater than four feet and less than or equal to 20 feet. Figure 1-2.16 shows an example of a large culvert.

1-2.11(01) Purpose

Large Culvert Inspections are basically Routine Inspections for these types of structures. They are regularly scheduled inspections consisting of observations and measurements needed to determine the physical and functional condition of the structure to identify any changes from previously recorded conditions. The Large Culvert Inspection also ensures that the structure continues to satisfy present service requirements.

1-2.11(02) Precision

These inspections should be conducted with the same precision and attention to detail outlined for Routine Inspections in Section 2.4.

The State Program Manager should be notified of all Critical Findings identified in this inspection as detailed in 1-4.02 of this manual. Critical Findings should be created in BIAS for all structures.

All inspection results should be fully documented in BIAS.

1-2.11(03) Frequency

All state-owned large culverts should be inventoried. State-owned large culverts with a condition rating of 6 or above may be scheduled for a Large Culvert Inspection not to exceed 60 months.

State-owned large culverts with a condition rating of 5 should be scheduled for a Large Culvert Inspection every 24 months. State-owned large culverts with a condition rating of 4 or less should be scheduled for a Large Culvert Inspection every 12 months as a minimum.

All Indiana Toll Road large culverts should be inventoried. Indiana Toll Road large culverts should be inspected as described above for INDOT large culverts.

County and local agency large culverts should be inspected at the discretion of the owner in consultation with the Inspection Consultant. It is recommended that all counties inventory all large culverts.

Large Culvert Inspections may be scheduled in conjunction with any other inspection type.

1-2.12 Bridges Closed To Traffic

If a bridge is **closed for construction** when an inspection is due, the inspection team shall:

1. Document the bridge is properly closed with photos. If the bridge is being used to maintain traffic, the bridge must be inspected.
2. Code NBI #41 as “G” (new structure not yet open to traffic) or “K” (closed to traffic), as appropriate, in BIAS.
3. Code the appropriate NBI Date Item(s) with the date the inspectors were at the bridge.
4. Note that the inspection date was changed in the Central Data base
5. Verify the estimated date of completion of the construction.
6. Schedule a new Initial Inspection and all other required inspections for the estimated completion date. All rescheduled inspections must be completed within 90 days of being opened to traffic. The Routine Inspections shall remain in the month that it had been prior to construction, once the Initial Post-construction Inspection is complete.
7. Leave other NBI data items unchanged.

If a bridge has been **closed permanently** when inspection is due, the inspection team shall:

1. Document the bridge is properly closed with photos. No other inspection work is required. If the bridge is not properly closed, a critical finding must be immediately submitted.
2. Code NBI #41 as “K” (closed to traffic) in BIAS.
3. Code the appropriate NBI Date Item(s) with the date the inspectors were at the bridge.
4. Note that the inspection dates were changed in the BIAS.
5. Leave other NBI data items unchanged.
6. Recommend the removal of the bridge be scheduled as soon as possible.

1-3.0 REPORTING SYSTEMS

1-3.01 Bridge File

The bridge file is the collective term for all documents necessary to provide a comprehensive history of each Bridge Asset. There are two official repositories for documents that comprise the bridge file: the Bridge Inspection Application System (BIAS) and the INDOT Electronic Records Management System (ERMS). The FHWA *Manual for Bridge Evaluation* contains various documents that should be included in the bridge file. At a minimum, the bridge file is to contain the following documents prior to being identified as complete. Each item is annotated with the required repository.

1. Bridge Inspection Reports – BIAS. A minimum of 10 years of inspection history is required for all assets more than 10 years old.
2. Scour Screening/Scour Assessment - BIAS
3. Load Rating Reports – BIAS and Load Rating Calculations/Models - ERMS
4. Original Plans (Either Approved Design signed by PE or As-Built Record) - ERMS
5. All Bridge Rehabilitation Plans (Either Approved Design signed by PE or As-Built Record) - ERMS
6. Hydraulic Calculations/Hydraulic Models - ERMS
7. Asbestos Reports – ERMS
8. Significant Correspondence – ERMS. Significant correspondence includes agreements regarding inspection responsibility, ownership, or other issues that have an impact on timely inspections.
9. Scour Plan of Action – ERMS. For scour critical bridges, provide a copy of the plan of action.
10. Memoranda of Agreement (including Maintenance Agreements), where applicable – ERMS
11. Relinquishment Agreements, where applicable - ERMS

BIAS

All bridge reports, including bridge inspection, scour screening, scour assessment, and load rating are to be housed in BIAS. Bridge inspection reports - routine, fracture critical, under water, special, damage, and other - must be created in a BIAS report. All report sections must be added in the Report Sections tab - Add Sections/PDF Attachments and the file uploaded into the report. The added sections must also be included in the report table of contents. Uploading a PDF attachment without adding it to the report reduces the efficiency of retrieving/reviewing the information and is not acceptable.

The required bridge inspection report sections are listed below. Instructions on how to create a report in BIAS and upload a file into a report as well as the required file naming convention are attachments to this memo and will be available for future reference from the INDOT Bridge Inspection webpage.

The required report sections in a bridge inspection report include the following:

1. Report Cover.
2. Location Map.
3. Executive Summary. The executive summary is to include a general statement of condition of the bridge and a statement of areas of concern.
4. National Bridge Inventory and Miscellaneous Asset Data.
5. Field Inspection Information. Field inspection information is to include sketches and photographs showing typical and deteriorated conditions. A brief narrative is required to justify a change in condition rating. An NBI item rated below 5 or condition state 3 requires a picture or sketch in addition to narrative descriptions of the deteriorated condition. A plan of action is to be included, if required. All pictures inspection report are to be labeled.
6. Critical Findings. Critical finding documentation is to be in accordance with Part 1of the Bridge Inspection Manual.
7. Waterway Information. Waterway information is to be in accordance with Part 1 of the Bridge Inspection Manual.
8. Other Inspection Procedures. Other inspection procedures include other required reports such as fracture critical and under water. These reports are to be in accordance with Part 1of the Bridge Inspection Manual.
9. Load Rating. Load rating documentation is to include a dated load rating along with identification of the analysis used to determine capacity. Results are to clearly identify the loads and methodology used in the analysis. Controlling structural members are to be identified. Include any updates that reflect changes in the condition of structural members. If calculations cannot be provided due to lack of information, documentation to support the determined load rating is to be provided.
10. Posting Documentation. Posting documentation is to be in accordance with Part 1 of the Bridge Inspection Manual.
11. Scour Assessment. The assessment conducted to determine the scour vulnerability of the bridge is to be documented.
12. Pictures and Sketches. All pictures and sketches in the inspection report are to be labeled.

ERMS

ERMS is the only repository other than BIAS that may house bridge file documents. When properly indexed, documents in ERMS for a bridge asset can be viewed in BIAS from the Asset tab. Instructions on how to upload a file into the ERMS Bridge File Documents folder using the Multiple File Upload Tool and the required file naming convention are attachments to this memo and will be available for future reference from the INDOT Bridge Inspection webpage.

Note: The ERMS County Bridge Inspection Reports folder is for County Summary documents only. All other documents and reports should be in BIAS or the ERMS Bridge File Documents folder.

1-3.02 Structure Identification

1-3.02(01) NBI Item 8 Structure Number

NBI Item 8, Structure Number, is called Item 8, Structure Number (NBI number) in BIAS. This number is assigned by the Inspection Consultant for county bridges and by the State Program Manager for state bridges. This number is seven digits long for county bridges. The first two digits are the county number. State bridges use up to six digit numbers. The NBI number is unique and remains unchanged throughout the life of a bridge. When a bridge is replaced, the new bridge gets a new NBI number.

1-3.02(02) INDOT Bridge Number

The state uses an alpha-numeric numbering system to identify the Indiana Department of Transportation (INDOT) Bridge Number. Up to 19 digits are reserved for this number, excluding parentheses and dashes, and for new bridges it is generally in the form "A (123)456-789-12345 BCDE." The following describes each part of the INDOT Bridge Number:

1. A: Up to one letter to indicate property designation:
   a. I for Interstate bridges
   b. P for state properties including parks, prisons, and hospitals
   c. Blank for bridges on a designated United States (U.S.) or state route (S.R.)
2. (123)456: Up to six digits to designate the road number. Parentheses are required only if the road number has changed. For these situations, indicate the current road number within the parentheses and indicate the old road number to the right of the parenthesis. Do not include leading zeros if the road number is less than three digits (e.g., use 8 and not 008 for Route 8). If the bridge route has changed since being built, as in the example, (123) is the current route and 456 is the route the bridge was originally built on.

3. 789: Up to three digits to designate Interstate log mile or county number, depending on the bridge. If the bridge is located on an interstate, this number is up to three digits long, with no leading zeros, and designates the mile post rounded to the nearest whole mile. If the bridge is located on any other type of road, this is always a two-digit number, with a leading zero if necessary, that designates the county number. There are 92 counties in Indiana. County number 93 is used for border bridges that are inventoried by Kentucky or Illinois, or are Indiana's inventoried bridges located south of the state line on US 41.

4. 12345: Five digits to designate the Structure Number. It is a consecutively assigned number assigned by the State and is not related to Item 8, the Structure Number (NBI Number). Leading zeros are required to ensure five digits. Typically, the 02000 series bridges are reserved for bridges over or under a railroad.

5. BCDE: Up to four letters to designate the structure designation.

   a. The first letter indicates:

      i. J Parallel, but different bridge

      ii. A First contract rehabilitation

      iii. B Second contract rehabilitation

      iv. C Third contract rehabilitation, etc.

   b. The remaining three letters complete the structure designation as follows:

      i. EBL Eastbound Lane

      ii. WBL Westbound Lane

      iii. NBL Northbound Lane

      iv. SBL Southbound Lane

      v. ADJ Adjacent to Mainline

      vi. CD Collector Distributor

      vii. DR Directional Ramp

      viii. R Ramp

      ix. NC Northbound Collector

      x. NWE Northwest-to-East Ramp

      xi. SC Southbound Collector

      xii. DRN Directional Ramp North

      xiii. RWN Ramp West to North

When a bridge is both a parallel bridge and has been rehabilitated, use the first two letters of BCDE to show this and drop the third letter describing the structure designation. For example; JCNB would indicate that the bridge is one of two parallel structures, has been rehabilitated three times, and serves northbound lanes.

Many older bridges within Indiana do not adhere to these guidelines. Bridges along state borders may have special agreements that determine the ownership of the bridges and the bridge number.

1-3.02(03) Toll Road Bridge Numbers

The Indiana Toll Road uses a numbering system similar to the state bridge numbering system that is generally in the form "A(123)456-78-91234 BCD." The following describes the state bridge numbering system:

1. A: One letter coded I for all toll road bridges.
2. (123): Current road number. The leading zero is sometimes omitted.
3. 456: Original road number. This number is omitted if the road number has never changed.
4. 78: Two-digit county code.
5. 91234: Five-digit structure number assigned by the Toll Authority according to the mileage east of the Illinois state line. The Toll Authority does not utilize any special conventions for bridges over or under railroads.
6. BCD: Structure designation similar to the state bridge numbers except the Indiana Toll Road does not assign letters to identify parallel structures or the number of rehabilitations a structure has undergone.

There are several Indiana Toll Road-owned and maintained bridges that were designed and built by the State which have bridge numbers similar to those used by the State.

1-3.02(04) County and Local Agency Bridge Numbers

County and local agency bridge numbers are supplied to INDOT by the County/County Consultant. This number is five digits and may contain letters. A "B" after the bridge number indicates the bridge is the second bridge at this location, using the same Bridge Number. A "C" indicates the third bridge, etc.

In order for a county/local bridge to be entered into BIAS, the county/consultant must supply INDOT the new bridge number, new NBIH, Latitude, Longitude, Features Intersected, Facility Carried, and contract Number and Des# if let through INDOT. INDOT shall create the initial bridge file in BIAS using this information.

1-3.03 County Border Inventory

For state bridges, inventory all bridges along or crossing the north and west borders of a county as being in that county. Inventory all bridges along or crossing the south and east borders of a county as being in the adjacent county.

For county bridges, inventory all bridges along or crossing the south and east borders of a county as being in that county. All bridges along or crossing the north and west borders of a county are inventoried in the adjacent county. See Indiana Code IC: 8-17-1-45(a).

For bridges along the stateline borders, special agreements with the adjacent state/county may determine the ownership and maintenance responsibility of the bridges.

1-4.0 EMERGENCY NOTIFICATION/CRITICAL FINDINGS

1-4.01 Introduction

The procedures in this chapter set forth a uniform method for timely notification of serious bridge deficiencies that require an immediate response. They also document the baseline requirements for assuring that appropriate corrective or protective measures have been taken within a reasonable time frame and that established documentation protocol has been followed. Counties and other local government agencies may have additional guidelines for alternate route information, public relations, and information dissemination procedures that should be followed.

The procedures outlined in this chapter should be used to report conditions posing danger to persons or property or conditions that, if left unattended, would likely become such a danger.

This chapter outlines the responsibilities of the Inspection Team Leader, Inspection Consultants, District Inspection Engineers, and the State Program Manager in an emergency. Any Inspection Team Leader may close any bridge if it appears to be unsafe.

1-4.02 Critical Findings

A critical finding is a structural or safety related deficiency that requires immediate follow-up inspection or action.

A structure-related deficiency can interrupt the load path, not allowing the loads to be transferred as designed. This can cause surrounding elements to become overstressed or unstable, potentially leading to partial or total collapse of the structure. Critical findings may also be non-structural deficiencies which jeopardize the safety of motorists or pedestrians.

The follow-up action may be a structural review to determine the strength or serviceability of an element or bridge.

1-4.02(01) Procedures for Inspectors

Upon identifying a potential critical finding, immediately report the deficiency to the appropriate agency officials. For non-state owned bridges, the finding is to be first reported to the employee of responsible charge (ERC). The finding for state owned bridges and the second reporting for non-state owned bridges is to be the State Program Manager (SPM).

The immediate actions taken by the inspector will vary with the circumstance. The inspector may close all or part of the structure until further analysis can be performed to determine the structural integrity of the structure. Alternatively, the inspector may recommend that remedial work be performed within a short time frame. Even if no immediate action is taken, it is still required to report the potential critical finding immediately, even in situations where the structural review will ultimately resolve the structure as having adequate strength.

In addition to the initial reporting of the potential critical finding, which may be verbal notification, a critical finding must be submitted in BIAS within 24 hours. On the Forms tab, the last field is Critical Finding. The critical finding is created by clicking the plus symbol. Enter all of the requested data and upload picture, sketches, and other related files. The work flow must be changed and assigned to the State Program Manager.

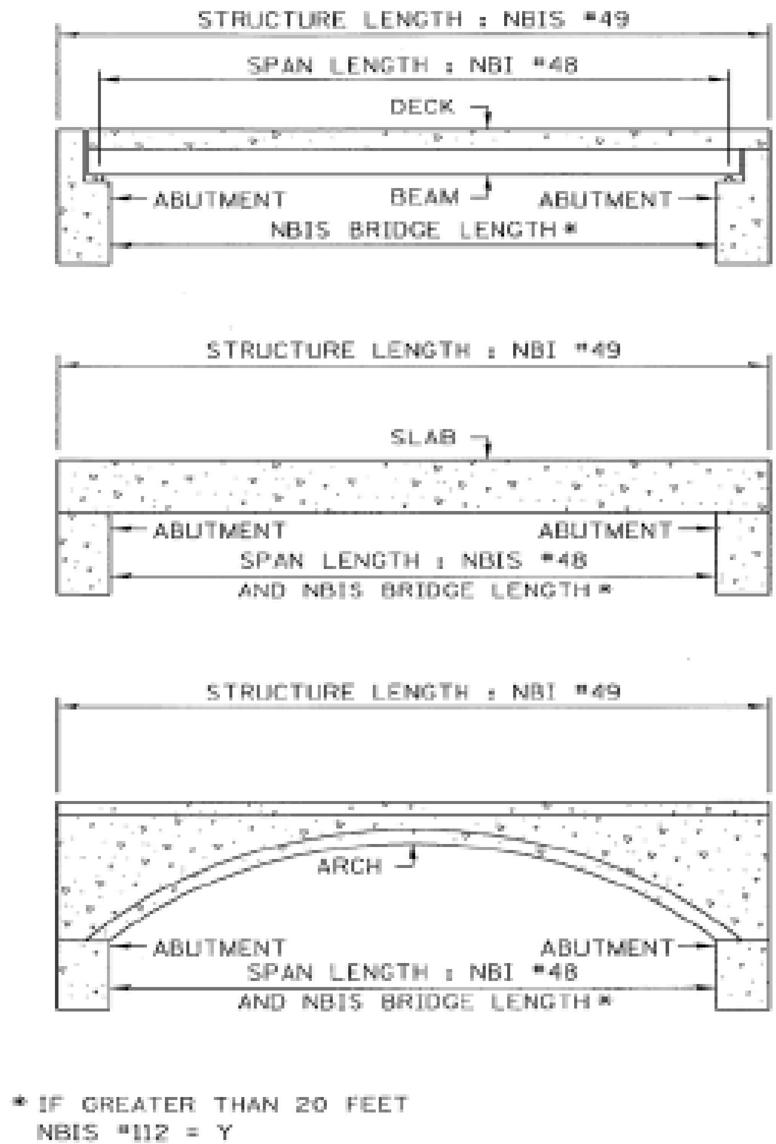
The State Program Manager will record the critical finding for tracking and will notify the FHWA in a timely manner. If further action is required, the SPM will change the workflow back to the inspector. Once the immediate safety concerns are addressed, the inspector will resubmit the critical finding back to the SPM for close out.

1-4.02(02) Documentation

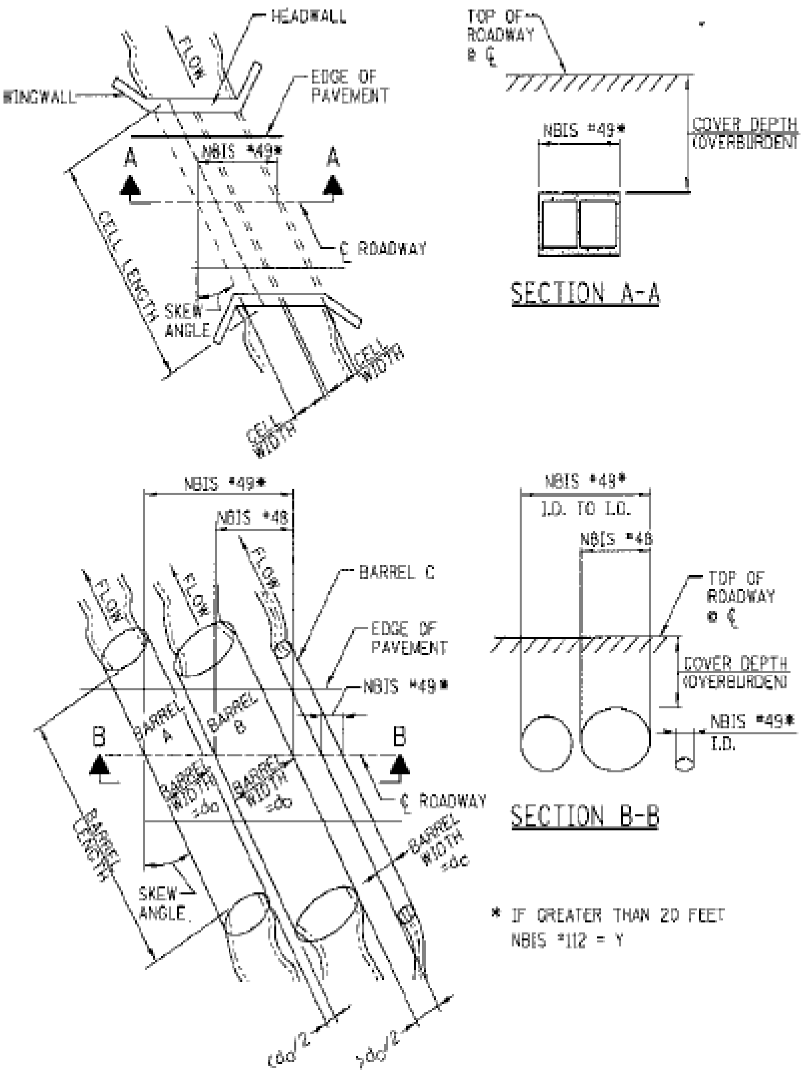
Critical Findings must be documented in BIAS within 24 hours for all bridges. The Critical Finding will become a permanent record in the bridge file.

FIGURES

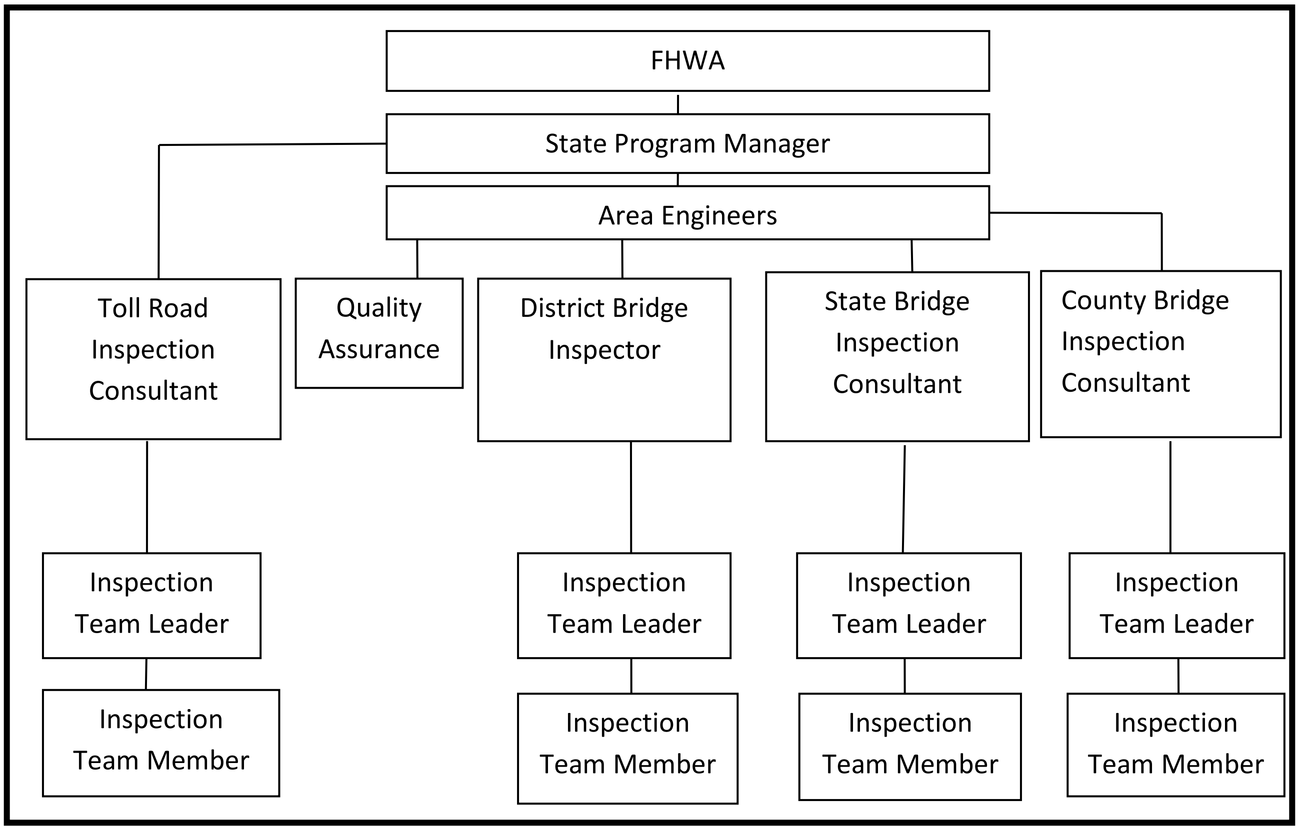
1-1.1: Bridge Structure Measurements



1-1.2: Additional Bridge Structure Measurements



1-1.3: State Bridge Inspection Program Organization



1-2.1: Arch Bridge Near Spring Village

1-2.2: Bridge Inspection Types and Maximum Intervals

Inspection Type	Maximum Inspection Interval	Agency
Initial	After Construction or Major Rehabilitation 90 Days	FHWA Mandate
Routine	24 months	FHWA Mandate
Fracture Critical* (92A)	24 months	FHWA Mandate
Underwater (92B)*	60 months	FHWA Mandate
Special (92C)	60 months	FHWA Mandate
In-Depth	96 months	INDOT Policy
Damage	As needed	FHWA Mandate
Channel Survey	As required	INDOT Policy
Large Culvert	60 months	INDOT Policy

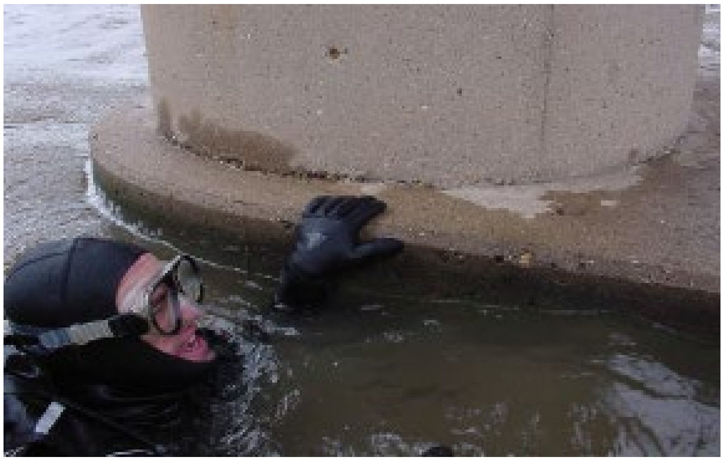
* Plan of action required

1-2.3: Inspector Performing an Initial Inspection

1-2.4: Steel Girder Bridge

1-2.5: Inspector Conducting a Wading Inspection

1-2.6: Diver at Pier

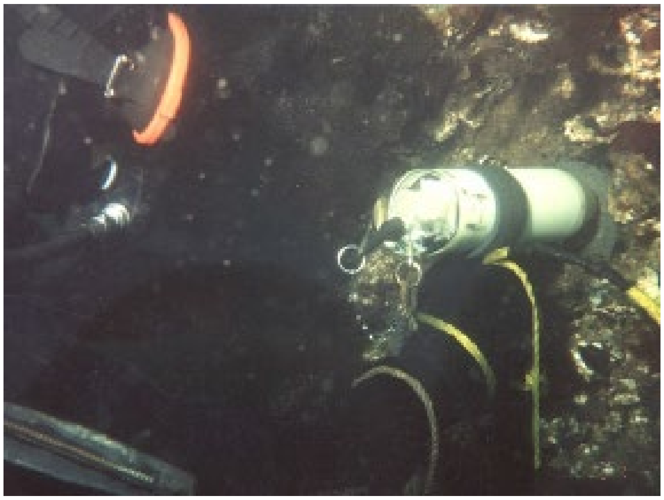


1-2.7: Summary of Inspection Intensity Levels

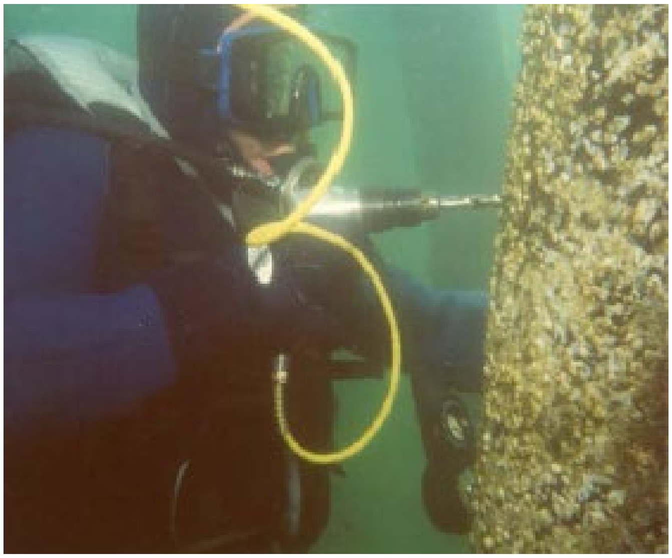
Level	Purpose	Typical Detectable Defects			
		Steel	Concrete	Timber	Composite
I	General visual/tactile inspection to confirm as-built condition and detect severe damage	Extensive corrosion and holes Severe structural damage	Major spalling and cracking Severe reinforcement corrosion Broken piles	Major loss of section Broken piles and bracings Severe abrasion or marine borer attack	Permanent deformation Broken piles Major cracking or structural damage
II	To detect surface defects normally obscured by marine growth	Moderate structural damage Corrosion pitting and loss of section	Surface cracking, spalling, erosion Rust staining Exposed reinforcing steel and/or prestressing strands	External pile damage due to marine borers Splintered piles Loss of bolts and fasteners Rot or insect infestation	Cracking Delamination Material degradation
III	To detect hidden or interior damage, evaluate loss of cross-sectional area, or evaluate material homogeneity	Remaining thickness of material Electrical potentials for cathodic protection Change in material properties	Onset of reinforcing steel corrosion Internal voids Change in material properties	Internal damage due to marine borers (internal voids) Decrease in material strength Change in material properties	Change in material properties

1-2.8: Inspector Conducting a Level II Inspection Effort

1-2.9: Inspector Using a D-Meter to Conduct a Level III Inspection



1-2.10: Inspector Using a Drill in a Level III Inspection



1-2.11: Cantilevered Bearing

1-2.12: Load-Posted Truss Bridge

1-2.13: Inspectors Performing a Special Inspection

1-2.14: Impact Damage to a Concrete Girder Bridge

1-2.15: Aggradation and Vegetation in Channel

1-2.16: Large Culvert

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CHAPTER 1 INTRODUCTION

1.1 PURPOSE

Federal Regulation 23 CFR 650.313(g) requires each state use systematic quality control and quality assurance procedures to maintain a high degree of accuracy and consistency in the State Bridge Inspection Program. In order to meet this requirement, bridge owners shall implement the quality control and quality assurance measures described herein.

Quality control and quality assurance procedures shall include periodic field review of inspection teams, periodic bridge inspection refresher training, and independent review of inspection reports and computations.

1.2 SCOPE

This manual outlines the following items in the state quality control and quality assurance program:

- Bridge inspection training
- Quality control roles and review procedures
- Quality assurance roles and review procedures
- Maintenance of the bridge file
- Identification and resolution of data errors, omissions, and/or changes
- Disqualification and requalification processes

1.3 DEFINITIONS

- **Bridge Inspection Training:** Training that covers all aspects of bridge inspection and enables inspectors to relate conditions observed on a bridge to established criteria.
- **Critical Finding:** A structural or safety related deficiency that requires immediate follow-up inspection or action.
- **Inspecting Agency:** The organizational unit responsible for conducting or overseeing bridge inspection. The inspecting agency for a state-owned bridge is the appropriate District. The inspecting agency for a county, toll road, or other locally owned bridge is the Inspection Consultant.
- **Load Rating:** The determination of the live load-carrying capacity of a bridge using bridge plans and supplemented by information gathered from a field inspection.
- **Quality Assurance (QA):** The use of sampling and other measures to assure the adequacy of quality control procedures in order to verify or measure the quality of the inspection and load rating programs. Typically conducted from outside of the inspecting agency for the purpose of evaluating the quality of the program overall.
- **Quality Control (QC):** Procedures intended to maintain the quality of a bridge inspection and load rating at or above a specified level. Typically conducted from within an inspecting agency for the purpose of providing consistency within the inspecting agency, or from an external source when reviewing data for a specific district, county, toll road, or local agency.

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CHAPTER 2 QUALITY CONTROL

2.1 INSPECTION AND LOAD RATING TEAMS

The qualifications and responsibilities for the individuals performing inspections and load ratings are discussed in Part 1, Chapter 2, Section 2.4.

2.2 INSPECTION PROCESS

For information related to LPA – Consultant Bridge Inspection Contracts please refer to the Local Public Agency Project Development Process Guidance Document which can be found on the INDOT website.

2.3 QUALITY CONTROL REVIEWER (QCR)

A designated quality control reviewer must have team leader credentials. For firms without an active second Inspection Team Leader, another consulting firm with a qualified Inspection Team Leader will need to act as the quality control reviewer.

The QCR:

- Shall not be a member of the original inspection team to ensure an independent review.
- Shall have knowledge of required procedures and practices, as well as federal or state requirements.

2.4 QUALITY CONTROL OFFICE REVIEW

2.4.1 Purpose and Scope

The primary goal of the Quality Control Office Review is to ensure the accuracy and consistency within an Inspecting Agency, and completeness of the inspection data and all required reports. This should include reviewing the data and reports to make certain that they meet both federal and state requirements. Prior to the Quality Control Office Review, the Inspection Team Leader should run all data checks and make all required corrections.

2.4.2 Quality Control Criteria

This review by the QCR shall include the following:

- The quality control review will follow the NBIP File Review Checklist and forms that can be found in appendix of part 2.
- The metrics to be assessed in the review are: 12, 13, 14, 15, 16, 17, 18, 22, and 23.
- Guidance for evaluation criteria and metric commentary may be found in the Federal Highway document *Metrics for the Oversight of the National Bridge Inspection Program.*
- The Federal Highway document may be found at: http://www.fhwa.dot.gov/bridge/nbip/metrics.pdf

2.4.3 Sampling

The Quality Control Office Review shall be performed on bridges selected from a group that meet any of the following criteria if available:

- A rating of 4 or less for Items 58, 59, 60, or 62
- A rating that changed by two or more for Items 58, 59, 60, or 62
- A rating of 3 or less for Item 113A
- Posted

For the purposes of quality control, each team leader will ensure that two bridge files are reviewed per year. On or before June 1st and November 1st of each year a report will be available upon request. The quality control file will include the quality control office review forms filled out for the reporting period. The reports will remain in the file for three years.

2.5 QUALITY CONTROL FIELD REVIEW

2.5.1 Purpose and Scope

The primary goal of the Quality Control Field Review is to ensure consistency within an Inspecting Agency of the field inspection and data collection. The review will evaluate the consistency and accuracy of component ratings, inventory items, and adequacy of photographic documentation, notes, and recommended maintenance actions.

A Quality Control Field Review involves a field inspection of a bridge, including verification of data incorporated in the inspection report. The field inspection should take place within twelve months of the original inspection to ensure that conditions have not changed significantly.

2.5.2 Quality Control Criteria

This review should include the following:

- Perform an independent field review
- The quality control review will follow the NBIP File Review Checklist and forms that can be found in appendix of part 2.
- The metrics to be assessed in the review are: 12, 13, 14, 15, 16, 17, 18, 22, and 23.
- Guidance for evaluation criteria and metric commentary may be found in the Federal Highway document Metrics for the Oversight of the National Bridge Inspection Program.
- The Federal Highway document may be found at: http://www.fhwa.dot.gov/bridge/nbip/metrics.pdf

For the purposes of quality control, each team leader will ensure that one bridge file is field reviewed per year. On or before November 1st of each year a report will be available upon request. The quality control file will include the quality control review forms filled out for the reporting period. The reports will remain in the file for three years.

2.5.3 Sampling

The Quality Control Field Review shall be performed on bridges selected from a group that meet any of the following criteria if available:

- A rating of 4 or less for Items 58, 59, 60, or 62
- A rating that changed by two or more for Items 58, 59, 60, or 62
- A rating of 3 or less for Item 113A
- Posted
- A Critical Finding has been reported

For the purposes of quality control, each team leader will ensure that one bridge is field reviewed per year. On or before November 1st of each year, a report will be available upon request. The quality control file will include the quality control field review forms filled out for the reporting period. The reports will remain in the file for three years.

2.6 CORRECTIVE ACTIONS

The team leader is responsible for any corrective action that is needed for an existing bridge file under review. The office and field reviews are intended to be an instructive process where errors and omissions can be found and eliminated. The only repercussion to the quality control reviews would be the lack of quality of the review or if corrections were recommended but not completed or explained by the team leader.

The INDOT Data Manager will review the submitted files.

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CHAPTER 3 QUALITY ASSURANCE

3.1 QUALITY ASSURANCE

The INDOT Bridge Inspection Unit has revised the procedures for quality assurance, incorporating two quality assurance methods.

The first method will incorporate a procedure for inspecting a control bridge or bridges. The control bridge will be evaluated by a designated team of highly qualified bridge inspectors which will establish the target values for the control bridge. The team leaders will then be assigned a time to inspect the control bridge or bridges.

The second quality procedure will be independent oversight. In this method, a third party is enlisted to re-inspect a bridge previously inspected by a team leader. The independent reviewer will then compare the inspections.

These two new procedures will be further developed in the next two section of the manual.

3.2 CONTROL BRIDGE

As a minimum, one bridge will be selected every 24 months as a control bridge. The control bridge will be evaluated by a designated team of inspectors. The team members will be highly qualified and will independently determine the rating values for the bridge. The team members will also identify any deficiencies and critical findings. Any required notes or explanation of findings will be noted in the inspection. The inspection team will then meet and determine the values and findings to assign to the structure.

All team leaders will inspect the control bridge. The directions and expectations will be clearly defined well in advance of the date selected for the control bridge inspection. The exact testing procedures and review of results may vary for testing sessions, but all expectations will be outlined in the testing instructions.

All team members are required to inspect the control bridge. Failure to inspect the control bridge will be cause for review of the team member’s credentials. This review may include a review of bridge files submitted into BIAS and/or the basis for an independent oversight review. A team member missing two consecutive control bridge inspections will be disqualified.

Team members performing poorly on the control inspection will be subject to corrective actions.

On 12 month cycles not in the same year as a test bridge, the Bridge Inspection Program Manager may elect to have a training workshop. If scheduled, these training workshops will be mandatory and will include testing.

3.3 INDEPENDENT OVERSIGHT

As a minimum, 24 bridge files will be selected annually for independent oversight. These structures in part will be selected from the list of team leaders that failed to participate in the inspection of the control bridge. A portion of the files will be selected from team members that performed poorly on the control bridge inspection. The final portion of the selected files will be selected at random.

For the selected bridge files, a third party will re-inspect the bridge. This inspection will be a complete inspection which will generate a comparison of the original inspection. This will give a very accurate comparison for consistency and accuracy.

3.3.1 INDEPENDENT OVERSIGHT CLOSEOUT

For Quality Assurance Independent Oversight Reviews, after the inspections have been concluded, the reviewer will generate a Quality Assurance Report summarizing the findings. The findings shall be discussed with the State Program Manager and submitted to all Inspection Team Leaders involved in the inspections. An annual report will be generated which summarizes the findings.

3.4 BRIDGE FILE AND LOAD RATING REVIEW

3.4.1 Purpose and Scope

The primary goal of the Quality Assurance Bridge File Review is to ensure the completeness of the individual bridge files. The Quality Assurance Bridge File Review ensures that the QC efforts are effective across Inspecting Agencies, resulting in overall quality in the State Bridge Inspection Program. Bridge files should be reviewed to ensure that the bridges are properly load-rated and documented and that they contain any other required/available bridge documentation.

3.4.2 Bridge File Review

The INDOT Data Base Manager will select a minimum of 10 bridge files per quarter for quality control review. One half of those files will be selected by searching files for known or suspected inaccuracies. The remaining files will be selected at random.

The bridge files will be reviewed for accuracy and completeness. The items checked for the bridge file will be as outlined in the AASHTO Manual for Bridge Evaluation, Section 2.

The findings of the quarterly review will be submitted to the INDOT Bridge Inspection Program Manager.

3.4.3 Load Rating Verification Review

The INDOT Bridge Load Rating Engineer will select a minimum of 10 bridge files per quarter for quality control review. These files may have been selected for a bridge file review where the load rating section of the file was in question or the files may be selected at random.

The file will be reviewed for accuracy and completeness. The file must contain the summary sheet from the load rating and all supporting computations which must include a clear statement of all assumptions used in calculating the load rating. For computer modeling, an input data file will be included in the file.

The findings of the quarterly review will be submitted to the INDOT Bridge Inspection Program Manger.

3.5 CORRECTIVE ACTIONS

Data errors, omissions, and/or changes can occur during the inspection and inventory process, as well as during the quality assurance process. The identification and resolution of these items shall be done in an expedited manner. Notification of the issue shall occur immediately to the appropriate INDOT inspector or Inspection Consultant. The issue will be discussed in-depth. Any revision to the report shall be documented and submitted to the State Program Manager. Once reviewed and accepted by the State Program Manager, the corrected information shall be submitted to the Inspecting Agency for their files or further action.

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CHAPTER 4 DISQUALIFICATION & REQUALIFICATION

4.1 DISQUALIFICATION PROCESS

When Quality Assurance Reviews indicate that an Inspection Team Leader and/or an Inspecting Agency continue to make the same or similar mistakes or omissions, the State Program Manager shall implement disqualification procedures as follows:

1. Upon receiving INDOT's Quality Assurance Report, the team leader shall address the findings of the report and take steps to correct the problems to ensure they will not be repeated in the future.
2. The Inspection Team Leader will be placed on probation and two inspected bridges will be reviewed within the next inspection cycle. This review will be conducted by a team selected by the Program Manager.
3. If the inspections are found to be of poor quality, the team leader will be disqualified.
4. INDOT reserves the right to disqualify immediately and indefinitely if gross negligence, misconduct, and/or major omissions are found. These errors may adversely affect the safety of the public and/or the capacity of the bridge.

4.2 DISQUALIFICATION CRITERIA

The criterion for disqualification of an Inspecting Agency or Inspection Team Leader includes, but is not limited to, the following:

1. Lack of proper follow-up with the bridge owner for Critical Deficiencies, such as broken load-carrying members, critical scour at foundations, vehicular impacts which could adversely affect load-carrying members, or bridges requiring closure
2. Lack of follow-up with the bridge owner for correcting load-posting deficiencies
3. Failure to satisfy the required testing for quality control
4. Failure to correct findings from Quality Control or Quality Assurance Reviews, including recurring unacceptable scores
5. Recurring miscoded critical inventory items such as National Bridge Inventory (NBI) Items 41 (Open, Posted, or Closed), 43 (Structure Type), 51 (Bridge Roadway Width), 54 (Vertical Underclearance), 90 (Inspection Date), 92 (Critical Feature Inspection), 93 (Critical Feature Inspection Date), and 113A (Scour Critical Bridge)
6. Recurring miscoded critical rating items such as condition states
7. Recurring condition rating deviations of more than one above or below an independent condition review
8. Failure to submit completed inspection data and/or corrections in a timely manner
9. Failure to maintain the bridge file to meet minimum requirements
10. Failure to maintain or update any required scour Plans of Action
11. Failure to inspect the bridges within the required frequency (unless the notice to proceed was given too late to make this possible)
12. Dishonest or unethical behavior that adversely affects the inspection results

INDOT has the final authority to carry out this disqualification process. Inspecting Agencies must accept these procedures as part of any bridge inspection agreement before they will be allowed to perform any bridge inspections.

4.3 REQUALIFICATION PROCESS

1. A disqualified Inspection Team Leader and/or Inspection Agency may be re-qualified after the two-year period if they explain in writing how they will correct their deficiencies. Upon approval by INDOT, the Inspection Team Leader or Inspecting Agency shall be placed back on the qualified list and under probation for 12 months.
2. A disqualified Inspection Team Leader may also be re-qualified following the two-year disqualification period after he/she has retaken the Safety Inspection of In-Service Bridges (FHWA-NHI-130055) class and achieved a score of 70 percent or better on the examination given at the end of the course. Attendance in the entire course is mandatory for requalification.
3. Henceforth, prospective Inspection Team Leaders taking the Safety Inspection of In-Service Bridges (FHWA-NHI-130055) class must attend the entire course and achieve a score of 70 percent or better on the examination given at the end of the course to be considered re-qualified.

NBIP File Review Checklist

Structure No.:

Structure No.: Review Date:____________________

Item 1 - State: **Review Performed by:** ____________________

Item 7 - Feature Carried:

Item 6A - Feature Crossed:

Item 27 - Year Built: **Item 90 - Most Recent NBIS Insp. Date:**

Metrics assessed in file review:

M12	M13	M14	M15	M16	M17	M18	M22	M23

Metric 12 – Inspection Procedures – Quality Inspections			
NBI Data			
Item 58:		Risk Category:	
Item 59:		Item 65 – Inventory Rating Method:	
Item 60:		Does the narrative justify given ratings?	
Item 62:			
Review Observations			
Metric 12 Notes:			

NBIP File Review Checklist

Structure No.:

Metric 13 – Inspection Procedures, Load Rating									
NBI Data									
Item 41:				Risk Category:					
Item 59:		Item 60:		Item 62:		Item 67:		Item 92A:	
Item 63 – Operating Rating Method:					Item 64 – Operating Rating:				
Item 65 – Inventory Rating Method					Item 66 – Inventory Rating:				

Review Observations			
Bridge is Load Rated (Y/N):		**Calculation Components**	
Load rating matches SI&A Data (Y/N):		Load Rating Summary (Y/N):	
Load rating Consistent with condition (Y/N):		Calculations (Y/N):	
		Input/Output (Y/N):	
Metric 13 Notes:			

NBIP File Review Checklist

Structure No.:

Metric 14 – Inspection Procedures, Post or Restrict					
NBI Data					
Item 41:		Item 62:		Item 31:	
Item 59:		Item 70:		Item 103:	
Item 63 – Operating Rating Method:			Item 64 – Operating Rating:		
Item 65 – Inventory Rating Method			Item 66 – Inventory Rating:		
Review Observations					
Confirmation of posting/closure in bridge file (Y/N):					
Posting/closure is consistent with Items 41 & 70 (Y/N):					
Posting/closure is consistent with load rating (Y/N):					
Metric 14 Notes:					

Metric 15 – Inspection Procedures, Bridge Files					
File Components Present – (Y)es/(N)o/(R)eferenced					
Inspection Reports:		Waterway Information:		Correspondence:	
Inspection Procedures:		Load Rating:		Posting Information:	
Critical Findings:		Scour Assessment:		Scour POA:	
Inventory Data:					
Metric 15 Notes:					

NBIP File Review Checklist

Structure No.:

Metric 16 – Inspection Procedures, Fracture Critical Members			
NBI Data			
Item 43B – Structure Type:			
Item 41:		Item 29:	
Item 59:		Item 109:	

Review Observations

FCM Proc. in bridge record (Y/N):	
Proc. Type (Gen./Bridge Specific):	
Procedures identify FCMs (Y/N):	
Procedures adequate (Y/N):	
Procedures followed (Y/N):	

Risk Factors (check all that apply)			
Fatigue prone details:		Posted for load:	
Problematic materials:		Low super. Condition:	
Poor welding:		Impact damage:	
Age:		Previous cracking:	
High ADTT:		Cold service temps:	
Distortion-prone details:			

Metric 16 Notes:

Metric 17 – Inspection Procedures, Underwater					
NBI Data					
Item 60:		Item 62:		Item 113:	

Review Observations

UW Proc. in bridge record (Y/N):	
Proc. Type (Gen./Bridge Specific):	
Proc. identify UW elements (Y/N):	
Procedures adequate (Y/N):	
Procedures followed (Y/N):	

Risk Factors (check all that apply)			
Rapid stream flows:		Pollutants:	
Debris accumulation:		Brackish water:	
Constricted opening:		Marine environment:	
Unstable streambed:		Meandering channel:	

Metric 17 Notes:

NBIP File Review Checklist

Structure No.:

Metric 18 – Inspection Procedures, Scour Critical Bridges			
NBI Data			
Item 113:			
Review Observations			
Scour evaluation in bridge record (Y/N):		**Event Response**	
Scour POA Developed (Y/N):		Has there been a triggering event (Y/N):	
Scour POA Implemented (Y/N):		Was POA executed (Y/N):	
Trigger Events and Tracking Methodology Identified in POA (Y/N)			
Metric 18 Notes:			

Metric 22 – Inventory – Prepare and Maintain			
Directions: Selected NBI items to be reviewed for accuracy			
NBI Data			
Review Observations			
1.	Verify inspection dates for items 90, 93A, 93B, 93C		
2.	Verify inspection frequencies in items 91, 92A, 92B, and 92C updated and correct based on condition		
3.	Verify items 94, 95, 96, and 97 updated		
4.	Verify element level data and quantity computations on NHS bridges		
Metric 22 Notes:			

NBIP File Review Checklist

Structure No.:

Metric 23 - Inventory – Timely Updating of Data	
NBI Data	
60 Day requirement:	
Metric 23 Notes:	

INDOT BRIDGE INSPECTION MANUAL

PART 3

LOAD RATING

Inspection Memorandum	Revision Date	Sections Affected
18-01	Apr. 2018	3-9.02(01), 3-9.02(02)
18-03	Oct. 2018	3-5.02, Appendix C
18-04	Oct. 2018	3-4.02
19-02	Apr. 2019	3-6.04, Appendix D

The revision date is noted in brackets next to the heading for each affected section.

TABLE OF CONTENTS

LIST OF FIGURES

3-1.0 INTRODUCTION

The primary purpose of this part of the manual is to establish a uniform policy of load rating procedures and standards for determining the safe load carrying capacity of bridges within the state of Indiana. This part is heavily influenced by the guidelines established in Section 6 of the *Manual for Bridge Evaluation*, 2nd Edition, including all interim revisions. Any variance with these guidelines is discussed in the sections to follow. At no point shall the requirements set forth in this document be in conflict with state or federal law. In the event of discrepancy, the law shall apply.

3-2.0 REFERENCE MATERIAL

AASHTO. (2008). *The Manual for Bridge Evaluation* (1st ed.). Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. (2011 with 2011, 2013, 2014, 2015, and 2016 Interim Revisions). *The Manual for Bridge Evaluation* (2nd ed.). Washington, DC: American Association of State Highway and Transportation Officials.

** References to the MBE in this manual refer to the 2nd Edition and its Interim Revisions. However 23 CFR 650.317 references the 1st Edition, making this the binding edition.**

AASHTO. (2002). *Standard Specifications for Highway Bridges* (17th ed.). Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. (2014 with 2015 and 2016 Interim Revisions). *AASHTO LRFD Bridge Design Specifications* (7th ed.). Washington, DC: American Association of State Highway and Transportation Officials.

Vehicle weight limitations – Interstate System, 23 U.S.C. 127 (2017)

National Bridge Inspection Standards, 23 CFR 650 subpart C (2016)

Hartmann, Joseph L. (November 3, 2016). *Load Rating for the FAST Act's Emergency Vehicles*. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Bridges and Structures.

FHWA. (March 2017). *QUESTIONS AND ANSWERS Load Rating for the FAST Act's Emergency Vehicles*. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Bridges and Structures.

Size and Weight Regulation, IC 9-20 (2017)

Indiana Department of Transportation. (September 2011). *Bridge Inspection Program Coding Guide, Bridge Reporting for Appraisal & Greater Inventory* (Vols. 1-3)

(2011 with Revisions 1, 2, and 3). *Indiana Manual on Uniform Traffic Control Devices for Streets and Highways*. http://www.in.gov/dot/div/contracts/design/mutcd/2011rev3MUTCD.htm

Indiana Department of Transportation. (2013-2017). *Indiana Design Manual*. http://www.in.gov/indot/design_manual/design_manual_2013.htm

3-3.0 ROLES & RESPONSIBILITIES

Load rating roles for bridge owners, the Indiana Department of Transportation, and load rating engineers are described below.

3-3.01 Bridge Owner

Bridge owners in Indiana include the state, counties, other local agencies, toll roads, and private firms owning bridges open to public traffic. For bridges within their authority, bridge owners are responsible for the following items:

- Ensuring all bridges within their jurisdiction are load rated for their in-service condition.
- Ensuring that new, replacement, or rehabilitated bridges are load rated no later than the initial inspection.
- Quality control and maintaining of all required load rating documentation.
- Posting of bridges as required.

3-3.02 Indiana Department of Transportation

The Indiana Department of Transportation (INDOT) is responsible for ensuring bridge owners are in compliance with the *National Bridge Inspection Standards* (NBIS) as given in 23 CFR 650 Subpart C, Bridges, Structures, and Hydraulics.

3-3.03 Load Rating Engineer

Qualifications for a load rating engineer (LRE) are discussed in Part 1 of this manual. LREs must certify and be actively involved in reviewing the quality and accuracy of all load ratings performed. A qualified LRE is also responsible for submitting all required documentation as specified in 3-9.02.

3-4.0 VEHICLES

Vehicles are classified into three main subcategories: design, legal, and permit. Each of these categories is discussed in greater detail below. Vehicle configurations are shown in Appendix A.

3-4.01 Design

Design vehicles are live loads used for the purpose of designing new, replacement, or rehabilitation bridge projects. Applicable design vehicles are listed on the plans for which the structural element in question was designed. Rules regarding the applicability of design vehicles are specified in the *Indiana Design Manual* (IDM). See Figure 3-4.1 for a list of potential design vehicles. Additionally, rating factors at the Design Inventory Level for both the H-20 and HS-20 vehicles shall reflect the existing condition of the bridge as required by the Federal Highway Administration (FHWA). Furthermore, general Toll Road and Michigan Train Truck applicability is discussed below as well as in IDM 403-3.01.

Any bridge on the Indiana Toll Road or any state owned or maintained bridge within 15 miles of a toll road gate shall be rated for the Toll Road Truck configurations including a 0.64 klf lane load. Any bridge located on the Extra-Heavy Duty Highway, as described in IC 9-20-5-4, shall be rated for the Michigan Train Truck configurations including a 0.64 klf lane load. See Appendix B for supplementary information regarding the Indiana Toll Road and Extra Heavy Duty Highways.

Truck Configuration
HL-93
Fatigue*
H-20
HS-20
HS-25
Alternate Military
Toll Road Loading No. 1
Toll Road Loading No. 2
Special Toll Road Truck
Michigan Train Truck #5
Michigan Train Truck #8

* The Fatigue configuration shall be used for evaluating the Fatigue Limit State per MBE Table 6A.4.2.2-1 whenever HL-93 is specified on applicable plans

Figure 3-4.1 Potential Design Vehicles

3-4.02 Legal [Rev. Oct. 2018]

Legal vehicles are live loads used for the sole purpose of determining the safe load carrying capacity and posting of a bridge. This legal category is described in the Manual for Bridge Evaluation (MBE) section 6A.4.4 for Load and Resistance Factor Rating (LRFR) and 6B.7.2 for Load Factor Rating (LFR). Every bridge in Indiana is required to be rated for the vehicles listed in Figure 3-4.2; any vehicle not explicitly mentioned in the MBE shall be considered a "state legal load" as discussed in the MBE. For LRFR, the vehicles are broken down into two subcategories, Routine Commercial Traffic and Specialized Hauling.

Routine Commercial Traffic contains vehicles that represent typical commercial trucking configurations that are also encompassed by the Federal Bridge Formula. In addition to these vehicles are emergency vehicles, EV2 and EV3, required by 23 U.S.C. 127 and provided by the FHWA. The emergency vehicles should be considered to occupy a single lane only and one-lane distribution should be used to represent the low probability of these vehicle types being located adjacent to other heavily loaded vehicles. In addition, a live load factor of 1.3 should be used for emergency vehicles, regardless of the ADTT.

Specialized Hauling contains single unit, short wheelbase, multiple axle trucks typical of construction, waste management, and bulk cargo/commodities hauling industries. These configurations are also encompassed by the Federal Bridge Formula.

Truck Configuration	LRFR Subcategory
H-20	Routine Commercial Traffic
HS-20	Routine Commercial Traffic
Alternate Military	Routine Commercial Traffic
AASHTO Type 3	Routine Commercial Traffic
AASHTO Type 3S2	Routine Commercial Traffic
AASHTO Type 3-3	Routine Commercial Traffic
Lane-Type*	Routine Commercial Traffic
EV2	Routine Commercial Traffic
EV3	Routine Commercial Traffic
NRL**	Specialized Hauling
SU4	Specialized Hauling
SU5	Specialized Hauling
SU6	Specialized Hauling
SU7	Specialized Hauling

* Load and Resistance Factor Rating (LRFR) only
** Not to be used for load posting

Figure 3-4.2 Required Legal Vehicles

3-4.03 Permit

Permit vehicles are live loads that exceed legal load limitations. These vehicles can be issued routine or special permits. Vehicles for which routine permits are commonly issued shall be used for determining the safe load capacity and posting of a bridge. Special permits are for less frequent loads and often with additional limitations. Permit load rating is discussed in MBE 6A.4.5 for Load and Resistance Factor Rating (LRFR) and MBE 6B.8 for Load Factor Rating (LFR). See Figure 3-4.3 for a list of potential permit vehicles.

Any bridge on the Indiana Toll Road or any state owned or maintained bridge within 15 miles of a toll road gate shall be rated for the Toll Road Truck configurations. Any bridge located on the Extra-Heavy Duty Highway, as described in IC 9-20-5-4, shall be rated for the Michigan Train Truck configurations. It is acceptable to limit Michigan Train Truck vehicles to one lane located so as to cause extreme force effects while the other lanes are occupied by regular legal loads. A lane load shall be included with all Toll Road or Michigan Train Truck configurations if required by the MBE depending on rating method and bridge geometry. See Appendix B for supplementary information regarding the Indiana Toll Road and Extra Heavy Duty Highways.

Where analytical rating methods are used on state owned or maintained bridges, the "Special" vehicles, as shown in Figure 3-4.3 below, shall be evaluated. These "Special" vehicles shall be single trip, mixed with traffic, and without reduction in speed.

Routine	Special
Toll Road Loading No. 1	Superload – 11 Axles
Toll Road Loading No. 2	Superload – 13 Axles
Special Toll Road Truck	Superload – 14 Axles
Michigan Train Truck #5	Superload – 19 Axles (305K)
Michigan Train Truck #8	Superload – 19 Axles (480.09K)

Figure 3-4.3 Potential Permit Vehicles

3-5.0 METHODS

Analytical methods shall be used for load rating whenever possible. Engineering judgement may be used to supplement calculations. If necessary bridge geometry or material properties are not available and cannot be obtained economically, then engineering judgment may be used in place of analytical methods. In addition, bridge owners have the right to add conservativeness at their discretion; this can mean posting the bridge at a lower tonnage than required by analysis.

3-5.01 Analytical

The two primary analytical methods are Load and Resistance Factor Rating (LRFR) and Load Factor Rating (LFR). The department's vehicle classifications as defined in Section 3-4 most closely align with LRFR but still apply to LFR as well. An important distinction between the two methodologies is their definition of Inventory and Operating ratings.

As discussed in the MBE for LRFR, Inventory and Operating ratings are subcategories to the Design Load Rating category. Values for this category are required when construction work is proposed that will change the structural behavior or capacity of the bridge. For state owned or maintained bridges rated LRFR, only Inventory values are required when evaluating for design loads; Operating values will only be considered on a case by case basis. For LFR, Inventory corresponds to Design Load Rating and Operating to Legal Load Rating.

Regardless of method, the Legal Load category is always required whenever a load rating is performed. By definition, this means that Operating ratings are only required for LFR since they fall under the Design category for LRFR.

LRFR shall be used for any new or replacement superstructure. For state owned or maintained bridges, LRFR shall be used regardless of the original design method. In certain situations, LRFR is more restrictive than what earlier design codes required. This can lead to overly conservative ratings for existing structures that are performing well. In these situations, other rating methods may be considered. See Section 3-10.1 for additional details. Any situation not listed in 3-10.1 will require the approval of the INDOT load rating staff.

AASHTOWARE Bridge Rating "BrR" shall be used to perform load ratings whenever possible. It is permissible to use other programs and/or engineering judgment is cases where the use of BrR is insufficient or not plausible due to program limitations. Additional resources are available on the bridge design website including a list of programs that may be used to supplement BrR.

3-5.01(01) Load and Resistance Factor Rating (LRFR)

Load and Resistance Factor Rating (LRFR) analysis shall follow the procedures outlined in MBE Section 6A except as noted in this manual. As defined in this manual and discussed in the MBE, ratings fall into three categories, Design Load, Legal Load, and Permit Load. Please refer to Section 3-4 in this manual for a list of vehicles that fall within each category and a discussion regarding their applicability. In short, for determining the load capacity or safe posting load of a bridge, all vehicles within the Legal Load category and applicable vehicles designated as Routine Permit are required.

As discussed in MBE 6A.5.4 and with the exception of segmentally constructed bridges, service limit states in regards to crack control should not be considered for determining the load capacity or safe posting load of state owned or maintained reinforced concrete or prestressed concrete in-service bridge components. Crack control may be considered for determining the load capacity or safe posting load for local bridges at the discretion of the owner. This applies to both legal and routine permit loads. For special permit evaluation, use of these provisions is at the discretion of the permitting engineer. Crack control is a means for ensuring longevity of the structure and is therefore most applicable for design loading.

The condition factor Φ_C and system factor Φ_S shall be used per MBE 6A.4.2.3 & 6A.4.2.4 respectively. Where material properties are unknown, assumptions can be made per MBE 6A.5.2. In regard to MBE 6A.5.8, if the conditions of this article are met for reinforced concrete slab bridges, shear capacity need not be checked for design and legal loads. Similarly, shear need not be evaluated for any proposed work on reinforced concrete slab bridges. For any other reinforced, prestressed, or post-tensioned concrete bridge, the shear capacity shall always be evaluated for design, legal, and permit ratings regardless of condition or distress. When shear controls, refined analysis may be used to more accurately model boundary conditions and loading scenarios.

3-5.01(02) Load Factor Rating (LFR)

Load Factor Rating (LFR) analysis shall follow the procedures outlined in MBE 6B except as noted in this manual. As defined in this manual, ratings fall into three categories, Design Load, Legal Load, and Permit Load. Please refer to Section 3-4 in this manual for a list of vehicles that fall within each category and a discussion regarding their applicability. In short, for determining the load capacity or safe posting load of a bridge, all vehicles within the Legal Load category and applicable vehicles designated as Routine Permit are required. When referencing MBE 6B, Inventory is equivalent to Design Load and Operating is equivalent to both Legal Load and Permit Load.

3-5.01(03) Other

If the LRFR method is not used, bridges designed by the Allowable or Working Stress Method should be rated LFR, see Section 3-5.01(02).

3-5.02 Engineering Judgment [Rev. Oct. 2018]

MBE 6.1.4 discusses the use of engineering judgment in place of or as a supplement to analytical methods when necessary details to load rate are missing or incomplete.

Load rating based on engineering judgement may be used in lieu of analytical methods only when there are no plans or details available and physical measurement of the structural members is not possible, such as the reinforcing bars of a concrete structure. The LRE should consider all available information when determining the load rating, including, but not limited to

- Year of construction and common material properties for that time period,
- assumed design vehicle,
- all measurable structure dimensions,
- redundancy of load path,
- deterioration levels,
- signs of distress such as transverse cracks in high moment regions or diagonal cracks in high shear regions, and
- changes to the structure such as increased dead loads since original construction.

The load rating shall be determined for all vehicles described in Section 3-4.0. Consideration should be given to the size and configuration of vehicles that routinely use the bridge being evaluated. A comparison of shear and moments produced by vehicles that routinely use the bridge to those produced by load rating vehicles that may not routinely use the bridge may aid the Engineer in determining appropriate rating factors.

Engineering judgment may be used to assign lower ratings than computed at the owner's request or to increase conservativeness when desired.

3-6.0 POSTING

Bridges that cannot safely carry legal or applicable state routine permit loads, as defined in Section 3-4, must be posted. This is represented by a legal or routine permit rating factor of less than 1.0 for any of the required vehicles. Posting for design loads is conservative and therefore will only be allowed at the discretion of the bridge owner.

If **any** legal or applicable state routine permit vehicle rates below 1.0, then the bridge shall be posted for the safe posting load of **all** required vehicles; this applies to each vehicle even if it rates higher than 1.0. This is necessary because although only one vehicle may actually fall below the 1.0 rating factor threshold, the calculated load capacity or safe posting load may in fact be higher than a different legal vehicle that has a lighter gross vehicle weight.

Example:

Vehicle 1 (4-Axle, GVW = 38 Tons)

- Legal Rating Factor = 0.9 ➔ Safe Posting Load = 34 Tons

Vehicle 2 (4-Axle, GVW = 26 Tons)

- Routine Permit Rating Factor = 1.1 ➔ Safe Posting Load = 28 Tons

Based on the example above, even though Vehicle 2 has a higher rating factor than Vehicle 1, Vehicle 2 still has the lower safe posting load. Therefore it would be unsafe to post the bridge for 34 tons. Rating vehicles can be grouped together by the number of axles to determine the lowest tonnage for each group; see Section 3-6.04 for acceptable signage.

3-6.01 Load and Resistance Factor Rating Analysis

Where analytical models have been developed consistent with Section 3-5.01(01), load posting criteria shall conform to MBE 6A.8 except as noted below. The load capacity is determined according to MBE 6A.4.4.4. For rating factors below 1.0, the safe posting load is determined according to MBE 6A.8.3. For rating factors greater than or equal to 1.0, the safe posting load is equivalent to the load capacity.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-4 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.02 Load Factor Analysis

Where analytical models have been developed consistent with Section 3-5.01(02), load posting criteria shall conform to MBE 6B.7 except as noted below. The load capacity is determined according to MBE 6B.4.1. The safe posting load calculation is equivalent to the load capacity and further discussed in MBE 6B.7.3.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-4 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.03 Engineering Judgment

Where engineering judgment is warranted per Section 3-5.02, the load posting criteria shall conform to Section 3-6.02.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-5 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.04 Regulatory Signage [Rev. Apr. 2019]

There are multiple options for restricting vehicle weight. At a minimum, restrictions shall be for gross vehicle weight. At the discretion of the bridge owner, restrictions may be further refined by listing multiple gross vehicle weight restrictions based on the corresponding number of axles for all legal vehicles and for routine permit vehicles (where applicable). Posting for maximum permissible axle weights may be appropriate for short span bridges or critical bridge elements such as floor beams or stringers. Under no circumstances shall a restriction allow a legal or applicable routine permit vehicle in excess of the safe load carrying capacity of the bridge.

Regulatory signs shall conform to the *Indiana Manual on Uniform Traffic Control Devices* (IMUTCD). INDOT has developed additional word message signs for bridge weight limits (safe posting load). The sign details, including specific emergency vehicle signs, have been added to the INDOT Supplemental Sign Catalog and Appendix D of this document until such time as they are incorporated into the IMUTCD. The new signs have a sign code prefix of R12-Y.

Existing IMUTCD Sign R12-1 (WEIGHT LIMIT XX TONS) shall be used when the safe posting load is the same regardless of the number of axles. Each bridge shall be posted for the minimum calculated safe posting load as specified in this chapter. The R12-1 sign may be used when the safe posting load for all axles varies by no more than 2 tons, or if the bridge owner prefers to limit the gross vehicle weight regardless of the number of axles. Use of signs R12-3 (NO TRUCKS OVER XX LBS EMPTY WEIGHT) and R12-5 (WEIGHT LIMIT silhouette) is strongly discouraged as these signs are subject to misinterpretation. When the R12-5 sign is used, the tonnages listed shall correspond to the minimum calculated safe posting load for all legal and applicable routine permit vehicles for the number of axles shown. This means the sign will show a minimum tonnage for vehicles with two axles, three axles, and four or more axles.

Consider using signs R12-Y5 or sign variations R12-Y5a thru -Y5c (WEIGHT LIMIT AXLES XX WEIGHT XX) where the safe posting load varies by the number of axles. The tonnages listed shall correspond to the minimum calculated safe posting load for all legal and applicable routine permit vehicles that correspond to the number of axles shown. The number of axles may be grouped together and use the minimum safe posting load for the group.

For posting required due to emergency vehicle safe posting load, signs R12-1 with R12-Y1P (EMERGENCY VEHICLE) or signs R12-Y4-EVa thru -EVd (EMERGENCY VEHICLE …) shall be used as appropriate based on gross weight or gross weight per number of axles. Alternatively, signs R12-Y1P (EMERGENCY VEHICLE) or signs R12-Y4-EVa thru -EVd (EMERGENCY VEHICLE …) may be omitted provided the bridge is posted for the minimum safe posting load of all legal, applicable routine permit, and emergency vehicle loads using non-emergency vehicle specific signs shown in the IMUTCD and in Appendix D.

For bridge closures, the R11-2 sign shall be posted. Per IMUTCD Section 6F.08, "the words BRIDGE OUT (or BRIDGE CLOSED) may be substituted for ROAD (or STREET) CLOSED where applicable." Additionally, non-movable barriers and barricades per the standard specifications shall be erected at each end of the bridge to prevent crossing by vehicles and pedestrians.

At a minimum, additional signage shall be placed at the nearest intersection prior to the bridge in all directions to allow for vehicles to turn around. On limited access highways, additional signage shall be placed prior to the nearest exit ramp to allow for overweight vehicles to exit the highway. Any other signage shall conform to the IMUTCD and used at the discretion of the roadway owner.

3-7.0 DOCUMENTATION

Examples of the required documentation are shown in Appendix C. The load rating summary report, at a minimum, shall consist of the following:

- Title sheet
- Load rating method/program(s) used
- Geometric and material summary of the bridge
- Assumptions
- Rating factors for design vehicles specified on the plans (discussed in Section 3-4.01)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Rating factors and load capacity (in tons) for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Safe posting load, as required, for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana

- Rating factors and load capacity (in tons) for each applicable special (limited crossing) permit vehicle (discussed in Section 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Discussion, sketches, and photos of deterioration (if applicable)

If necessary details to load rate the bridge analytically are unavailable and engineering judgment is used per Section 3-5.02, the load rating summary report shall include the following note.

> *In accordance with the Manual for Bridge Evaluation, Second Edition, 2011, Section 6.1.4 – Necessary details for this bridge are unavailable. A physical inspection of the bridge was performed by a qualified inspector and evaluated by a qualified engineer to establish an approximate load rating based on rational criteria.*

3-8.0 QUALITY CONTROL (QC) & QUALITY ASSURANCE (QA)

For a more detailed discussion of Quality Control (QC) and Quality Assurance (QA), refer to Part 2 of this manual. In short, LREs are responsible for ensuring a high degree of accuracy and consistency for any performed ratings. The Indiana Department of Transportation's load rating staff will periodically review calculations and documentation for accuracy and completeness. Rating inaccuracies or any errors or deficiencies of procedure shall be addressed immediately.

3-9.0 PROCEDURE

This chapter discusses when to perform a load rating, what to submit, and who to notify.

For new, replacement, or rehabilitated structures, requests shall be made in accordance with the *Indiana Design Manual* (IDM) Chapter 103. All load rating requests for state owned or maintained bridges, shall be sent to INDOT Coordinator 8 (indotcoordinator8@indot.IN.gov) with the completed Load Rating Request Form attached and any plans, sketches, notes, and photos (where applicable) made accessible in BIAS.

The request form and instructions are available from the INDOT Editable Documents webpage at https://www.in.gov/dot/div/contracts/design/dmforms, under Bridges.

Load ratings for locally owned structures shall be performed by the owner or its designated appointee.

3-9.01 Frequency

In general, load ratings are required whenever there is a change in condition from one inspection to another. Load ratings may also be required whenever new bridge construction projects are proposed. A description of various load rating situations is discussed in the sections below.

3-9.01(01) Project Scoping

Prior to programming bridge work, owners should consider load rating to help determine whether to rehabilitate or replace existing structures. This is particularly useful when deciding whether to use a concrete (rigid) or thin polymeric (flexible) overlay. It is also useful to determine if existing bridge rail can be replaced. There are limits to the effectiveness of load rating at this early stage. A more complicated rehabilitation (e.g. widening, replacing members, etc.) requires a set of plans to accurately model.

For state owned or maintained bridges, the District Bridge Asset Engineer (BAE) should review the structure's existing loading rating prior to programming work that adds significant dead load, e.g., a concrete overlay.

3-9.01(02) New, Replacement, or Rehabilitated Structures

Bridge owners should consider requiring a load rating be performed prior to any new, replacement, or rehabilitation work to take place on their bridge assets; this shall be done no later than the initial inspection for locally maintained structures. For state owned or maintained structures, a load rating analysis shall be performed prior to construction. See *Indiana Design Manual* Chapter 14 for specific requirements.

Following the completion of construction work, the bridge file shall be updated within thirty (30) days for state maintained structures. To do this, a request shall come from the district bridge inspector and be sent to INDOT Coordinator 8. The bridge file for locally maintained structures shall be updated within ninety (90) days.

3-9.01(03) Deterioration

For bridges with a minor increase in or newly discovered minor damage or deterioration, a load analysis shall be performed. At a minimum, a load rating considering deterioration shall be on file for each bridge with a deck condition rating (NBIS Item 58), superstructure condition rating (NBIS Item 59), or culvert condition rating (NBIS Item 61) of 4 or less. For state owned or maintained structures, the load rating shall be performed and the bridge file updated within thirty (30) days of discovery. To do this, a request shall come from the District Bridge Inspector and be sent to INDOT Coordinator 8 within seven (7) days of discovery. For locally maintained structures, the load rating shall be performed and the bridge file updated within sixty (60) days of the end of the inspection compliance month.

See Section 3-9.01(04) for requirements regarding more severe changes in condition. Additionally, if there is loss of bearing area or a substructure condition rating (NBIS Item 60) of 3 or less, consideration should be made to reducing the load rating. See Section 3-10.2 for more information regarding the modeling of deterioration.

3-9.01(04) Critical Findings

For bridges with a significant increase in or newly discovered severe damage or deterioration, a load analysis shall be performed. This shall be performed within seven (7) days and the bridge file updated within fifteen (15) days of discovery for both state and locally maintained structures. For state maintained bridges, the District Bridge Inspector shall notify INDOT Coordinator 8 of the request within two (2) days of discovery. Notification shall be immediately for damage or deterioration considered severe enough to be an immediate safety concern for the traveling public.

3-9.01(05) Repairs

Bridge owners should consider requiring a load rating be performed prior to any repairs to take place on their bridge assets. For state maintained structures, this shall be done prior to reopening the bridge for closure situations or prior to construction for non-closure situations. Refer to the *Indiana Design Manual* for requesting a load rating for state maintained bridges. For locally maintained structures, ratings shall be performed no later than the initial inspection.

Following the completion of construction work, the bridge file shall be updated within thirty (30) days for state maintained structures and within ninety (90) days for locally maintained structures.

3-9.01(06) Permitting

Load ratings should be utilized when making determinations regarding the issuance of permits for overweight vehicles.

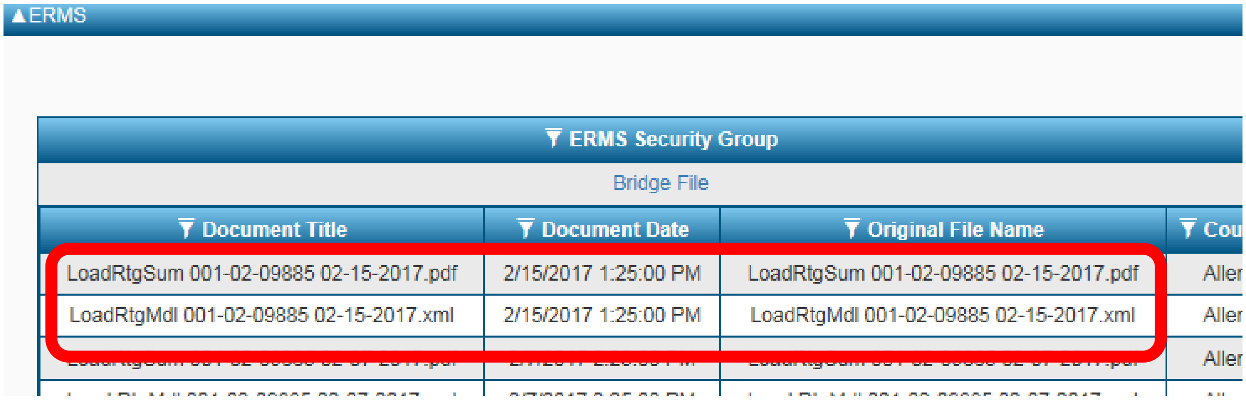
3-9.02 Submittal Process & Notification

The submittal process & notification can be broken into two categories, general and posting.

3-9.02(01) General [Rev. Apr. 2018]

For bridge construction projects, owners should be informed of load rating results prior to the commencement of any construction. For state maintained bridges, an email containing the load rating summary report and model shall be sent to INDOT Coordinator 8 within thirty (30) days of the receipt of the original load rating request.

Once the load rating reflects the "in-service" condition of the bridge, the bridge file shall be updated. The load rating summary report, as defined in section 3-7, and the load rating model shall be uploaded to ERMS. Once uploaded, each file will be accessible in BIAS from the ERMS link on the "Asset Info" tab for each bridge; see Figure 3-9.1. Refer to the bridge inspection website for detailed instructions regarding how to attach and upload documentation. Additionally, a new report shall be created in the Bridge Rating Application Database of Indiana (BRADIN) where rating factors shall be updated.



ERMS

ERMS Security Group			
Bridge File			
Document Title	Document Date	Original File Name	Cou
LoadRtgSum 001-02-09885 02-15-2017.pdf	2/15/2017 1:25:00 PM	LoadRtgSum 001-02-09885 02-15-2017.pdf	Aller
LoadRtgMdl 001-02-09885 02-15-2017.xml	2/15/2017 1:25:00 PM	LoadRtgMdl 001-02-09885 02-15-2017.xml	Aller
			Aller

Figure 3-9.1 BIAS ERMS Link to the Bridge File

3-9.02(02) Posting [Rev. Apr. 2018]

In addition to the general process in Section 3-9.02(01), the bridge owner shall immediately be notified by the LRE if load posting or any other restriction are required as discussed in Section 3-6. For state bridges, a summary of the details should be emailed to the District Bridge Asset Engineer and copied to the Bridge Director, Bridge Inspection Manager, District Bridge Inspection Engineer, System Assessment Manager, and the Technical Services Director.

Bridge owners shall have up to thirty (30) days to post all required signage and/or barriers. Once in place, the NBIS items in BRADIN shall be updated by the load rater within thirty (30) days to reflect the posting. See the INDOT Bridge Inspection website for detailed instructions. Additionally, photos should be uploaded to BIAS that show the bridge posting/closure items in place.

3-10.0 MODELING GUIDELINES & ASSUMPTIONS

This section is under development.

3-11.0 APPENDICES

3-11.1 Appendix A: Vehicle Configurations

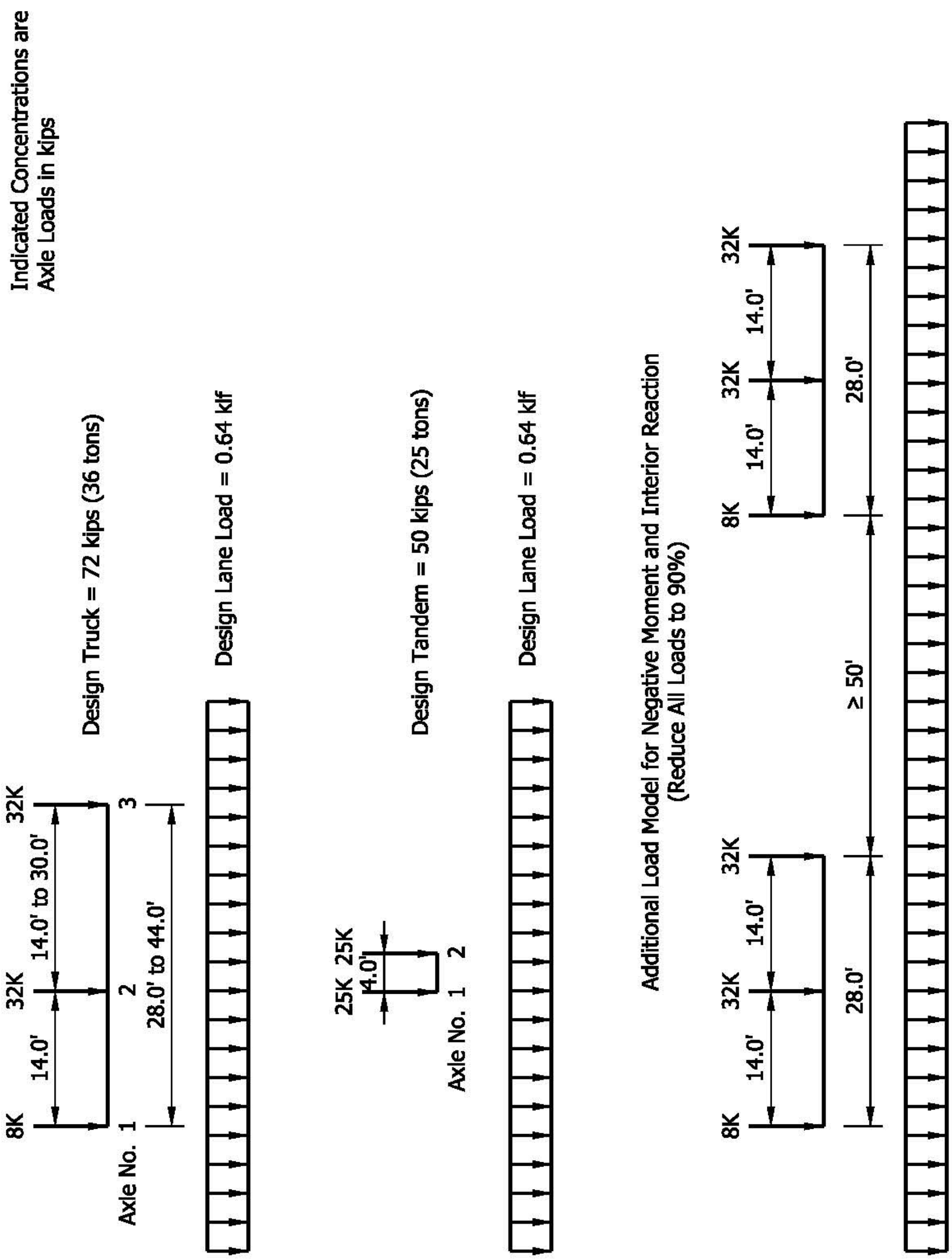


Figure A-1
HL-93 Loading

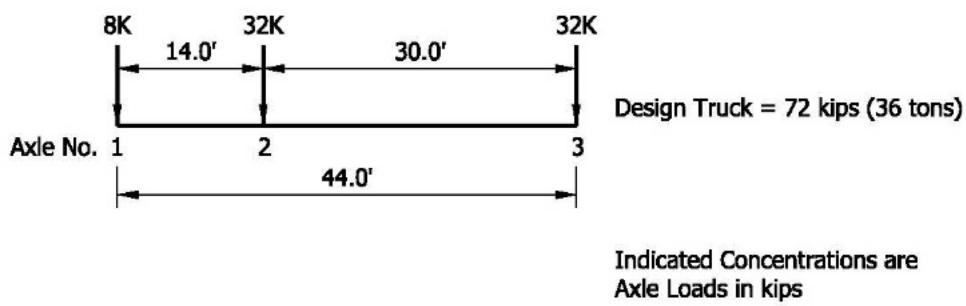


Figure A-2
Fatigue Loading

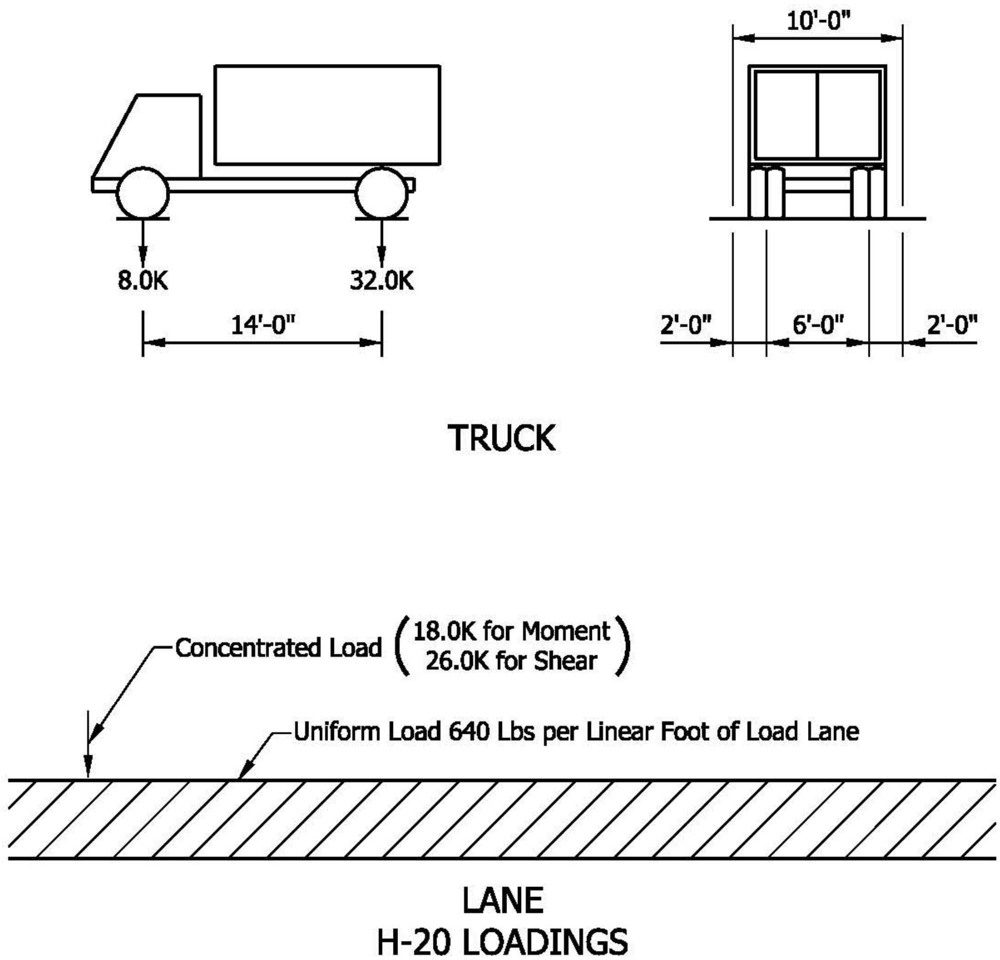


Figure A-3
H-20 Loading

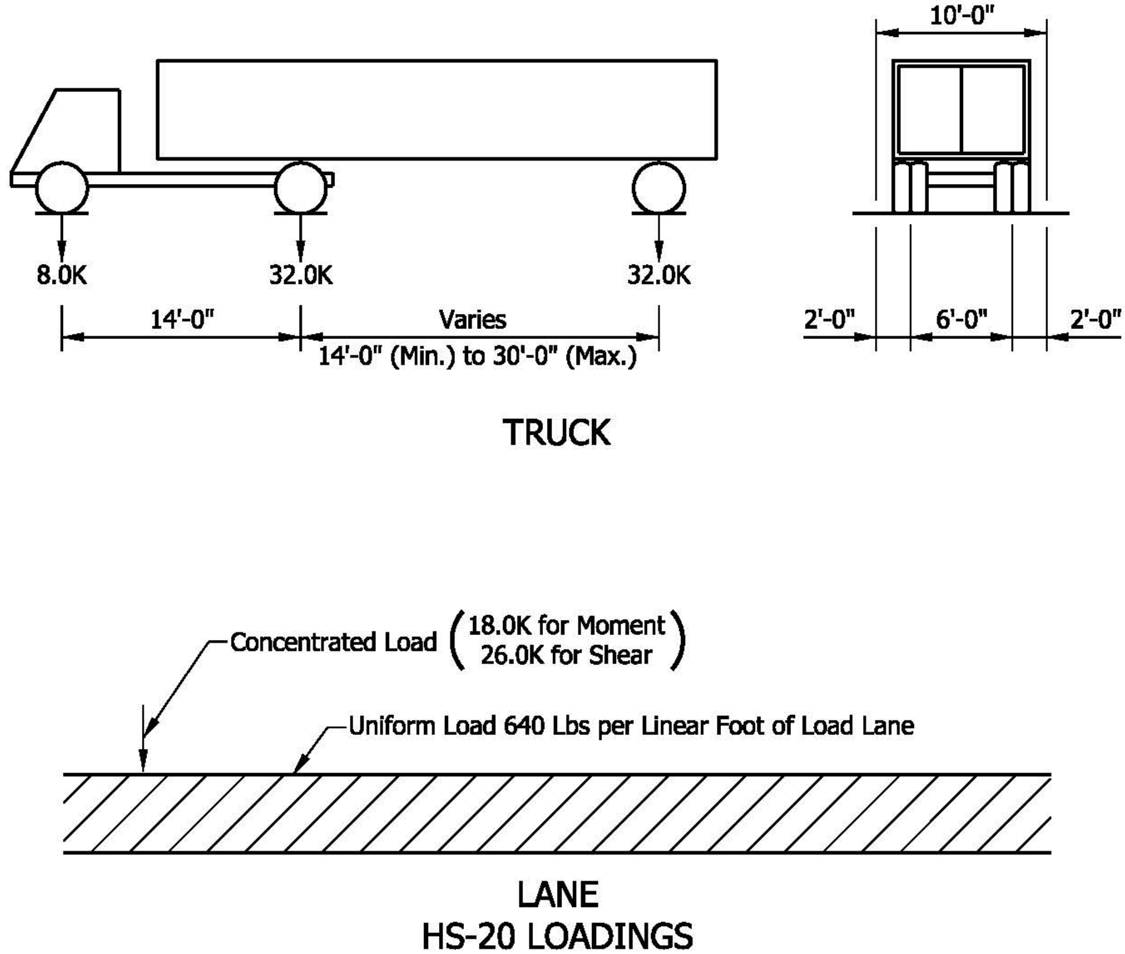


Figure A-4
HS-20 Loading

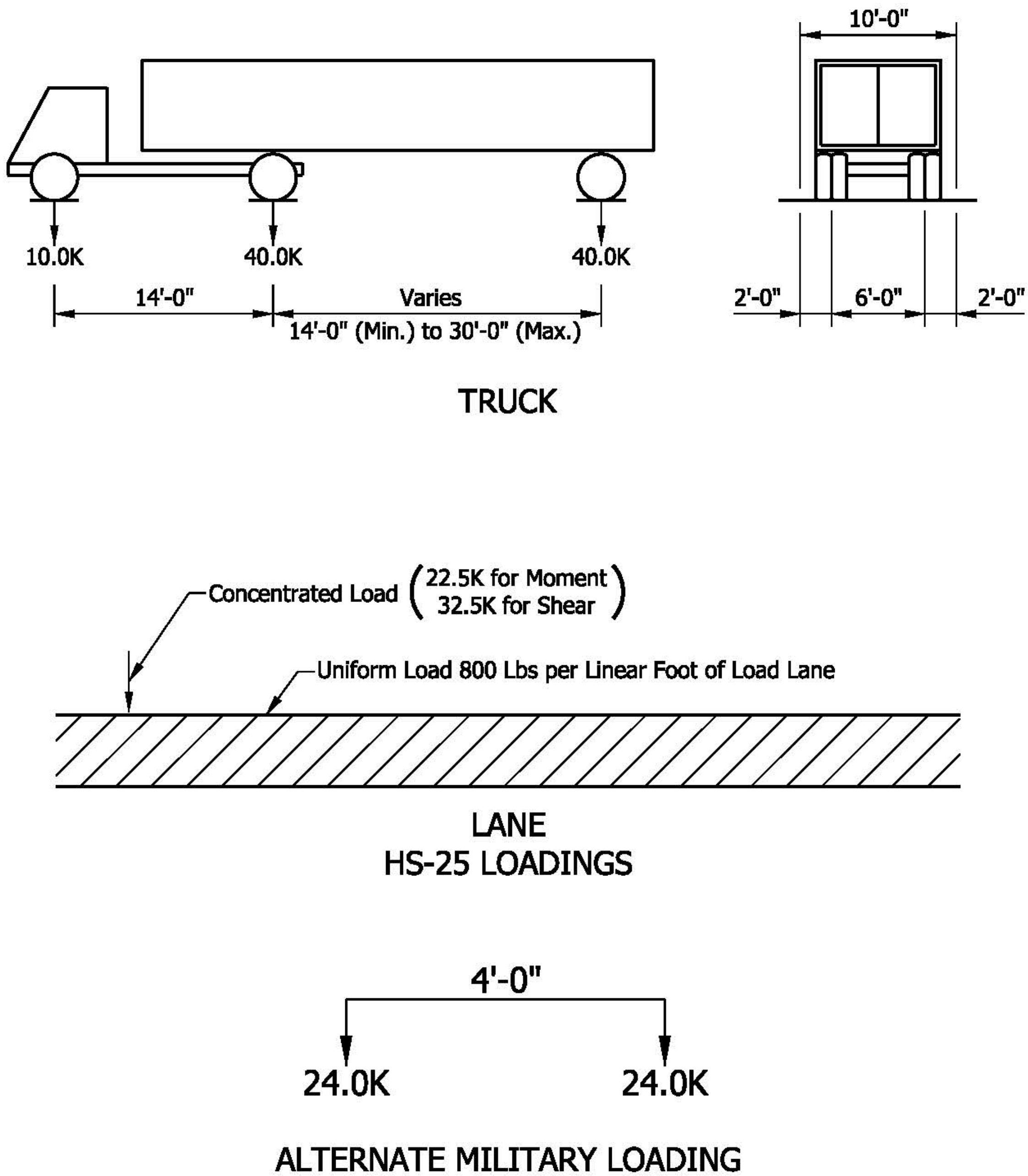


Figure A-5
HS-25 And Alternate Military Loading

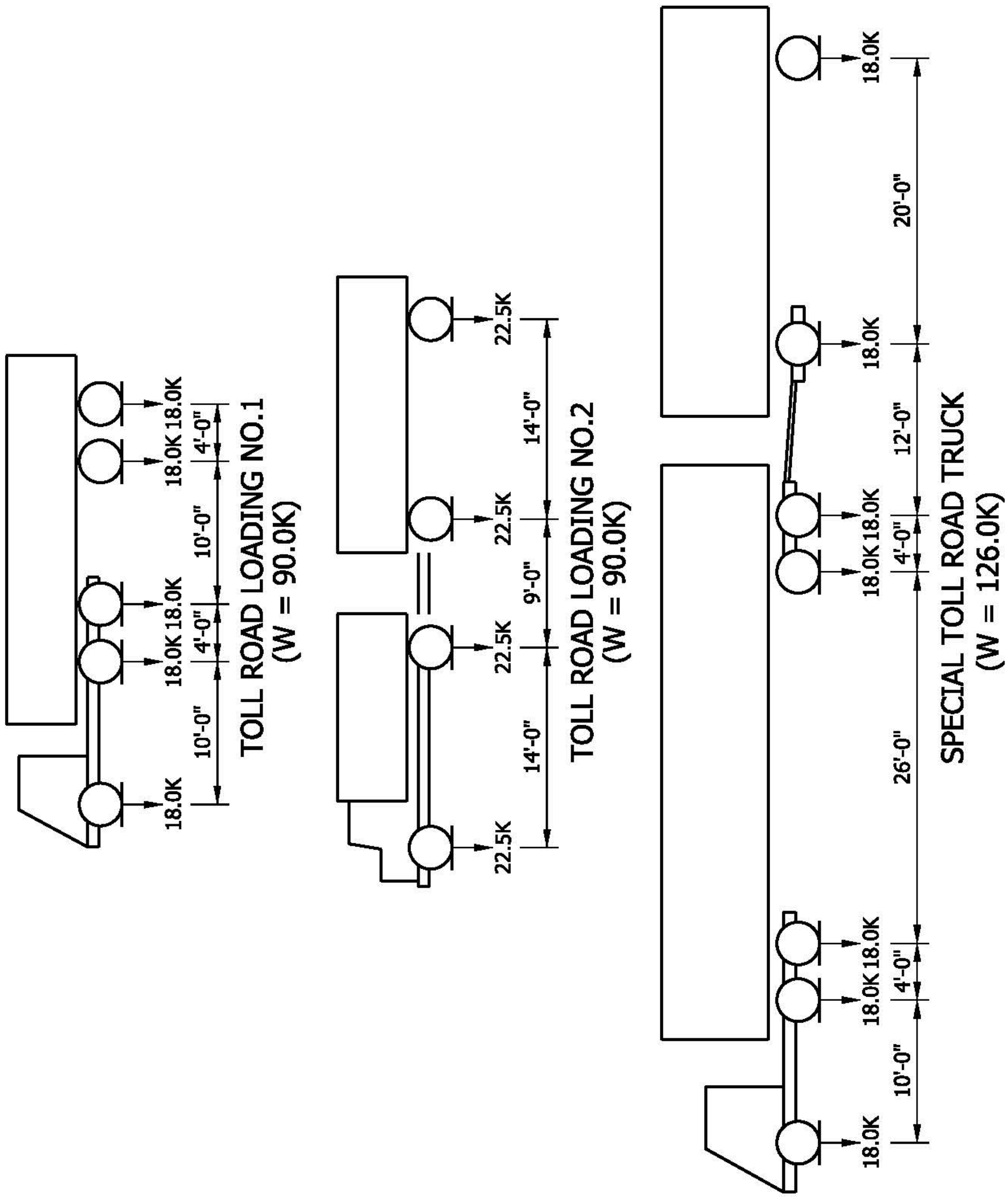


Figure A-6
Toll Road Truck Loads

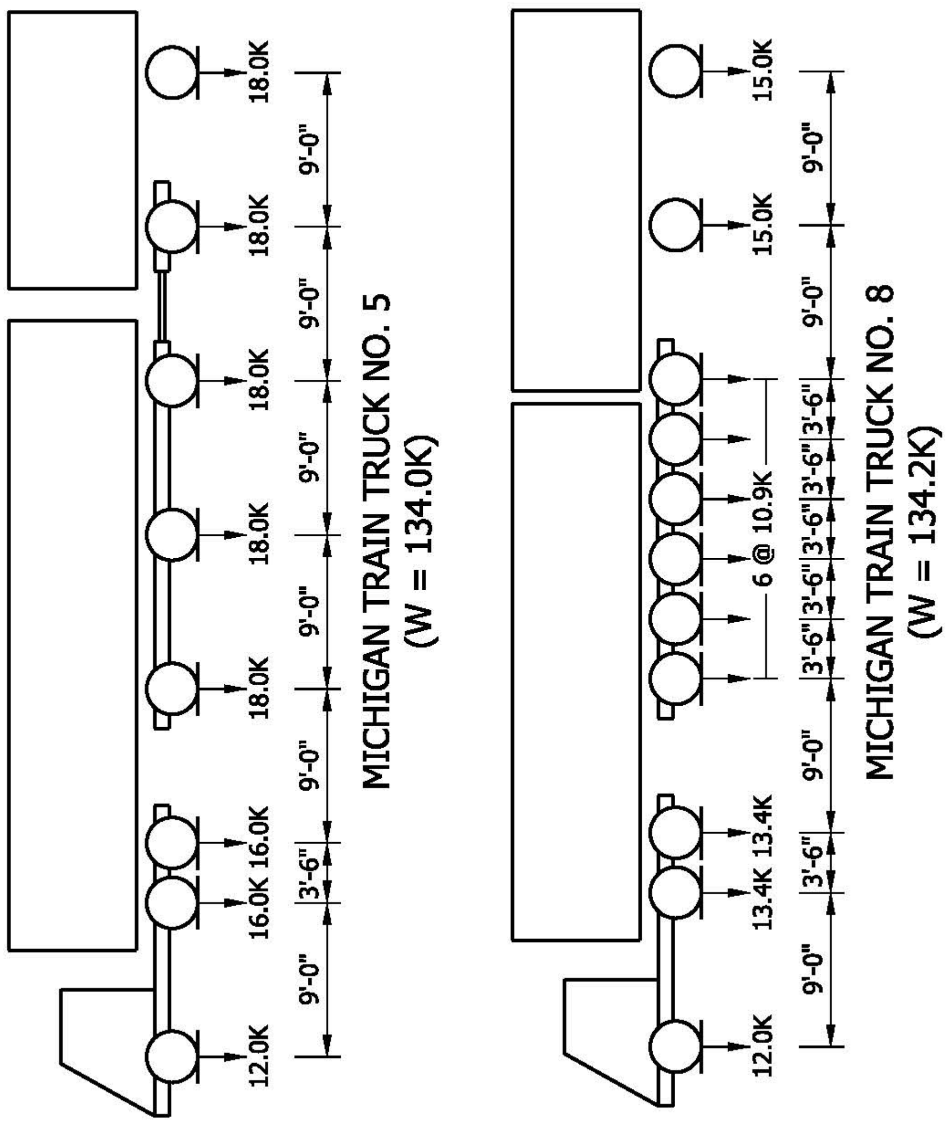


Figure A-7
Michigan Train Truck Loads

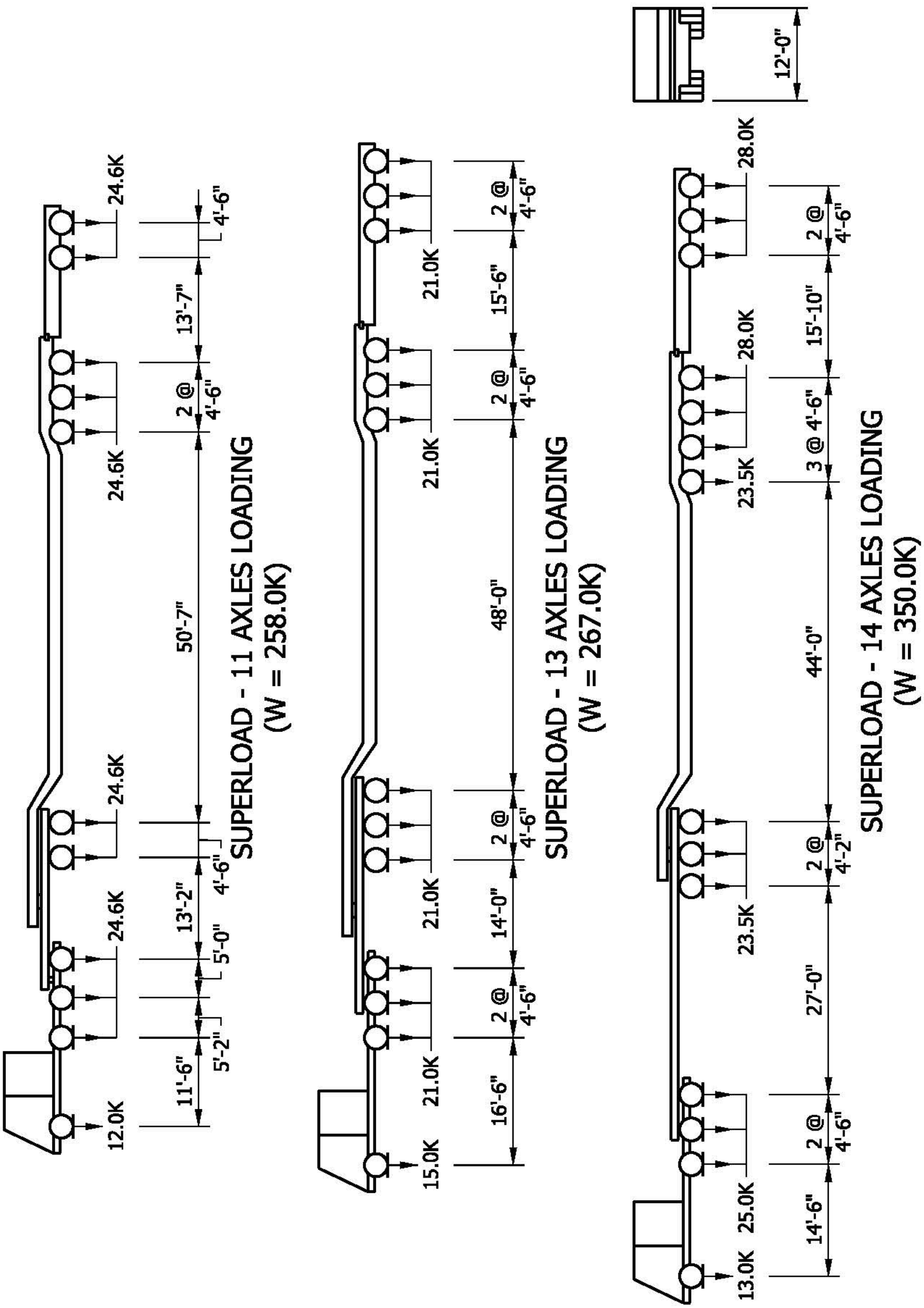


Figure A-8
Superload Vehicle Loads

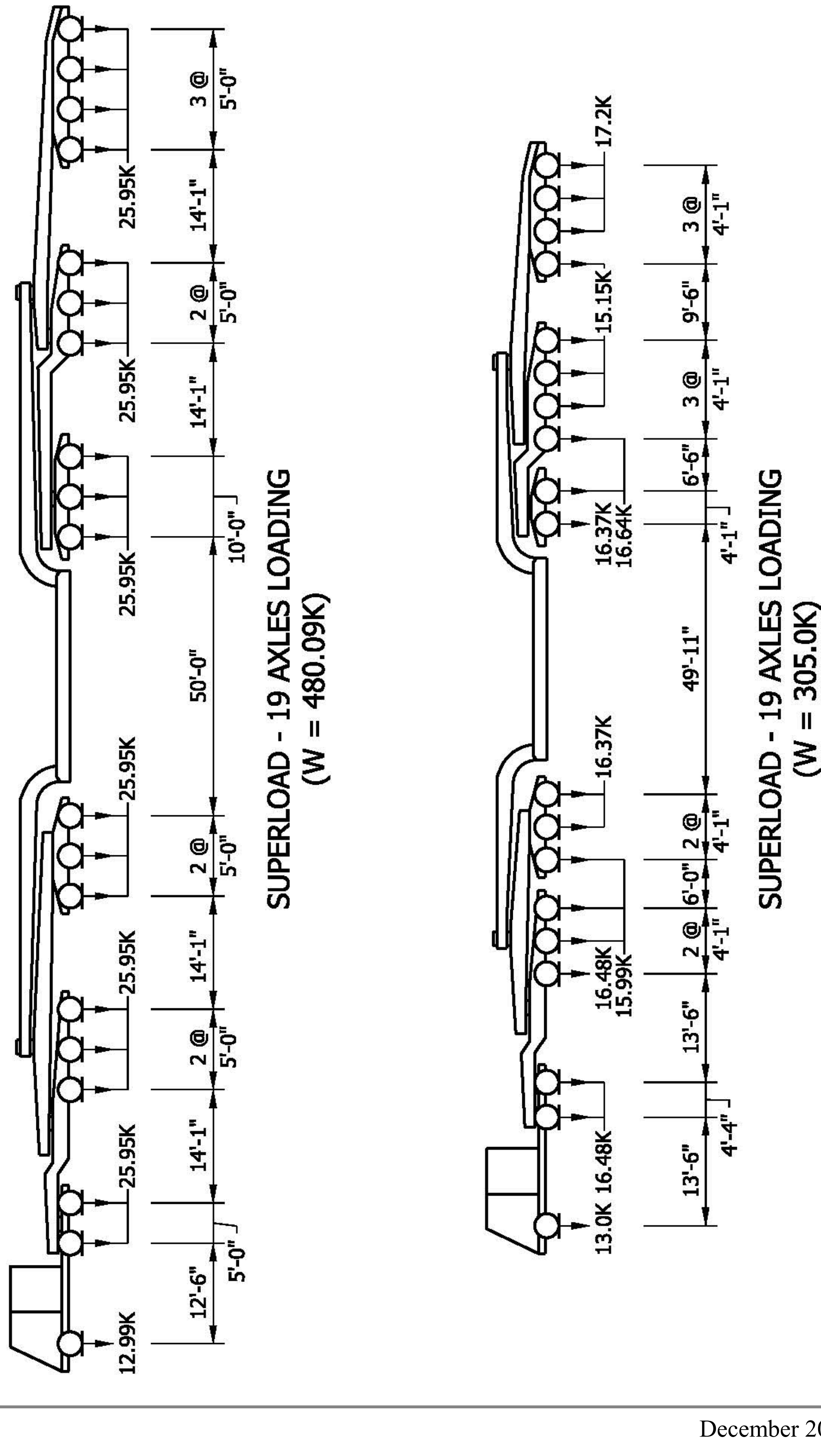
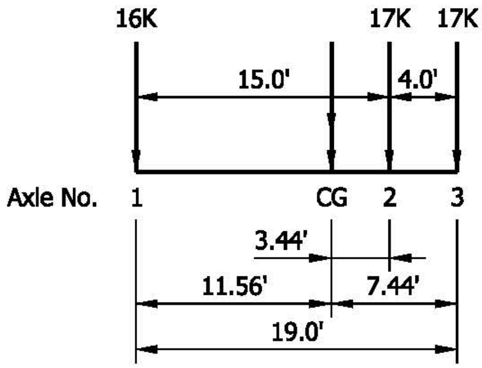


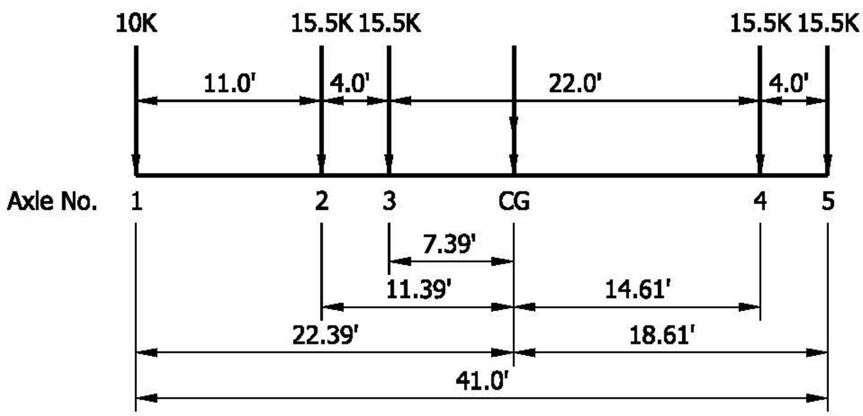
Figure A-9
Superload Vehicle Loads



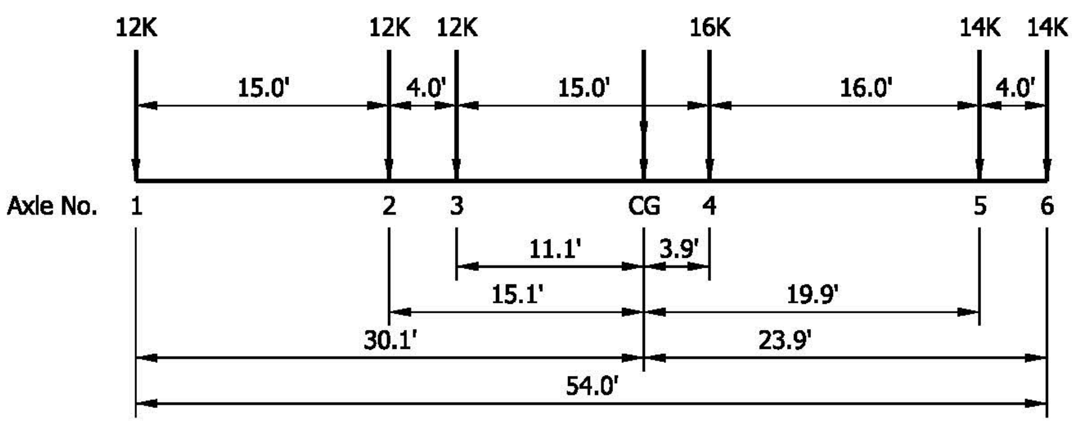
Indicated Concentrations are Axle Loads in kips

CG = Center of Gravity

TYPE 3 UNIT
Weight = 50 kips (25 tons)



TYPE 3S2 UNIT
Weight = 72 kips (36 tons)



TYPE 3-3 UNIT
Weight = 80 kips (40 tons)

Figure A-10
AASHTO Legal Loads

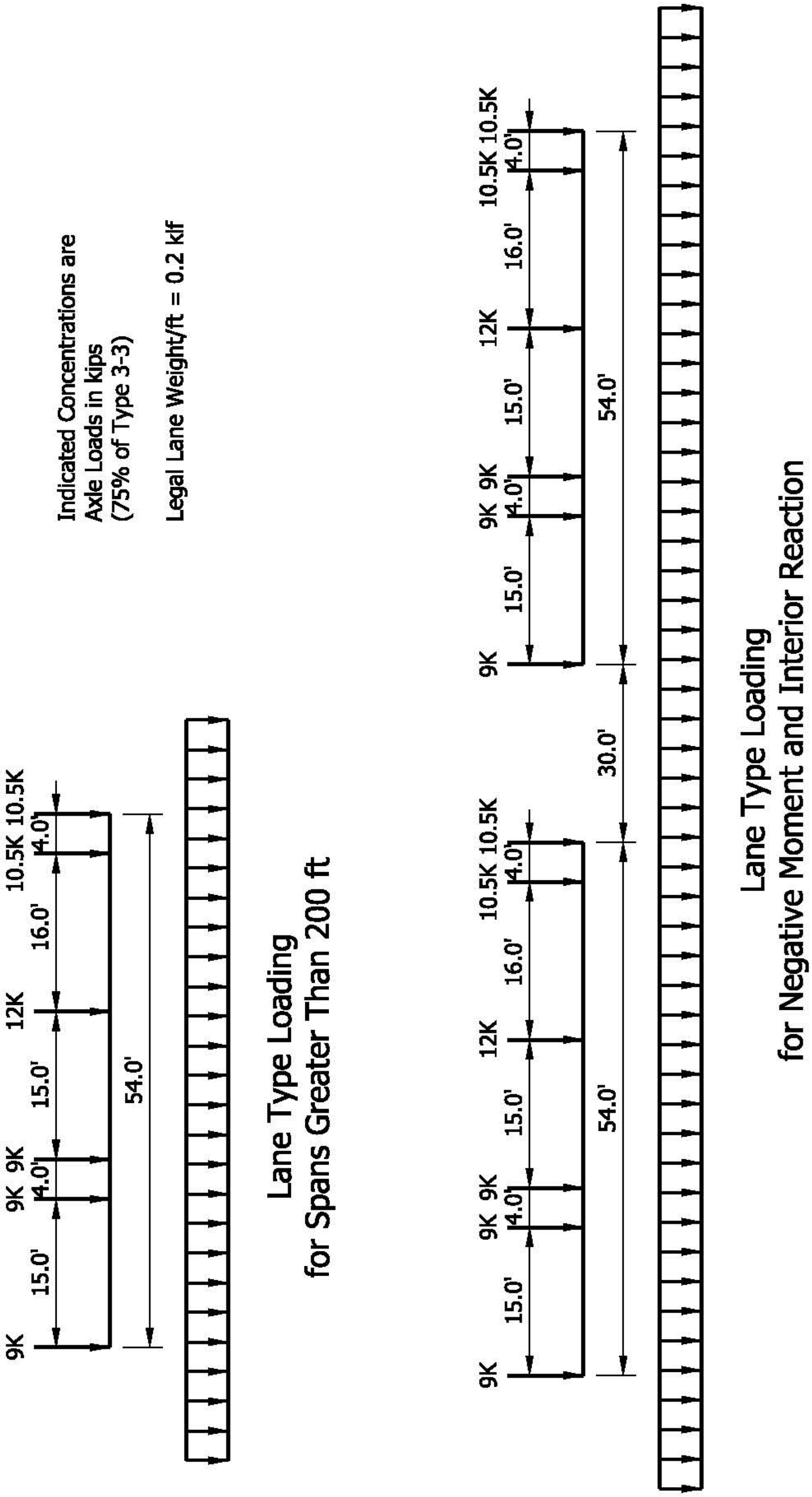
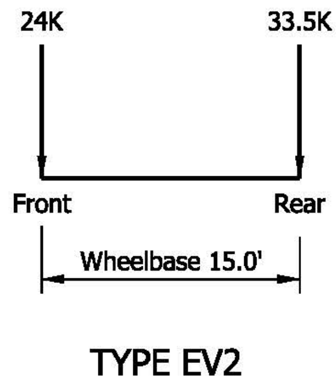


Figure A-11
Lane-Type Loading



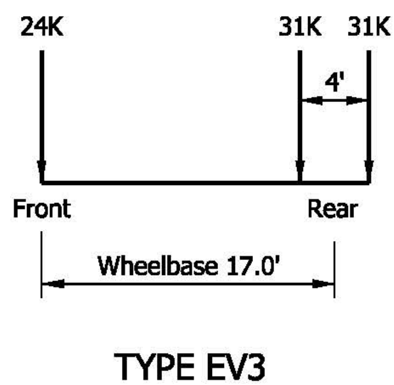
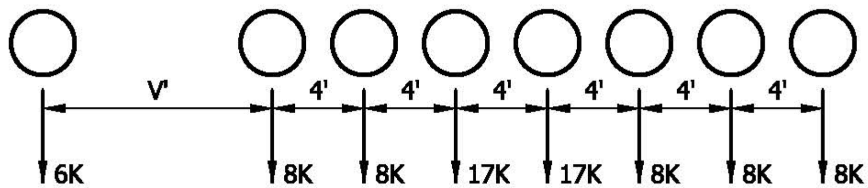


Figure A-12
FAST Act EV Loads



V = Variable Drive Axle Spacing - 6'-0" to 14'-0". Spacing to be used is that which produces maximum load effects.

Axles that do not contribute to the maximum load effect under consideration shall be neglected.

Maximum GVW = 80 Kips

Axle Gage Width = 6'-0"

Figure A-13
Notional Rating Load (NRL)

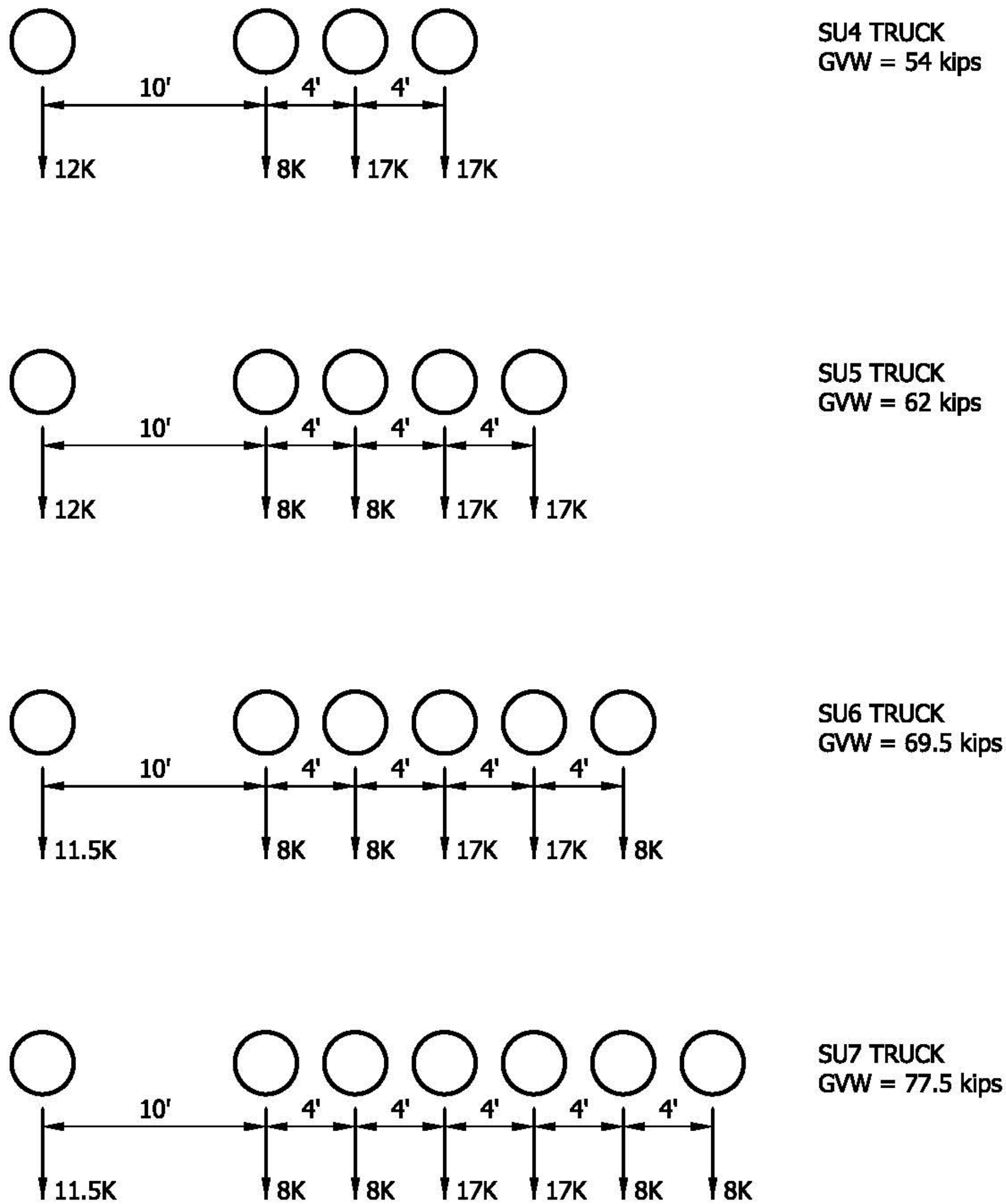


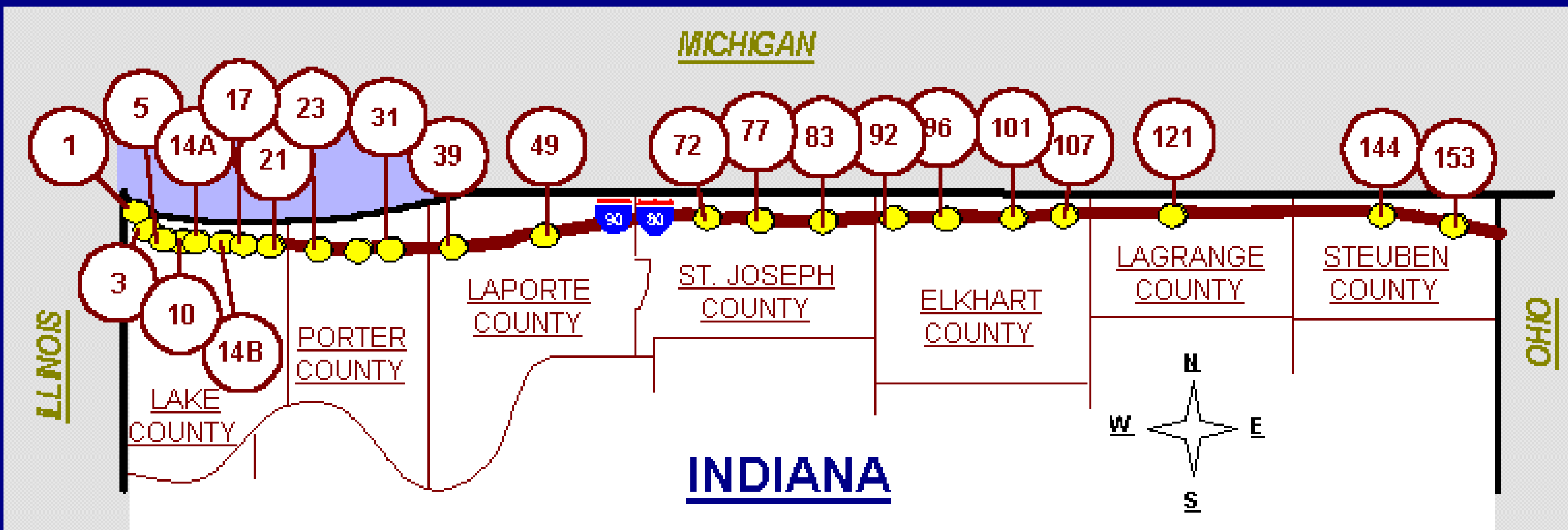
Figure A-14
Specialized Hauling Vehicles (SHV)

3-11.2 Appendix B: Extra-Heavy Duty Highways

As of June 16, 2017

http://www.in.gov/indot/2350.htm

INDIANA TOLL ROAD
"Main Street of the Midwest"



EXIT & ENTRY LOCATIONS

Mile Marker	Toll Plaza	Intersecting Routes
1	Westpoint Barrier	Chicago Skyway & Indianapolis Blvd. & US 41
3	Exit 3 (Eastbound Only)	SR 912 North
5	Calumet Avenue	Calumet Avenue & US 41
10	Cline Avenue	SR 912 South
14A	Gary West	Grant & Buchanan Streets
14B	Broadway	US 12 & US 20
17	Gary East	I-65 & US 12 & US 20
21	Lake Station	I-80/94
23	Portage/Willow Creek	Willow Creek Road
31	Valparaiso/Chesterton	SR 49
39	Michigan City	US 421
49	LaPorte	SR 39
72	South Bend West	US 31 Bypass
77	South Bend/Notre Dame	SR 933 & Business US 31
83	Mishawaka	SR 23
92	Elkhart	SR 19
96	Elkhart East	CR 17
101	Bristol/Goshen	SR 15
107	Middlebury	SR 13 & US 131
121	Howe/LaGrange	SR 9
144	Angola	I-69 & US 27 & SR 127 & SR 120
153	Eastpoint Barrier	Ohio Turnpike

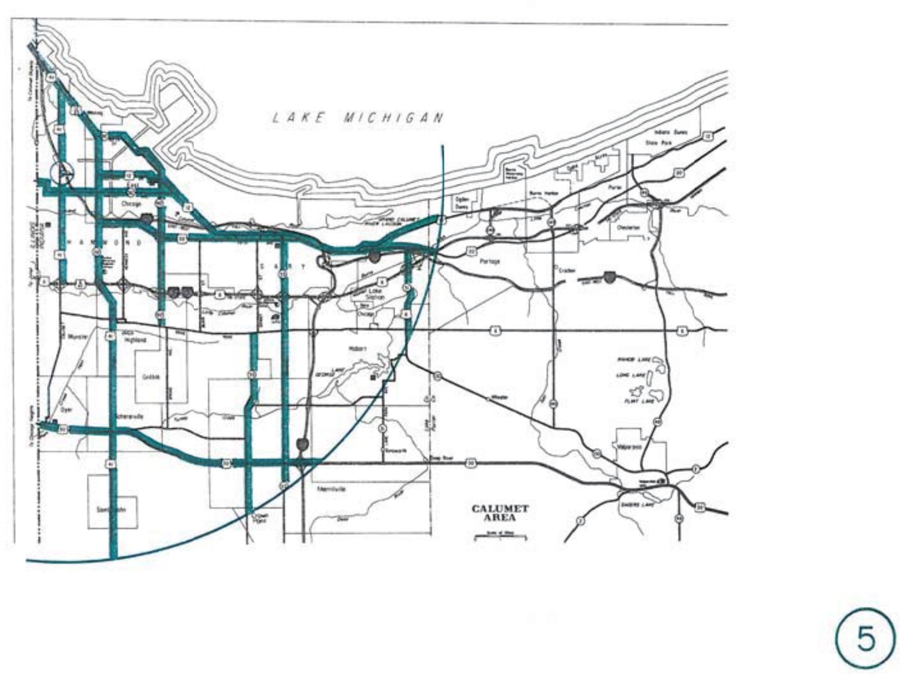
As of June 16, 2017
http://www.in.gov/indot/2350.htm

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ **Yes**	**Toll Road:**	☒ **Yes**	**Input Format:**	☒ **Drop-Down**	☐ **Manual**
INDOT:	☒ **Yes**	**County/Local:**	☒ **Yes**	**X**	☐ **Check Box**	☐ **Read-Only**

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 5

Note that the following are excluded: All Interstate Highways, Indiana Harbor Canal Lift Bridges, and SR 51 Northbound between US 20 and I-94.

Notes: -

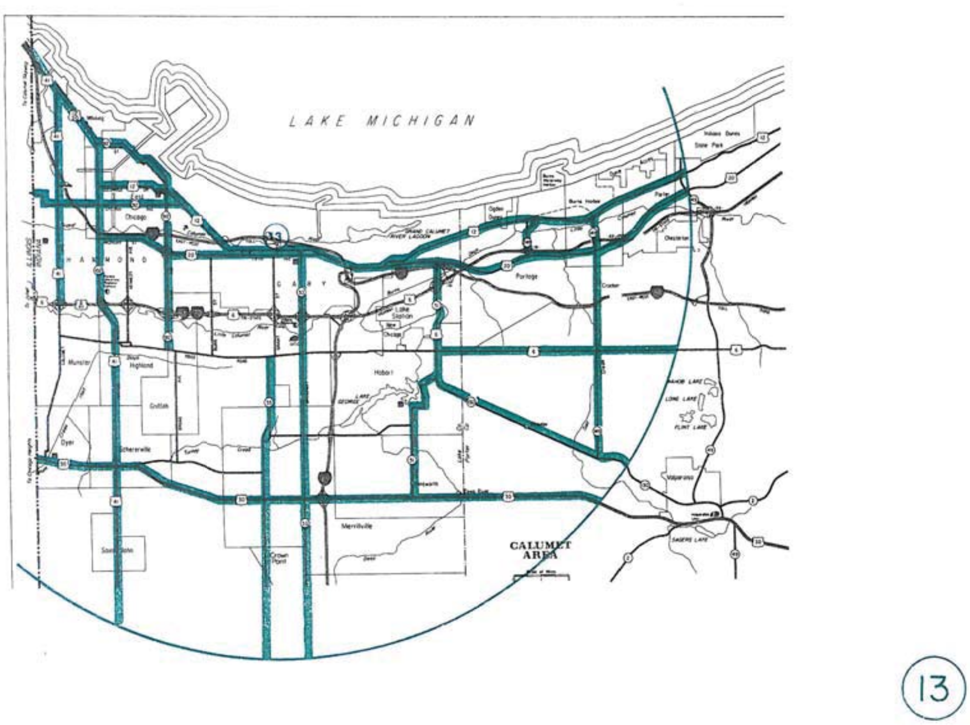
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 13

Note that the following are excluded: All Interstate Highways, Indiana Harbor Canal Lift Bridges, and SR 51 Northbound between US 20 and I-94.

Notes: -

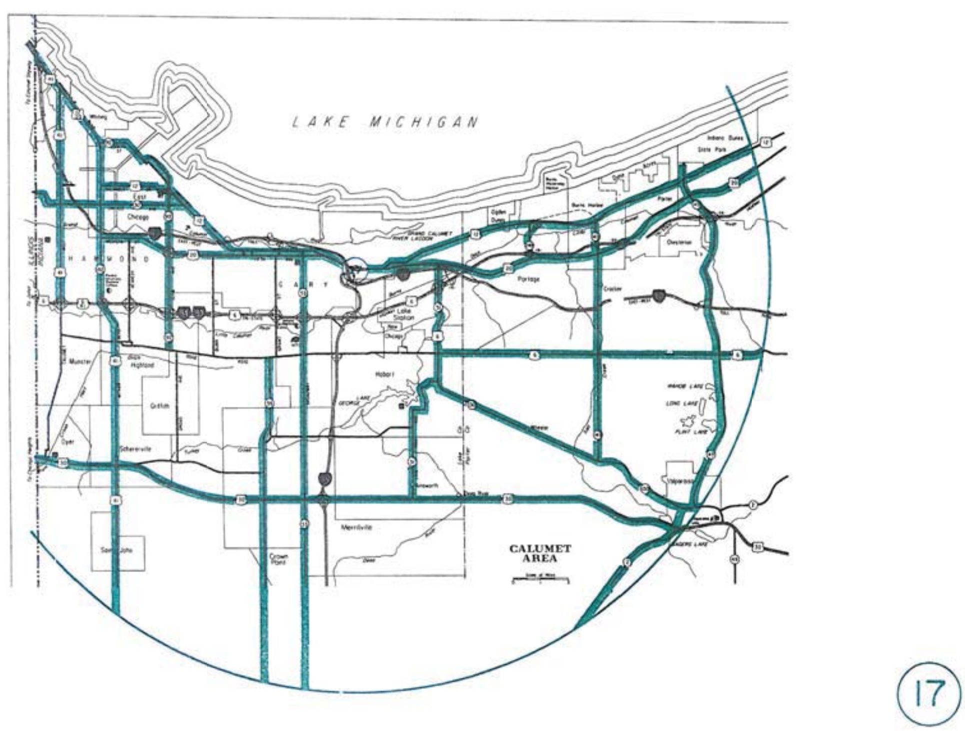
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 17

Note that the following are excluded: All Interstate Highways, Indiana Harbor Canal Lift Bridges, and SR 51 Northbound between US 20 and I-94.

Notes: -

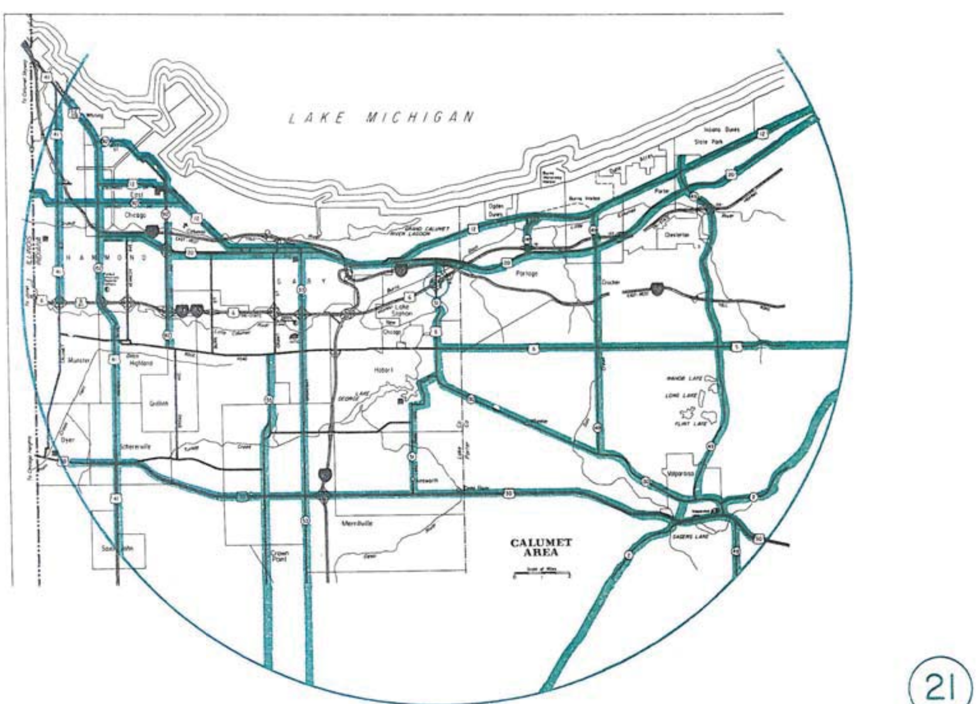
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ **Yes**	**Toll Road:**	☒ **Yes**	**Input Format:**	☒ **Drop-Down**	☐ **Manual**
INDOT:	☒ **Yes**	**County/Local:**	☒ **Yes**	**X**	☐ **Check Box**	☐ **Read-Only**

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 21

Note that the following are excluded: All Interstate Highways, Indiana Harbor Canal Lift Bridges, and SR 51 Northbound between US 20 and I-94.

Notes: -

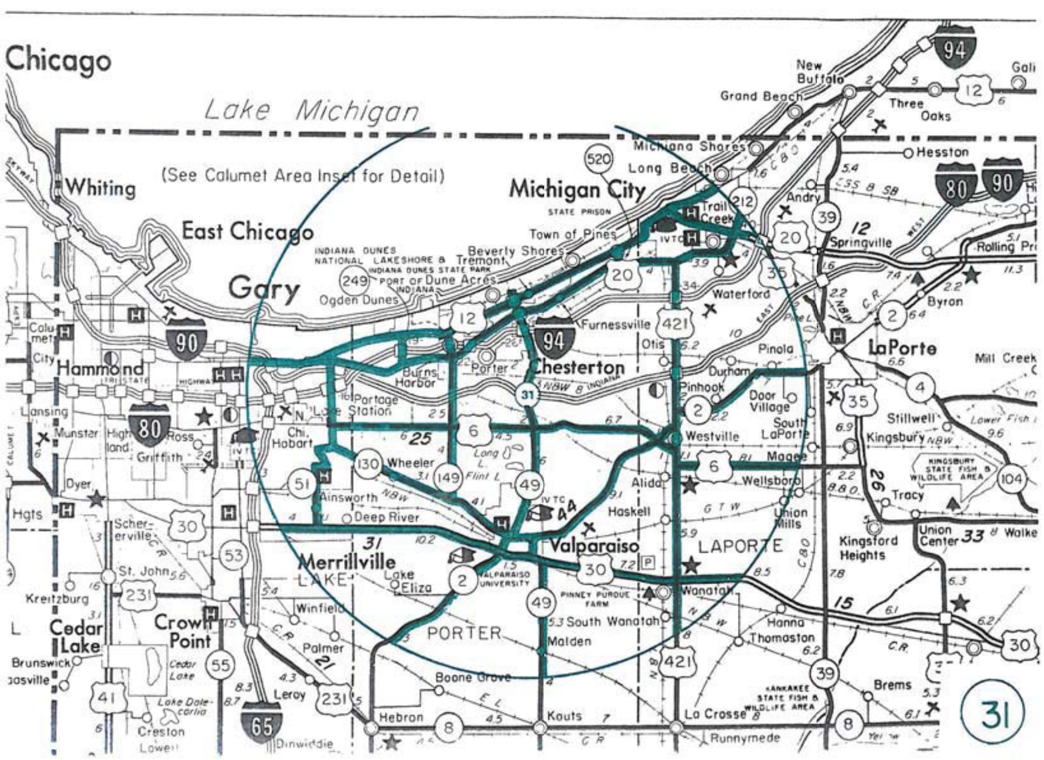
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	Item Name:	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual	
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only	

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 31

Note that the following are excluded: All Interstate Highways and SR 51 Northbound between US 20 and I-94.

Notes: -

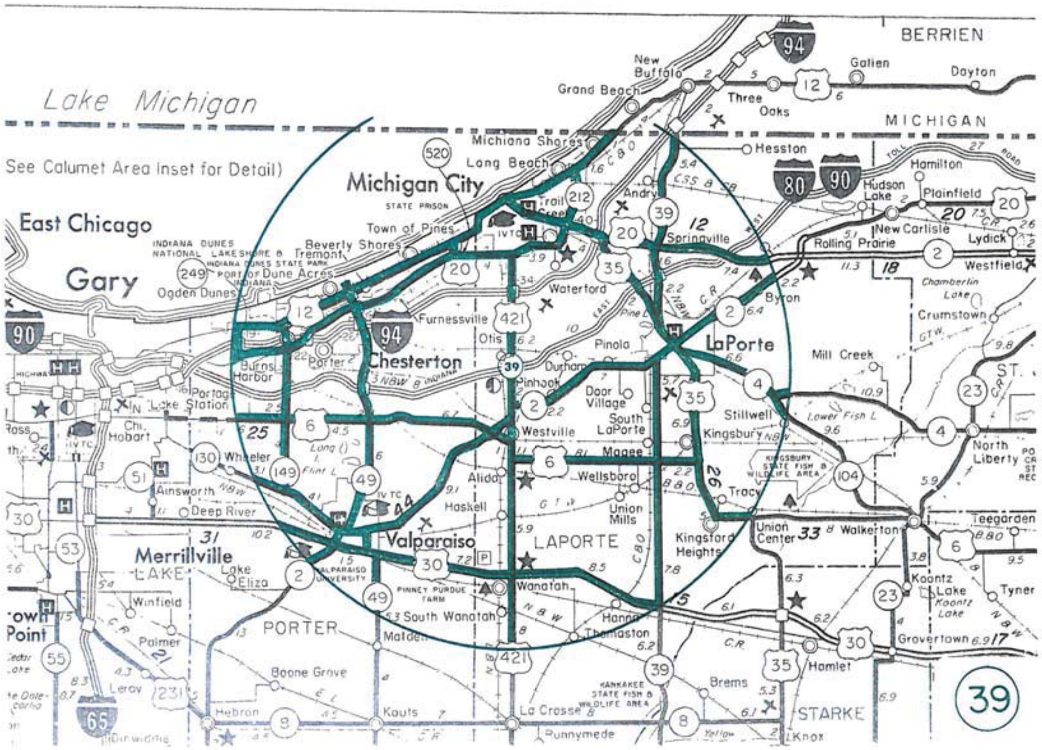
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 39

Note that the following are excluded: All Interstate Highways.

Notes: -

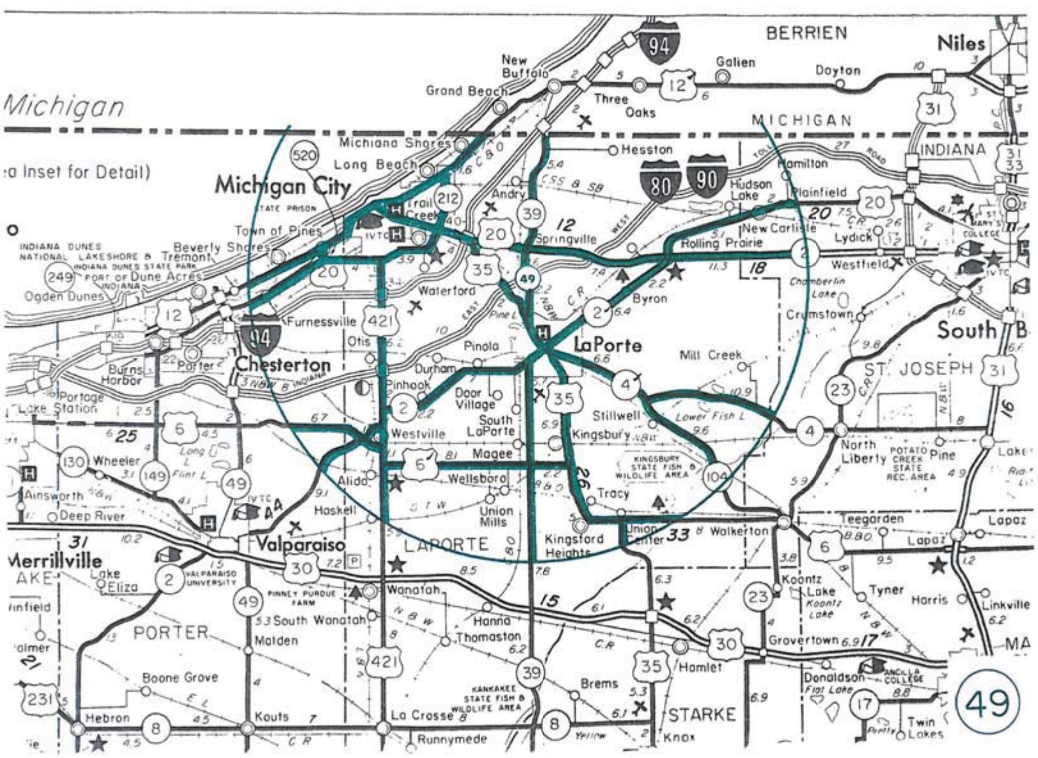
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 49

Note that the following are excluded: All Interstate Highways.

Notes: -

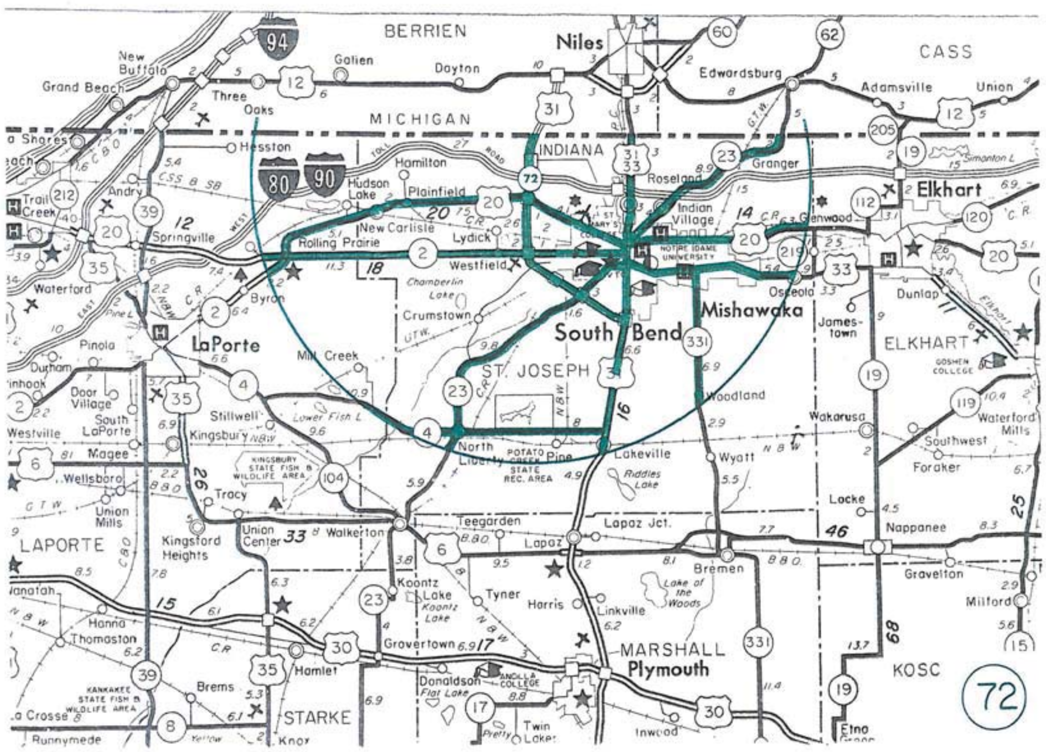
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 72

Note that the following are excluded: All Interstate Highways and over posted height on SR 2 between US 31 and SR 23.

Notes: -

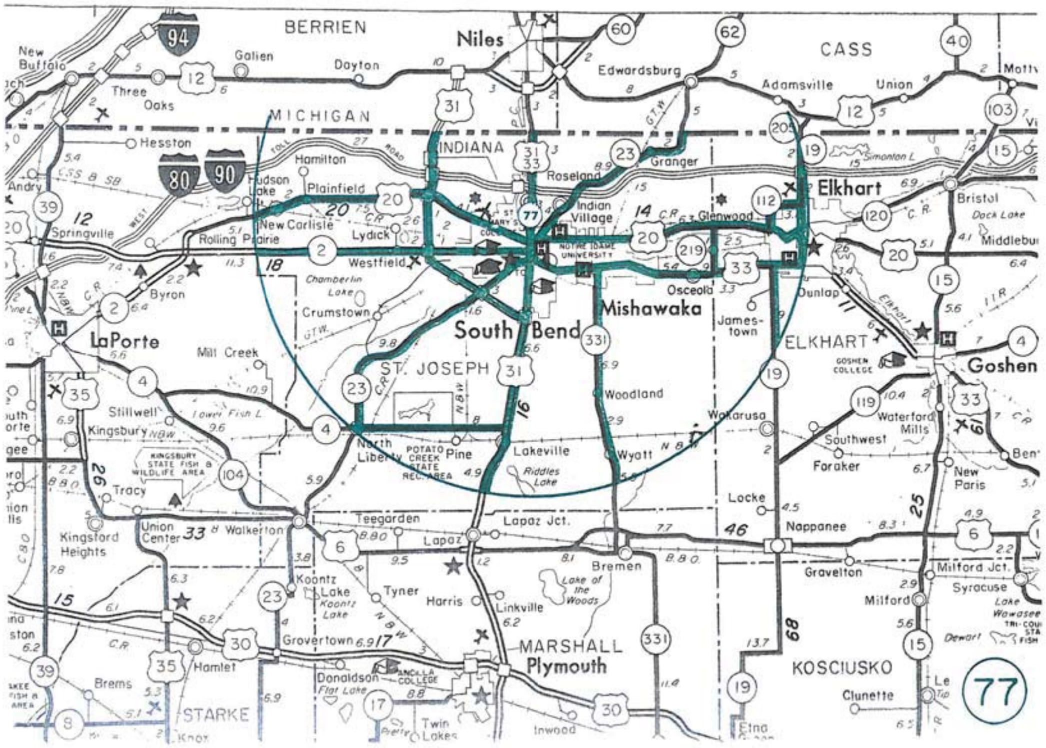
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 77

Note that the following are excluded: All Interstate Highways and over posted height on SR 2 between US 31 and SR 23.

Notes: -

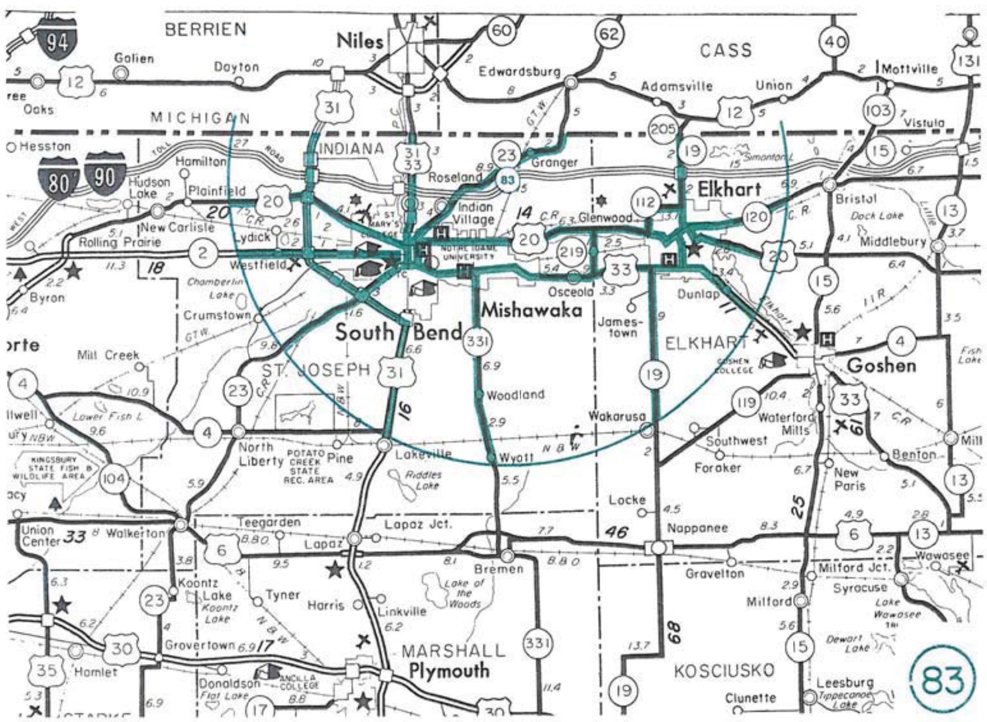
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 83

Note that the following are excluded: All Interstate Highways and over posted height on SR 2 between US 31 and SR 23.

Notes: -

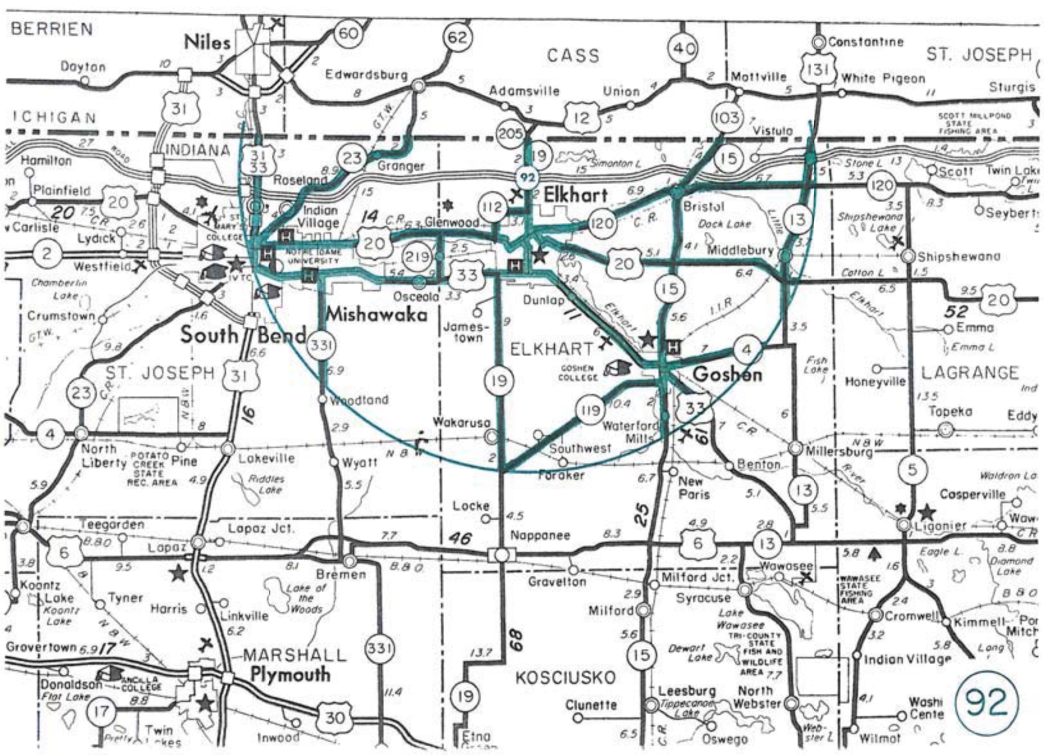
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	X	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 92

Note that the following are excluded: All Interstate Highways.

Notes: -

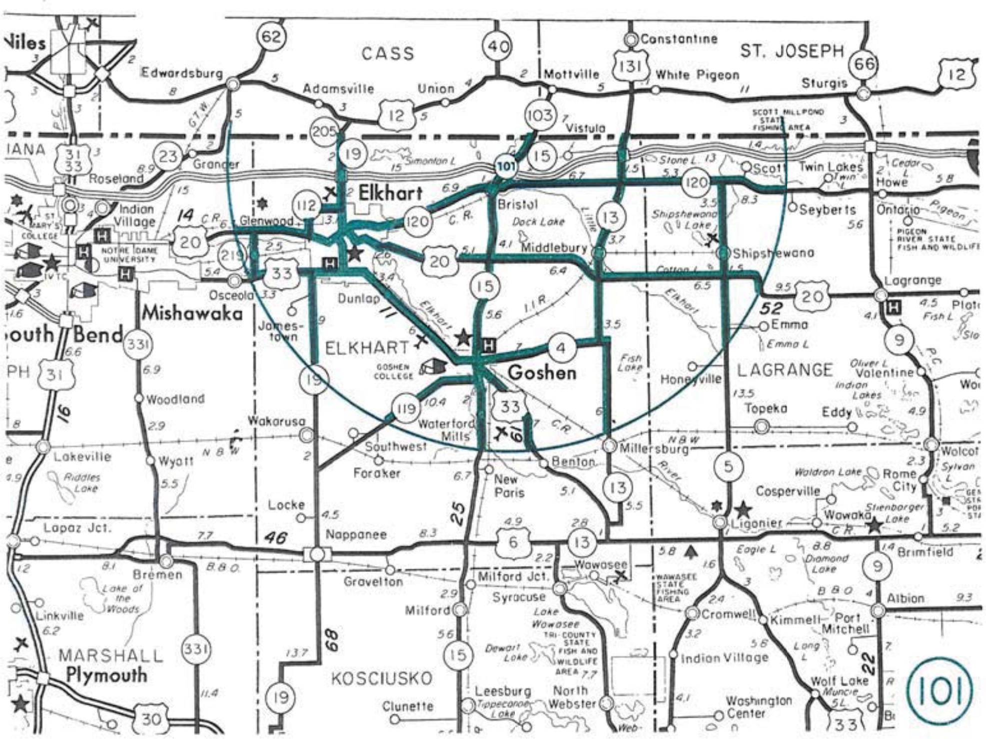
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down		☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box		☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 101

Note that the following are excluded: All Interstate Highways and any vehicles with an overall length in excess of 95 feet.

Notes: -

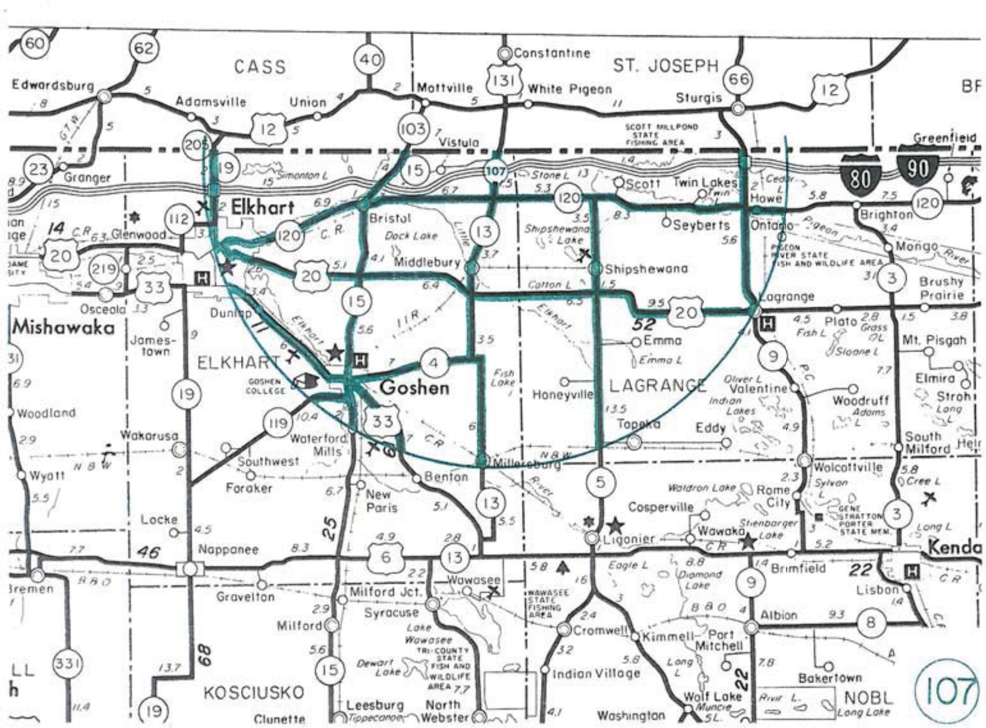
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 107

Note that the following are excluded: All Interstate Highways.

Notes: -

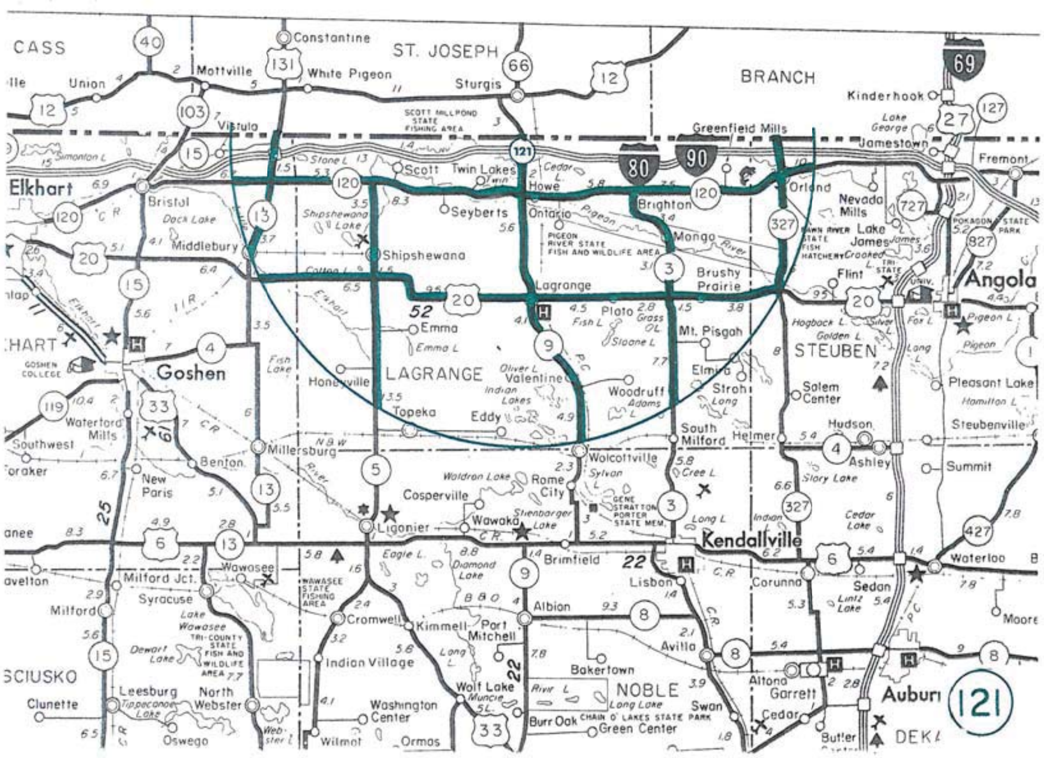
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS: ☐ Yes	**Toll Road:** ☒ Yes		**Input Format:**	☒ **Drop-Down**	☐ **Manual**
INDOT: ☒ Yes	**County/Local:** ☒ Yes		**X**	☐ **Check Box**	☐ **Read-Only**

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.



Exit 121

Note that the following are excluded: All Interstate Highways.

Notes: -

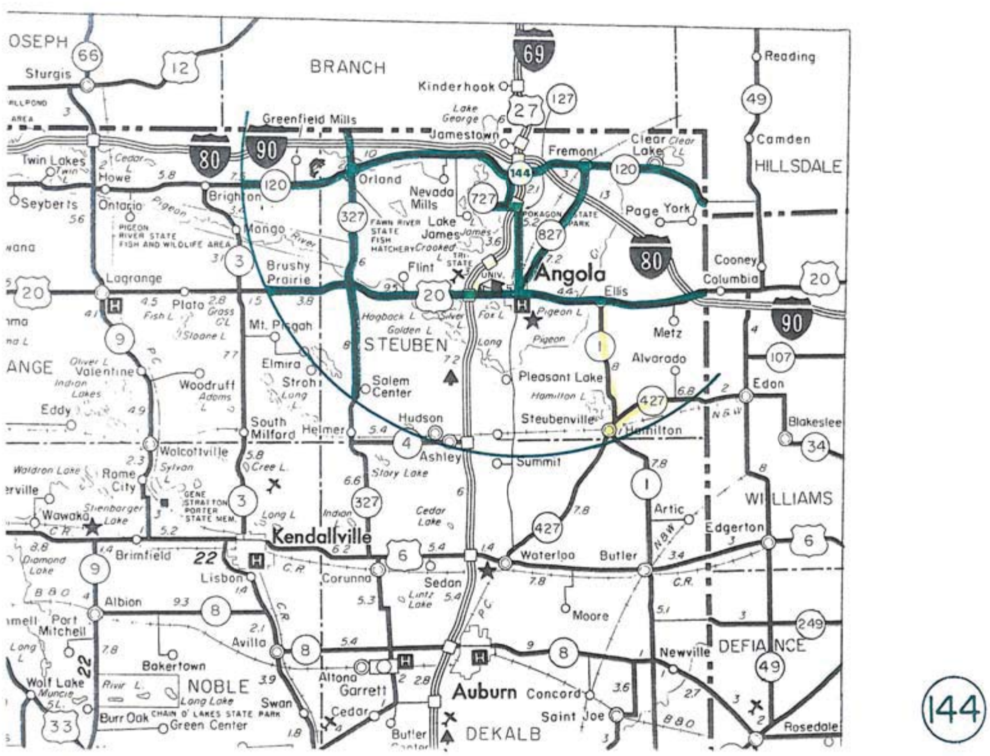
INDOT Coding Guide: *B*ridge *R*eporting for *A*ppraisal & *G*reater *I*nventory

Item Number:	501.02	**Item Name:**	"Heavy Duty Truck Route"
Main Tab/Sub Tab:	Aux. Forms/O.V. (501)	**Misc. Fields:**	501 Overall Comments
Main Tab/Sub Tab:	Load Rating/Struc. Data (1)	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-
Main Tab/Sub Tab:	-	**Misc. Fields:**	-

NBIS:	☐ Yes	**Toll Road:**	☒ Yes	**Input Format:**	☒ Drop-Down	☐ Manual
INDOT:	☒ Yes	**County/Local:**	☒ Yes	**X**	☐ Check Box	☐ Read-Only

Description: "Heavy Duty Truck Route" (continued)

Instructions: See the detailed map below for Heavy Duty Truck Routes in Indiana, which are defined as any route carrying public vehicular traffic within a 15 mile radius of Toll Road exits.

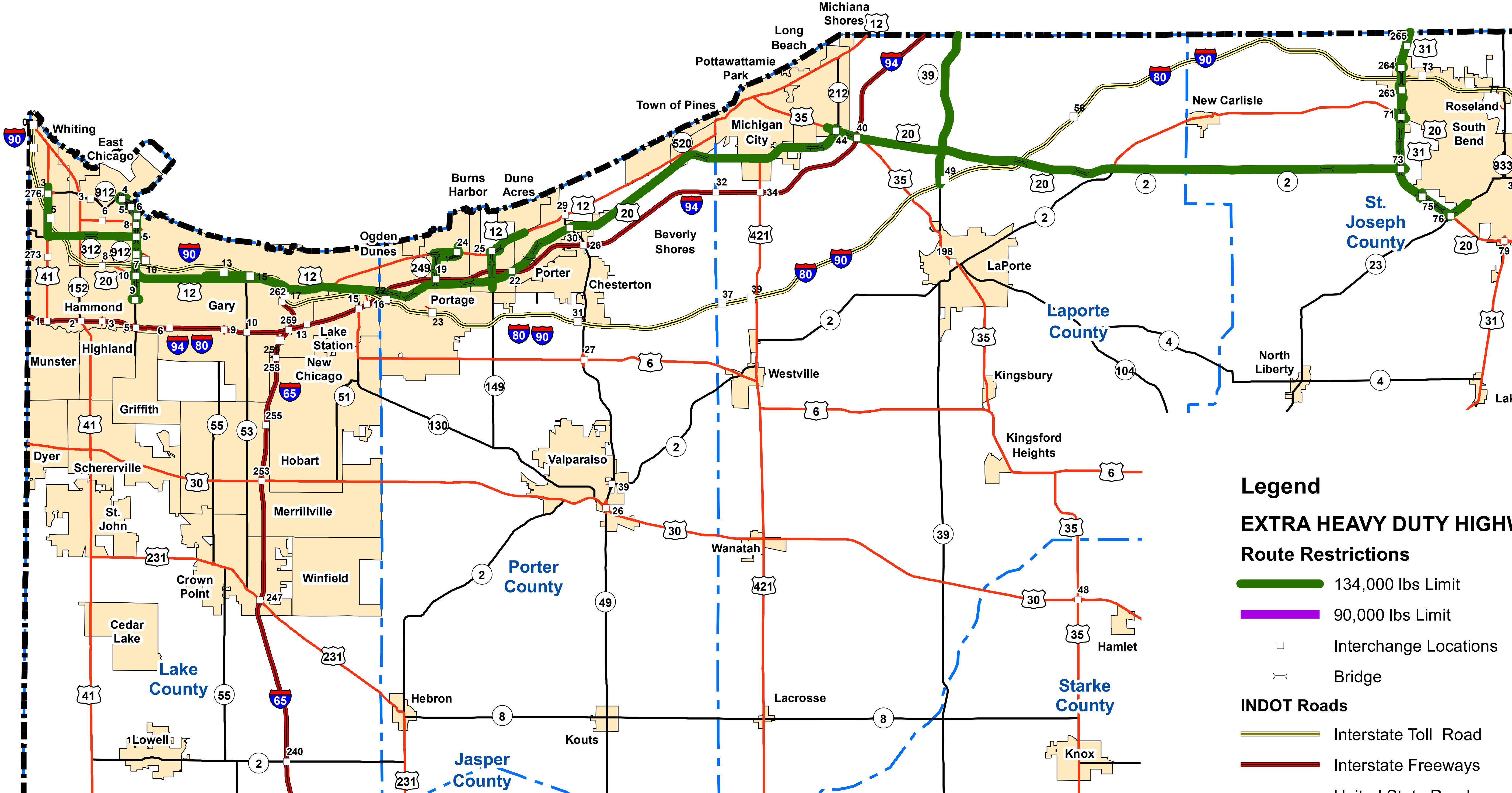


Exit 144

Note that the following are excluded: All Interstate Highways, SR 1, and SR 427.

Notes: -

INDIANA EXTRA HEAVY DUTY HIGHWAYS
North West Indiana



Legend

EXTRA HEAVY DUTY HIGHWAYS

Route Restrictions

- 134,000 lbs Limit
- 90,000 lbs Limit
- Interchange Locations
- Bridge

INDOT Roads

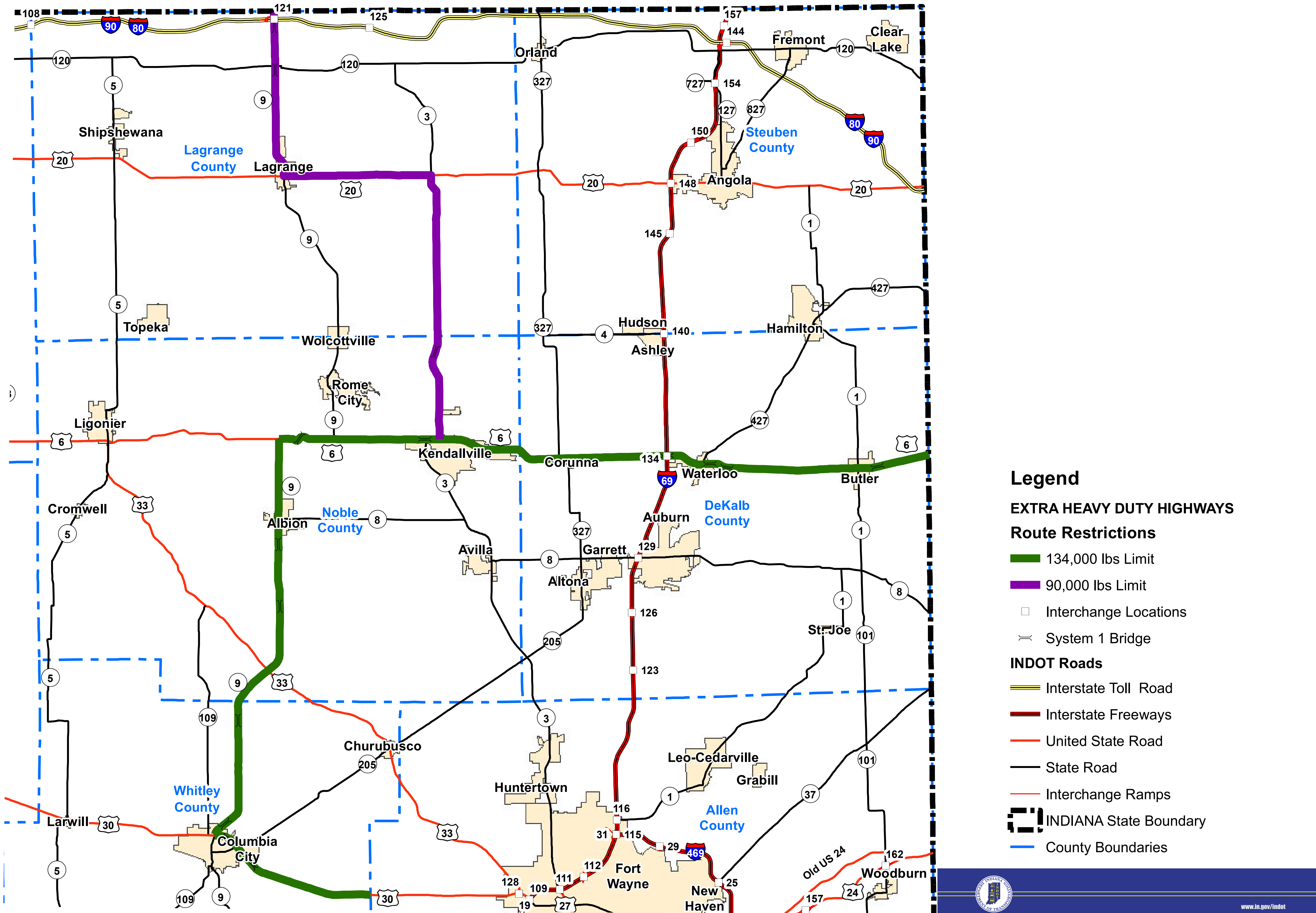
- Interstate Toll Road
- Interstate Freeways
- United State Road
- State Road
- Interchange Ramps
- INDIANA State Boundary
- County Boundaries

As of June 16, 2017
http://www.in.gov/indot/2350.htm

www.in.gov/indot

INDIANA EXTRA HEAVY DUTY HIGHWAYS

North East Indiana



As of June 16, 2017
http://www.in.gov/indot/2350.htm

IC 9-20-5

Chapter 5. Heavy Duty Highways and Extra Heavy Duty Highways

IC 9-20-5-1

Establishment and designation of heavy duty and extra heavy duty highways; removal of designation; publication of map

Sec. 1. (a) The Indiana department of transportation may adopt rules under IC 4-22-2 to do the following:

(1) Establish and designate a highway as a heavy duty highway.

(2) Remove the designation of a highway or part of a highway as a heavy duty highway.

(b) The Indiana department of transportation shall adopt rules under IC 4-22-2 to do the following:

(1) Establish and designate a highway as an extra heavy duty highway.

(2) Remove the designation of a highway or part of a highway as an extra heavy duty highway.

(c) Rules described in subsection (b)(1) must do the following:

(1) Designate the highways listed in section 4 of this chapter (before its expiration) as extra heavy duty highways.

(2) Establish maximum size and weight limits for vehicles operated with a special weight permit on an extra heavy duty highway as set forth in section 5 of this chapter (before its expiration).

(d) The Indiana department of transportation shall periodically publish a map showing all highways designated by the department at the time as heavy duty or extra heavy duty highways.

As added by P.L.2-1991, SEC.8. Amended by P.L.66-2012, SEC.1.

IC 9-20-5-2

Maximum weight limitations; heavy duty highways

Sec. 2. Whenever the Indiana department of transportation designates a heavy duty highway, the department shall also fix the maximum weights of vehicles that may be transported on the highway. The maximum weights may not exceed the following limitations:

(1) A vehicle may not have a maximum wheel weight, unladen or with load, in excess of eight hundred (800) pounds per inch width of tire, measured between the flanges of the rim, or an axle weight in excess of twenty-two thousand four hundred (22,400) pounds.

(2) The total weight concentrated on the roadway surface from any tandem axle group may not exceed eighteen thousand (18,000) pounds for each axle of the assembly.

(3) The total gross weight, with load, in pounds of a vehicle or combination of vehicles may not exceed eighty thousand (80,000) pounds.

As added by P.L.2-1991, SEC.8.

IC 9-20-5-3
Designation of heavy duty highways; conditions

Sec. 3. The Indiana department of transportation may not designate a highway as a heavy duty highway unless the department finds that the highway is:

(1) so constructed and can be so maintained; or

(2) in such condition;

that the use of the highway as a heavy duty highway will not materially decrease or contribute materially to the decrease of the ordinary useful life of the highway.

As added by P.L.2-1991, SEC.8. Amended by P.L.198-2016, SEC.340.

IC 9-20-5-4
Extra heavy duty highways; listing; expiration

Sec. 4. (a) In addition to the highways established and designated as heavy duty highways under section 1 of this chapter, the following highways are designated as extra heavy duty highways:

(1) Highway 41, from 129th Street in Hammond to Highway 312.

(2) Highway 312, from Highway 41 to State Road 912.

(3) Highway 912, from Riley Road in East Chicago to the U.S. 20 interchange.

(4) Highway 20, from Clark Road in Gary to Highway 39.

(5) Highway 12, from one-fourth (1/4) mile west of the Midwest Steel entrance to Highway 249.

(6) Highway 249, from Highway 12 to Highway 20.

(7) Highway 12, from one and one-half (1 1/2) miles east of the Bethlehem Steel entrance to Highway 149.

(8) Highway 149, from Highway 12 to a point thirty-six hundredths (.36) of a mile south of Highway 20.

(9) Highway 39, from Highway 20 to the Michigan state line.

(10) Highway 20, from Highway 39 to Highway 2.

(11) Highway 2, from Highway 20 to Highway 31.

(12) Highway 31, from the Michigan state line to Highway 23.

(13) Highway 23, from Highway 31 to Olive Street in South Bend.

(14) Highway 35, from South Motts Parkway thirty-four hundredths (.34) of a mile southeast to the point where Highway 35 intersects with the overpass for Highway 20/Highway 212.

(15) State Road 249 from U.S. 12 to the point where State Road 249 intersects with Nelson Drive at the Port of Indiana.

(16) State Road 912 from the 15th Avenue and 169th Street interchange one and six hundredths (1.06) miles north to the U.S. 20 interchange.

(17) U.S. 20 from the State Road 912 interchange three and seventeen hundredths (3.17) miles east to U.S. 12.
(18) U.S. 6 from the Ohio state line to State Road 9.
(19) U.S. 30 from Allen County/Whitley County Line Road (also known as County Road 800 East) to State Road 9.
(20) State Road 9 from U.S. 30 to U.S. 6.
(21) State Road 39 from Interstate 80 to U.S. 20.
(22) State Road 3 north from U.S. 6 to U.S. 20, U.S. 20 west from State Road 3 to State Road 9, State Road 9 north from U.S. 20 to the Michigan state line. However, the total gross weight, with load, of a vehicle or combination of vehicles operated with a special weight permit on these highways may not exceed ninety thousand (90,000) pounds.
(23) Highway 912, at an intersection approximately thirty hundredths (.30) of a mile southwest of the intersection of Dickey Road and Riley Road in East Chicago. The total gross weight, with load, of a vehicle or combination of vehicles operated with a special weight permit on this highway may not exceed two hundred sixty-four thousand (264,000) pounds.

(b) This section expires on the later of the following dates:
(1) The date on which rules described in section 1(c)(1) of this chapter are finally adopted.
(2) December 31, 2014.

As added by P.L.2-1991, SEC.8. Amended by P.L.12-1991, SEC.4; P.L.123-1993, SEC.1; P.L.124-1993, SEC.1; P.L.119-1995, SEC.2; P.L.45-1999, SEC.1; P.L.79-2000, SEC.3; P.L.147-2002, SEC.2; P.L.10-2004, SEC.1; P.L.17-2006, SEC.1; P.L.134-2007, SEC.1; P.L.120-2011, SEC.1; P.L.66-2012, SEC.2.

IC 9-20-5-4.5
Repealed

(Repealed by P.L.123-1993, SEC.2.)

IC 9-20-5-5
Maximum size and weight limitations; extra heavy duty highways; expiration

Sec. 5. (a) Except as provided in subsection (b), the maximum size and weight limits for vehicles operated with a special weight permit on an extra heavy duty highway are as follows:
(1) A vehicle may not have a maximum wheel weight, unladen or with load, in excess of eight hundred (800) pounds per inch width of tire, measured between the flanges of the rim.
(2) A single axle weight may not exceed eighteen thousand (18,000) pounds.
(3) An axle in an axle combination may not exceed thirteen thousand (13,000) pounds per axle, with the exception of one (1) tandem group that may weigh sixteen thousand (16,000) pounds per axle or a total of thirty-two thousand (32,000)

pounds.

(4) Except as provided in section 4(a)(22) of this chapter, the total gross weight, with load, of any vehicle or combination of vehicles may not exceed one hundred thirty-four thousand (134,000) pounds.

(5) Axle spacings may not be less than three (3) feet, six (6) inches, between each axle in an axle combination.

(6) Axle spacings may not be less than eight (8) feet between each axle or axle combination.

(b) A vehicle operated in accordance with section 4(a)(23) of this chapter may not have a:

(1) maximum wheel weight, unladen or with load, in excess of one thousand six hundred fifty (1,650) pounds per inch width of tire, measured between the flanges of the rim; or

(2) single axle weight that exceeds sixty-five thousand (65,000) pounds.

(c) This section expires on the later of the following dates:

(1) The date on which rules described in section 1(c)(2) of this chapter are finally adopted.

(2) December 31, 2014.

As added by P.L.2-1991, SEC.8. Amended by P.L.134-2007, SEC.2; P.L.120-2011, SEC.2; P.L.66-2012, SEC.3; P.L.13-2013, SEC.35.

IC 9-20-5-6

Safety procedures; implementation

Sec. 6. The Indiana department of transportation shall implement procedures that, in cooperation with the state police department and local police departments, enhance the safety of citizens along and near extra heavy duty highways listed in section 4 of this chapter (before its expiration) or described in rules adopted by the Indiana department of transportation under section 1 of this chapter.

As added by P.L.2-1991, SEC.8. Amended by P.L.66-2012, SEC.4.

IC 9-20-5-7

Special weight permits; extra heavy duty highways; fee; additional permit fee

Sec. 7. (a) The owner or operator of a vehicle or combination of vehicles having a total gross weight in excess of eighty thousand (80,000) pounds but less than two hundred sixty-four thousand (264,000) pounds must:

(1) obtain a special weight registration permit;

(2) register annually and pay annually a registration fee to the department of state revenue; and

(3) install an approved automated vehicle identifier in each vehicle operating with a special weight permit;

to travel on an extra heavy duty highway.

(b) The fee for an annual registration under subsection (a) is twenty-five dollars ($25). The fee imposed under this section must be deposited in the motor carrier regulation fund established under IC 8-2.1-23.

(c) The department of state revenue may impose an additional permit fee in an amount that may not exceed one dollar ($1) on each trip permitted for a vehicle registered under subsection (a). This additional fee is for the use and maintenance of an automated vehicle identifier. The fee imposed under this section must be deposited in the motor carrier regulation fund established under IC 8-2.1-23.

As added by P.L.2-1991, SEC.8. Amended by P.L.122-1993, SEC.2; P.L.129-2001, SEC.30; P.L.120-2011, SEC.3; P.L.198-2016, SEC.341.

IC 9-20-5-8

Conditions under which permits not to be issued

Sec. 8. The Indiana department of transportation may not issue a permit under this chapter for the operation of a vehicle if any of the following conditions apply:

(1) The owner or operator of the vehicle has not complied with IC 8-2.1-24.

(2) The owner or operator of the vehicle has not provided the Indiana department of transportation with the owner's or operator's Social Security number or federal identification number.

(3) The owner or operator of the vehicle has not registered the vehicle with the bureau, if the vehicle is required to be registered under IC 9-18.

As added by P.L.122-1993, SEC.3. Amended by P.L.110-1995, SEC.30.

LOAD RATING SUMMARY
For
BRIDGE DETERIORATION/CRITICAL FIND

BRIDGE NUMBER

XXX-XX-XXXXX

NBI NUMBER

XXXXXX

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	BrR 6.8.1
Rating Method:	LRFR	Rating Units:	US Customary

IDENTIFICATION

Structure Type:	CPCIB - Continuous Prestressed Concrete I-Beam Bridge		
Description:	Three (3) Span / Twelve (12) Beam System		
County:	49 - Marion	Year Built:	1976
District:	03 - Greenfield	Years Reconstructed:	1994
Reference Post:	21+75		

GEOMETRY

Spans:	45'-0", 55'-0", 45'-0"
Girder Spacing:	11 @ 6'-6"
O-to-O Coping:	77'-0"
Clear Roadway:	74'-0"
Left Overhang:	2'-9"
Skew:	30° 00' 00" RT

DECK

Original Thickness:	8"	Concrete f'c =	5 ksi
Structural Depth:	6.5"	Reinforcing Fy =	60 ksi
Additional Overlay:	N/A		
Future Wearing Surface:	35 psf		
Stay-in-Place Forms:	15 psf		

CONCRETE BEAMS

AASHTO Type II	Reinforcing Fy =	60 ksi	Concrete f'c =	5 ksi
	Strand Material:	1/2" Ø (7W-270ksi) SP LL	Concrete f'ci =	4 ksi

STEEL BEAMS

W33 x 130	Structural Steel:	ASTM - A709 Grade 50W
	Structural Steel:	
	Structural Steel:	

REHAB SUMMARY

Rehab A: miscellaneous patching and new rail

NOTES

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	BrR 6.8.1
Rating Method:	LRFR	Rating Units:	US Customary

DESIGN LOADS

(future wearing suface ==> 35 psf)

Applicable Design Vehicle	Vehicle Configuration	Inventory Rating Factors
☑	HL-93	0.400
☑	Fatigue	1.310
☑	H-20	0.842
☑	HS-20	0.842
☐	~~*HS-25*~~	
☐	~~*Alternate Military*~~	
☐	~~*Toll Road Loading NO. 2*~~	
☐	~~*Toll Road Loading NO. 1*~~	
☐	~~*Special Toll Road Truck*~~	
☐	~~*Michigan Train Truck NO. 5*~~	
☐	~~*Michigan Train Truck NO. 8*~~	

NOTES

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	BrR 6.8.1
Rating Method:	LRFR	Rating Units:	US Customary

LEGAL & ROUTINE PERMIT LOADS

(future wearing surface NOT included)

# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)	Safe Posting Load (tons)
2	EV2	0.834	23.98	
3	EV3	0.581	24.98	
			Single Axle	13.97
			Tandem	18.01
			Gross	23.98

Applicable Routine Permit	# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)	Safe Posting Load (tons)
	varies	NRL	0.945	X	X
	2	H20-44	1.106	22.12	22.12
	2	Alternate Military	0.982	23.57	23.38
	3	HS20-44	0.671	24.16	19.08
	3	AASHTO Type 3	1.510	37.75	37.75
	4	SU4	1.380	37.26	37.26
☐	~~*4*~~	~~*Toll Road Loading NO. 2*~~			
	5	AASHTO Type 3S2	1.177	42.37	42.37
	5	SU5	1.215	37.67	37.67
☐	~~*5*~~	~~*Toll Road Loading NO. 1*~~			
	6	AASHTO Type 3-3	1.150	46.00	46.00
	6	Lane-Type	0.763	30.52	26.46
	6	SU6	1.088	37.81	37.81
☐	~~*7*~~	~~*Special Toll Road Truck*~~			
	7 / 8	SU7	0.982	38.05	37.75
☑	8	Michigan Train Truck NO. 5	0.646	43.28	33.12
☑	11	Michigan Train Truck NO. 8	0.627	42.07	31.35

NOTES

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	BrR 6.8.1
Rating Method:	LRFR	Rating Units:	US Customary

SPECIAL PERMIT LOADS

(future wearing surface NOT included)

# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)
11	Superload	0.638	82.30
13	Superload	0.648	86.51
14	Superload	0.548	95.90
19	Superload (305K)	0.632	96.38
19	Superload (480.09K)	0.525	126.02

NOTES

XXXX X. XXXXXXX
REGISTERED
No.
#######
STATE OF
INDIANA
PROFESSIONAL ENGINEER

LOAD RATING SUMMARY
For
BRIDGE DETERIORATION/CRITICAL FIND

BRIDGE NUMBER

XXX-XX-XXXXX

NBI NUMBER

XXXXXX

3-11.3 Appendix C: Load Rating Report Documentation Example 2

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	N/A
Rating Method:	Engineering Judgment	Rating Units:	US Customary

IDENTIFICATION

Structure Type:	Concrete Cast-in-Place Slab			
Description:	Single Span			
County:	73 - Shelby	Year Built:	1941	(no plans available)
District:	03 - Greenfield	Years Reconstructed:	2000	(no plans available)
Reference Post:	44+28			

GEOMETRY

Spans:	20'-1"
Girder Spacing:	N/A
O-to-O Coping:	44'-6"
Clear Roadway:	42'-0"
Left Overhang:	N/A
Skew:	45° 00' 00" LT

DECK

Original Thickness:	Unknown	Concrete f'c:	2.5 ksi	assumed
Structural Depth:	Unknown	Reinforcing Fy:	33 ksi	assumed
Additional Overlay:	Unknown			
Future Wearing Surface:	N/A			
Stay-in-Place Forms:	N/A			

CONCRETE BEAMS

Reinforcing Fy:	Concrete f'c:
Strand Material:	Concrete f'ci:

STEEL BEAMS

Structural Steel:

Structural Steel:

Structural Steel:

REHAB SUMMARY

Rehab A	Wearing surface and bridge railing replaced.

NOTES

In accordance with the Manual for Bridge Evaluation, Second Edition, 2011, Section 6.1.4 - Necessary details for this bridge are unavailable. A physical inspection of the bridge was performed by a qualified inspector and evaluated by a qualified engineer to establish an approximate load rating based on rational criteria.

Material properties have been assumed based on guidance given in the MBE.

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	N/A
Rating Method:	Engineering Judgment	Rating Units:	US Customary

DESIGN LOADS

(future wearing suface ==> N/A)

Applicable Design Vehicle	Vehicle Configuration	Inventory Rating Factors
☐	~~*HL-93*~~	
☐	~~*Fatigue*~~	
☑	H-20	1.000
☑	HS-20	1.000
☐	~~*HS-25*~~	
☑	Alternate Military	0.830
☐	~~*Toll Road Loading NO. 2*~~	
☐	~~*Toll Road Loading NO. 1*~~	
☐	~~*Special Toll Road Truck*~~	
☐	~~*Michigan Train Truck NO. 5*~~	
☐	~~*Michigan Train Truck NO. 8*~~	

NOTES

There are no signs of distress or deterioration that would indicate that the current load carrying capacity is less than the design vehicle.

The inventory rating factors are based on the assumption that the bridge was designed for H-20 loading. Ratings for HS-20 and Alternate Military vehicles were determined by inspection of the moments produced by these vehicles compared with the assumed H-20 design vehicle. Shear was assumed to not control for this slab structure.

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	N/A
Rating Method:	Engineering Judgment	Rating Units:	US Customary

LEGAL & ROUTINE PERMIT LOADS

(future wearing surface NOT included)

# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)	Safe Posting Load (tons)
2	EV2	1.000	28.75	
3	EV3	1.000	43.00	
			Single Axle	N/A
			Tandem	N/A
			Gross	N/A

Applicable Routine Permit	# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)	Safe Posting Load (tons)
	varies	NRL	1.000		
	2	H20-44	1.000	20.00	N/A
	2	Alternate Military	1.000	24.00	N/A
	3	HS20-44	1.000	36.00	N/A
	3	AASHTO Type 3	1.000	25.00	N/A
	4	SU4	1.000	27.00	N/A
☐	~~4~~	~~Toll Road Loading NO. 2~~			
	5	AASHTO Type 3S2	1.000	36.00	N/A
	5	SU5	1.000	31.00	N/A
☐	~~5~~	~~Toll Road Loading NO. 1~~			
	6	AASHTO Type 3-3	1.000	40.00	N/A
	~~6~~	~~Lane-Type~~	~~N/A~~	~~N/A~~	~~N/A~~
	6	SU6	1.000	34.75	N/A
☐	~~7~~	~~Special Toll Road Truck~~			
	7 / 8	SU7	1.000	38.75	N/A
☐	~~8~~	~~Michigan Train Truck NO. 5~~			
☐	~~11~~	~~Michigan Train Truck NO. 8~~			

NOTES

The H-20, HS-20, and Alternate Millitary legal load rating factors were determined by comparison to their design load factors, but were conservatively limited to 1.0.

The EV2, EV3, AASHTO Type 3, AASHTO Type 3S2, AASHTO Type 3-3, SU4, SU5, SU6, and SU7 rating factors were determined by the assumption that all of these vehicle types have used the bridge in the past, and the inspection results that found no signs of distress or deterioration that would indicate that the current load carrying capacity is less than these legal vehicles.

Bridge #:	XXX-XX-XXXXX	Load Rater:	SBH 4/1/2017
NBI #:	XXXXXX	Reviewer:	JCH 4/3/2017
Rating Type:	Bridge Deterioration/Critical Find	Rating Program:	N/A
Rating Method:	Engineering Judgment	Rating Units:	US Customary

SPECIAL PERMIT LOADS

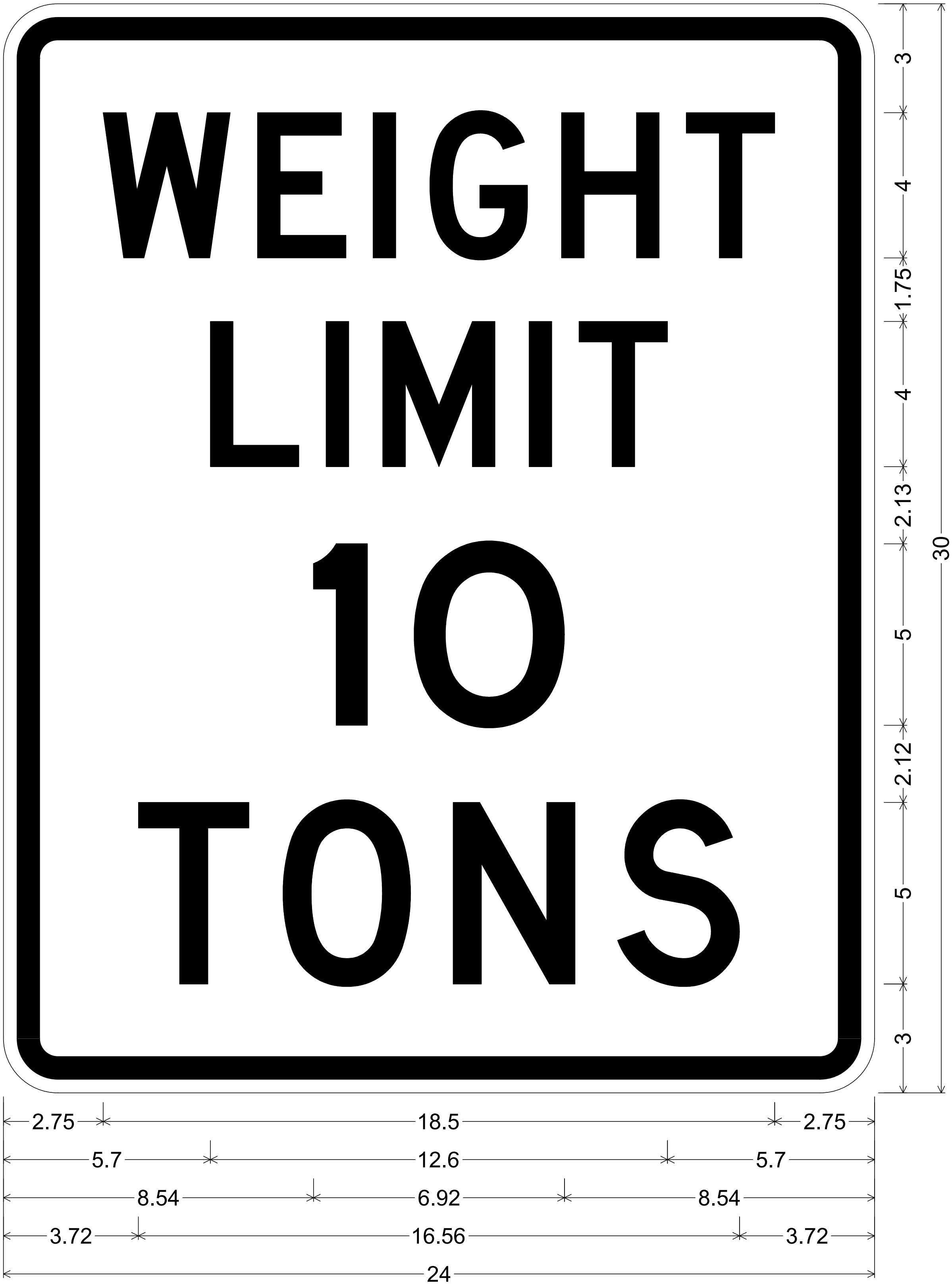
(future wearing surface NOT included)

# of Axles	Vehicle Configuration	Rating Factors	Load Capacity (tons)
11	Superload	0.700	90.30
13	Superload	0.800	106.80
14	Superload	0.600	105.00
19	Superload (305K)	0.900	137.25
19	Superload (480.09K)	0.700	168.03

NOTES

The Superload rating factors were determined by comparing the moments caused by these vehicles to the maximum moment caused by Legal Load vehicles with a 1.0 rating factor, as shown on the 'LEGAL & ROUTINE PERMIT LOADS' table.

R12-1 24"x30"



1.50" Radius, 0.63" Border, 0.38" Indent, Black on White;
“WEIGHT” D; “LIMIT” D; “10” E; “TONS” D;

R12-1 36"x48"

2.25" Radius, 0.88" Border, 0.63" Indent, Black on White;
"WEIGHT" D; "LIMIT" D; "10" E; "TONS" D;

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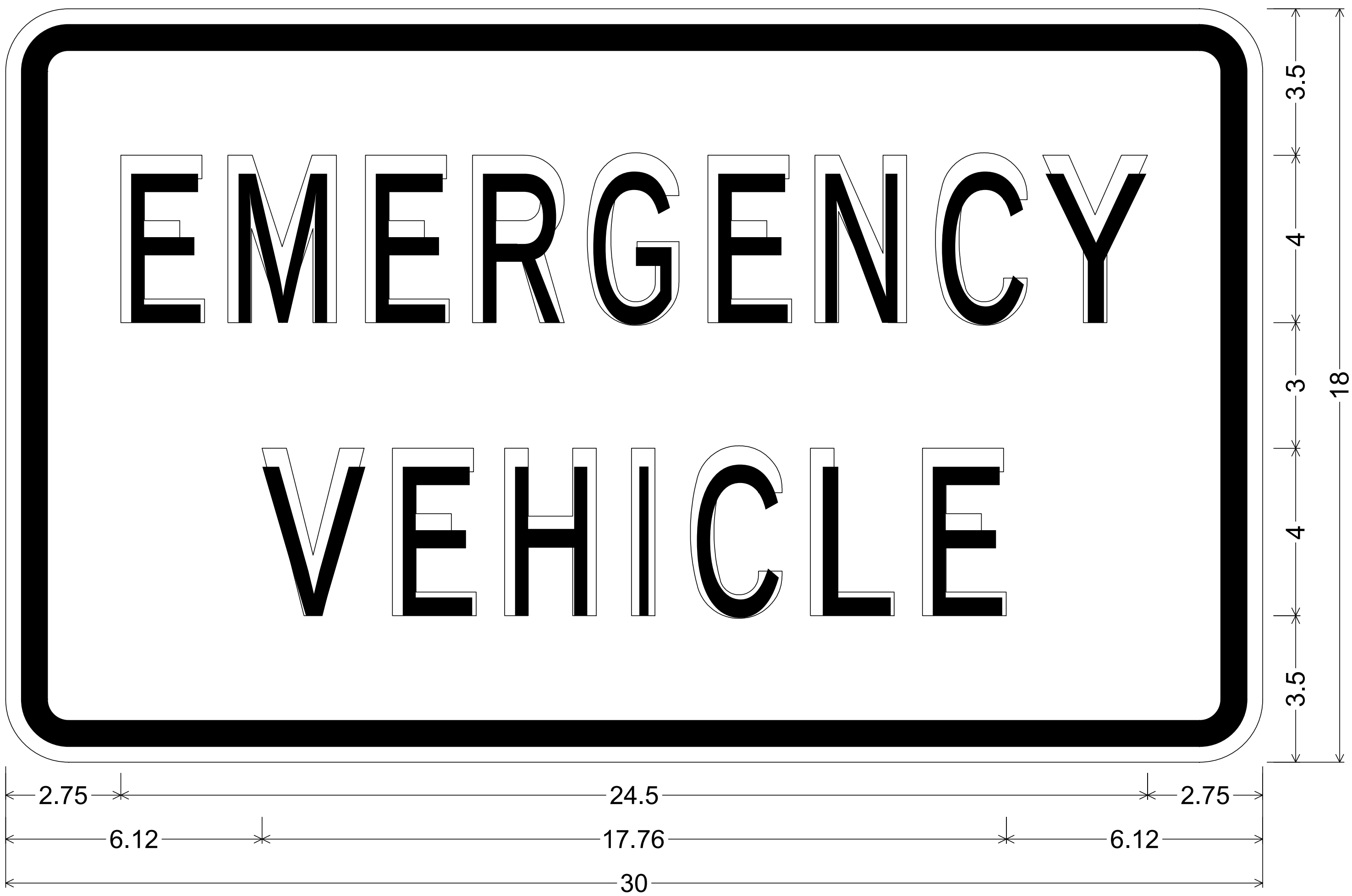

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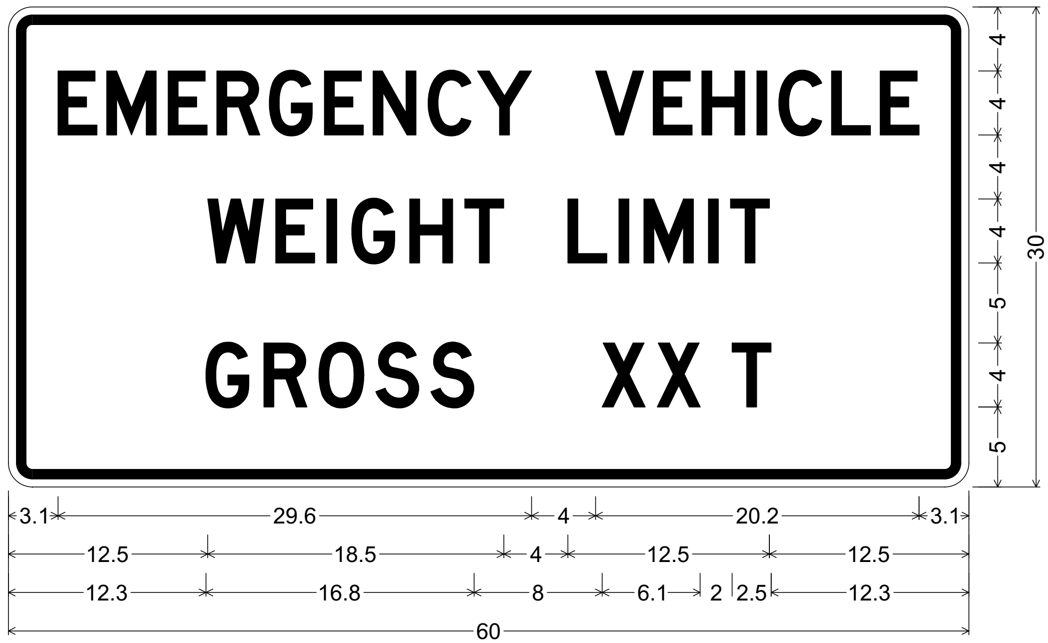

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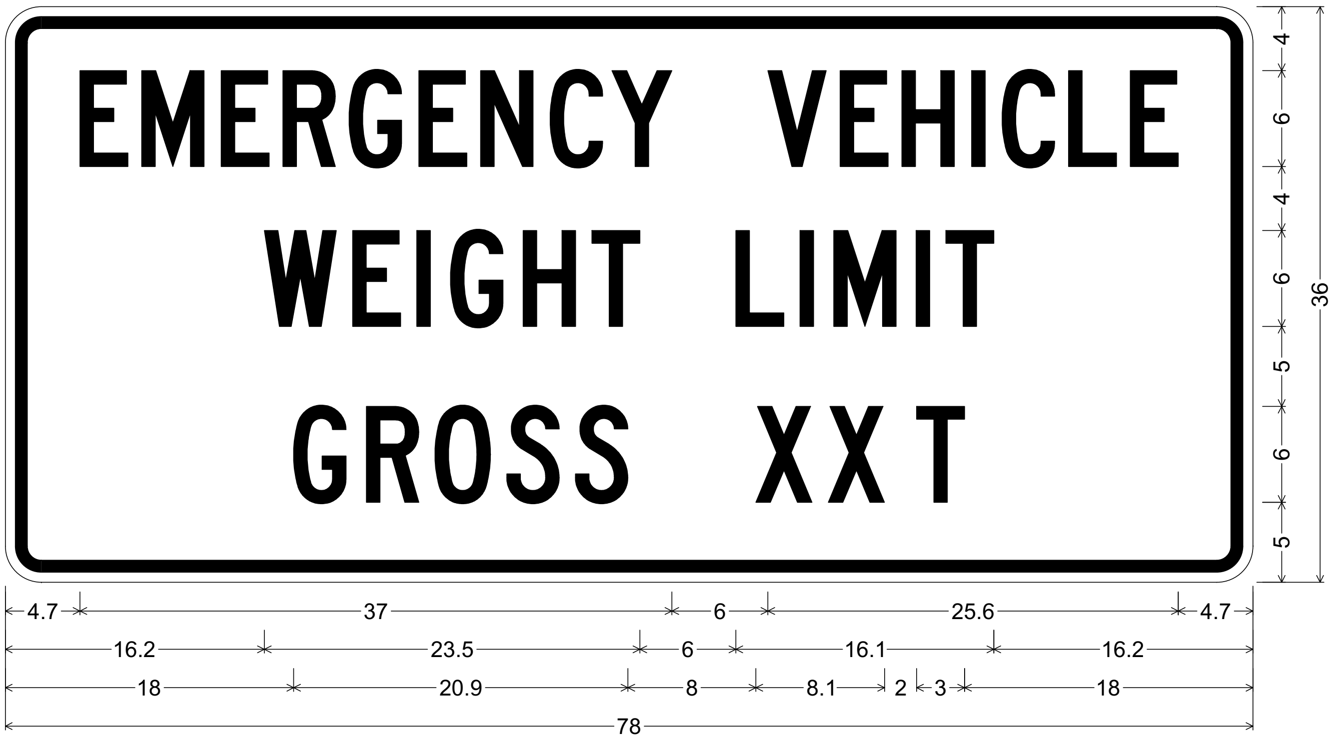

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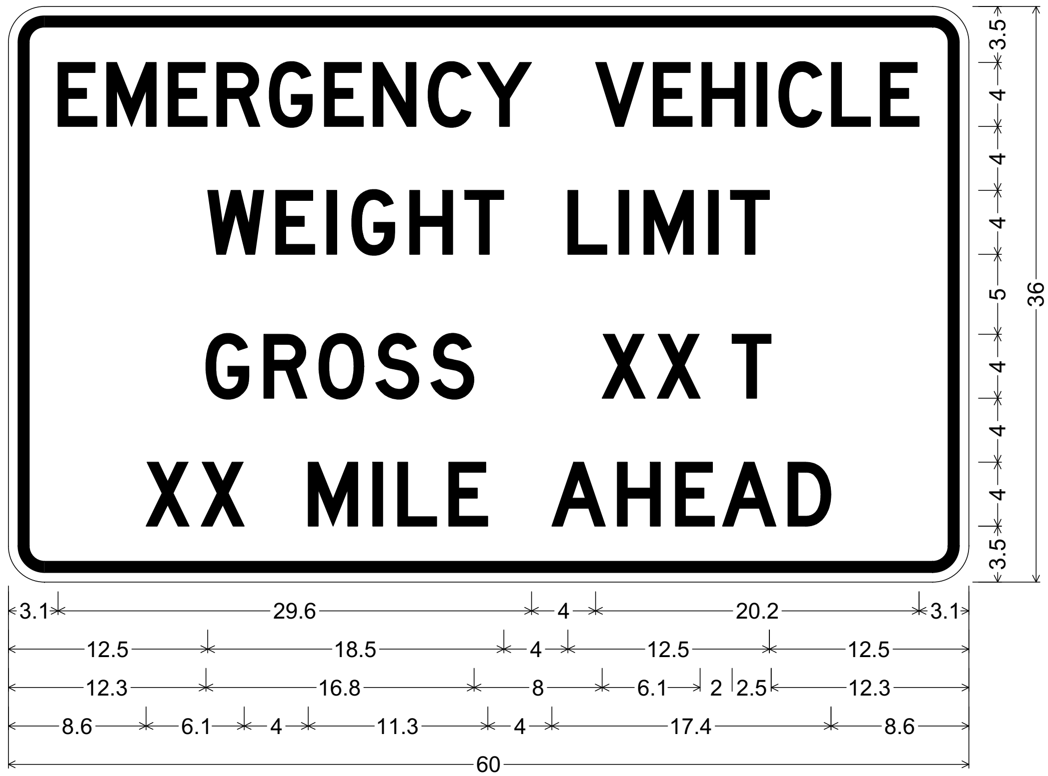

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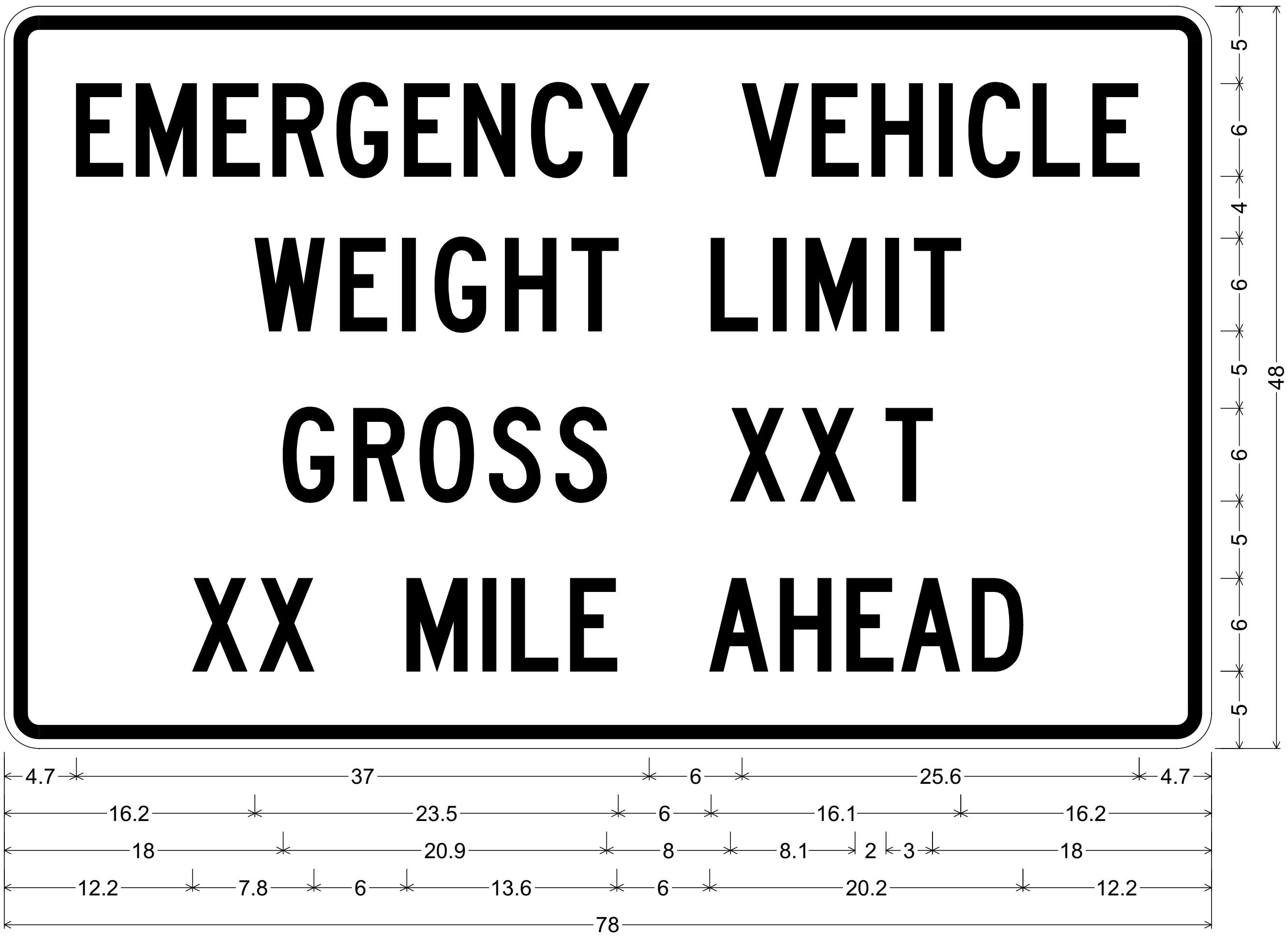

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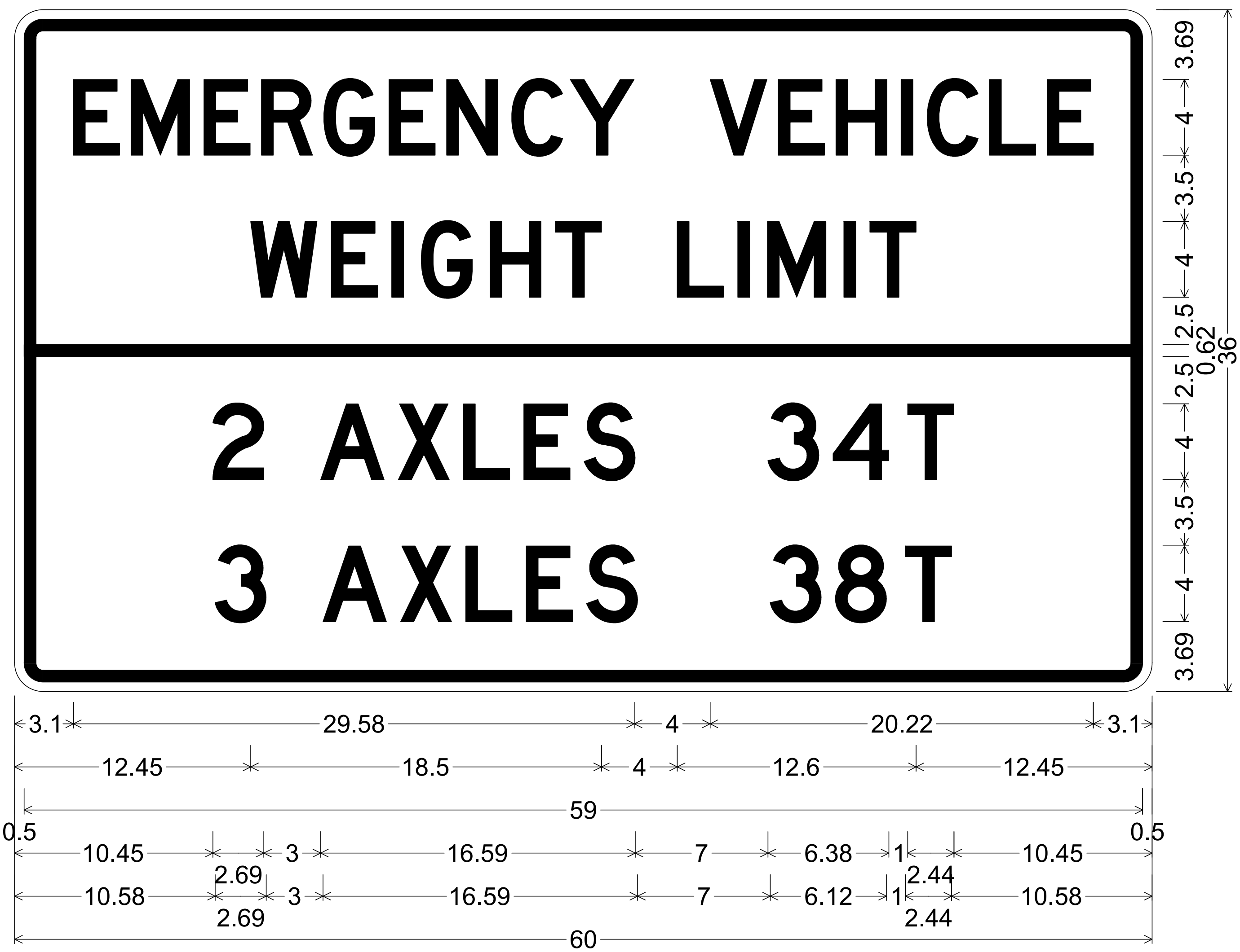

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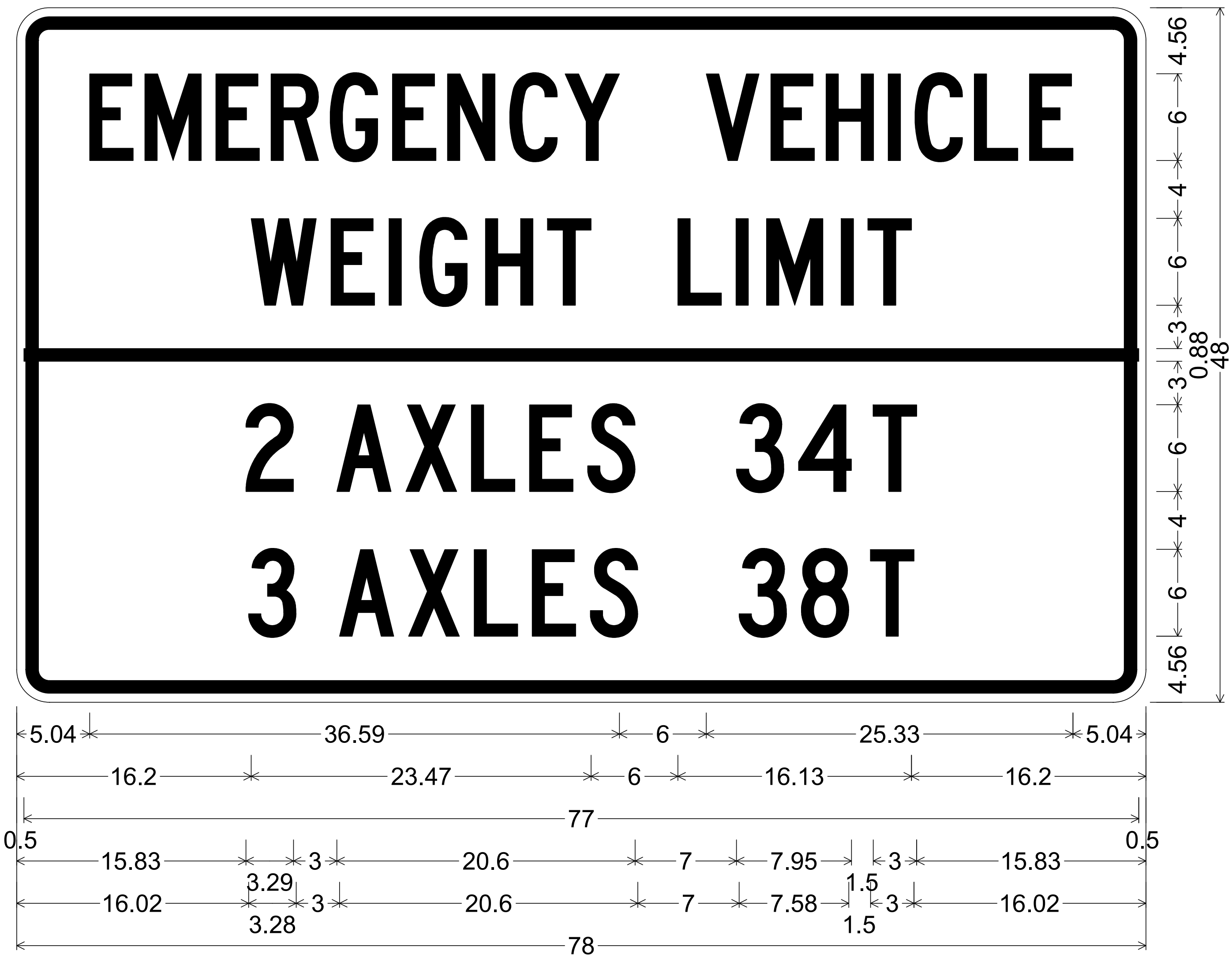
R12-Y4-EVc 78"x48"



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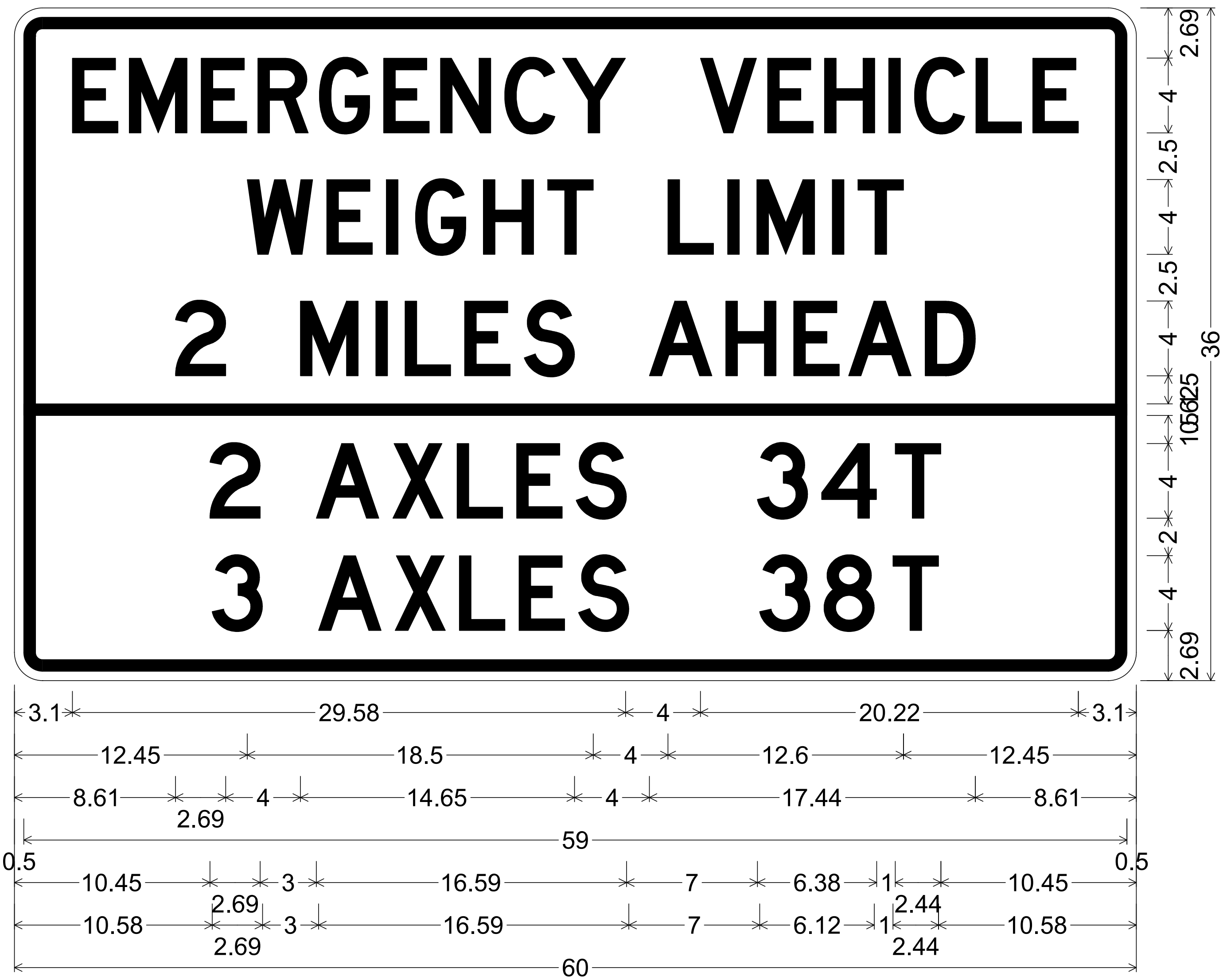
R12-Y4-EVd 60"x36"



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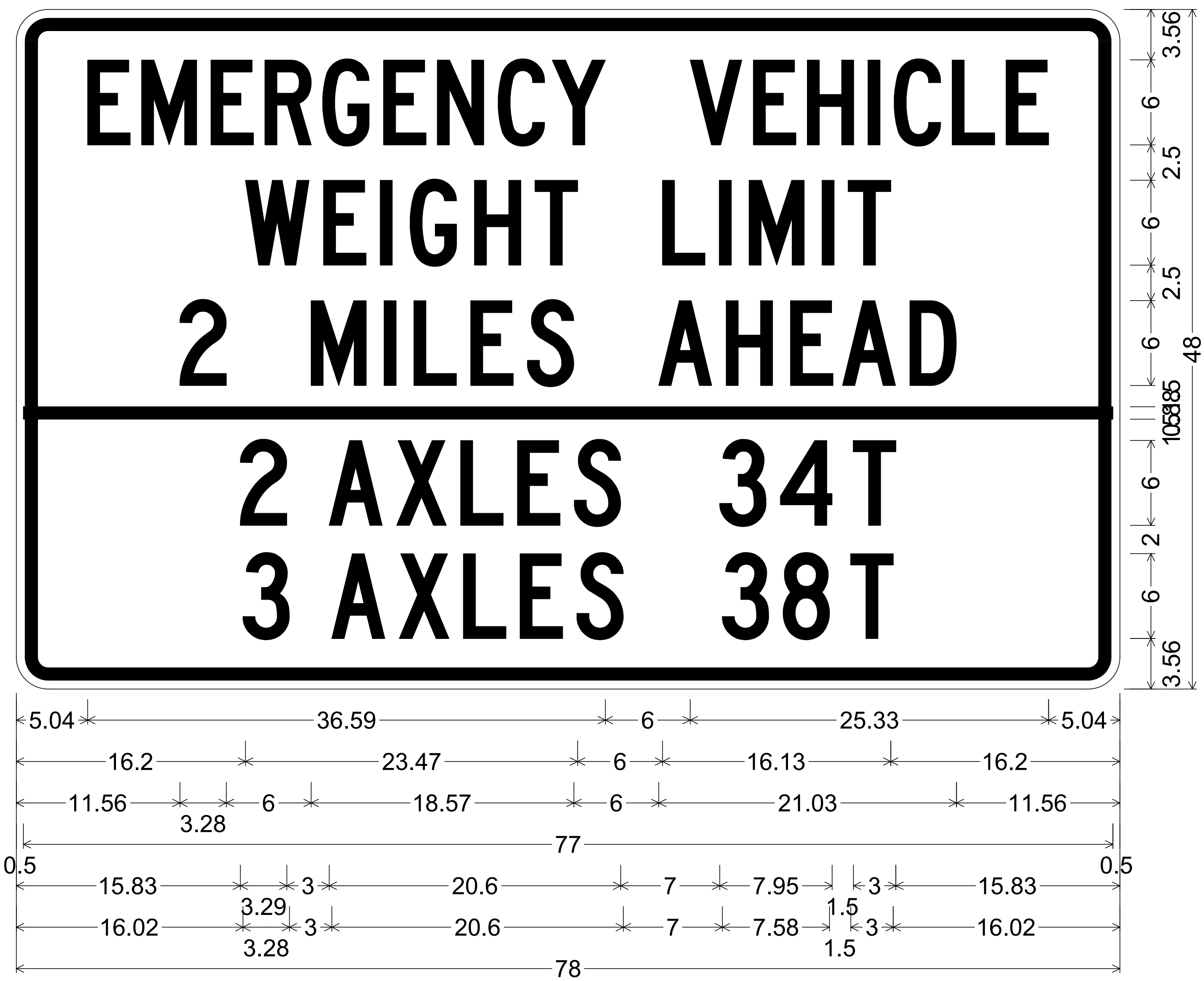

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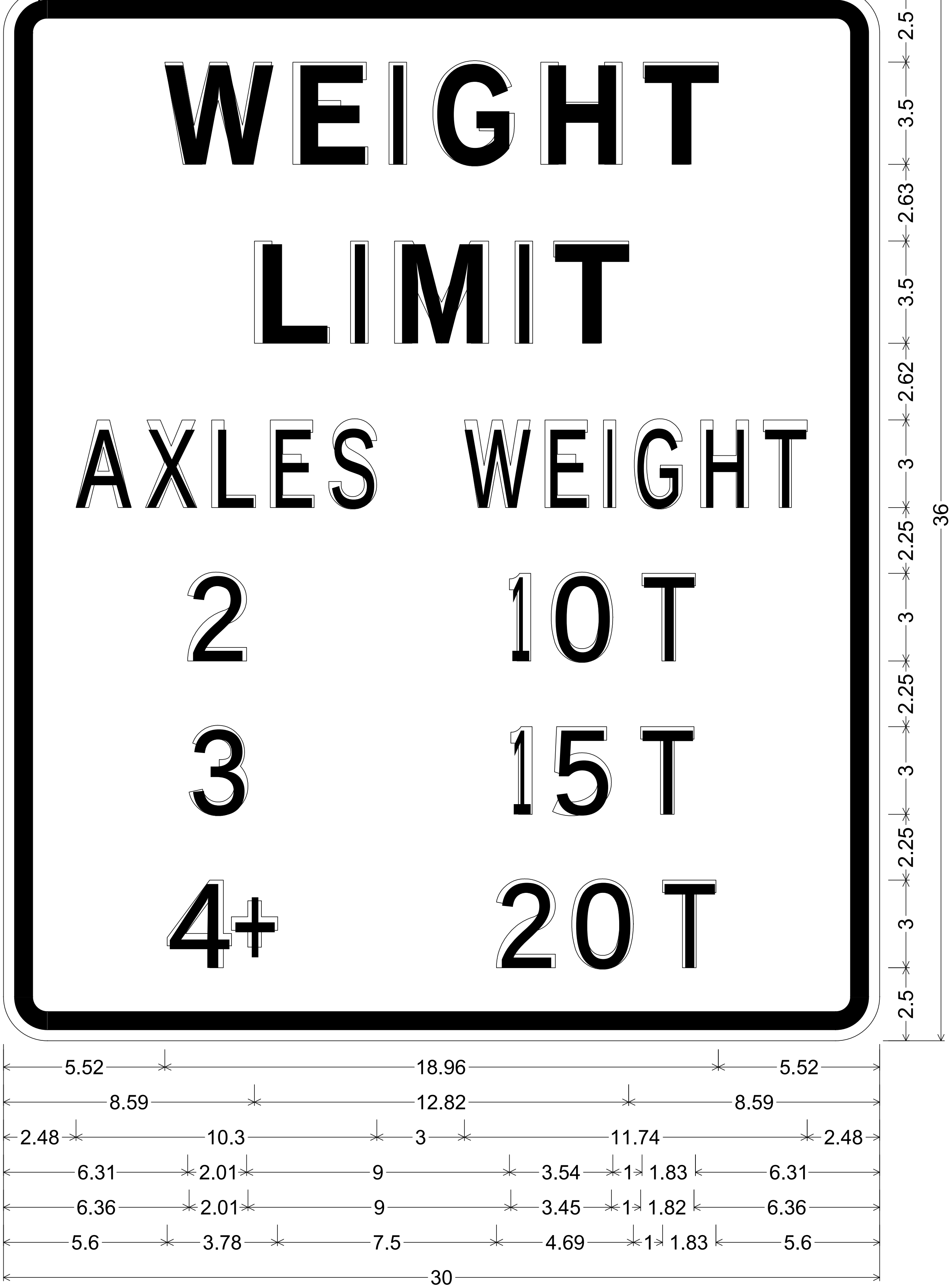

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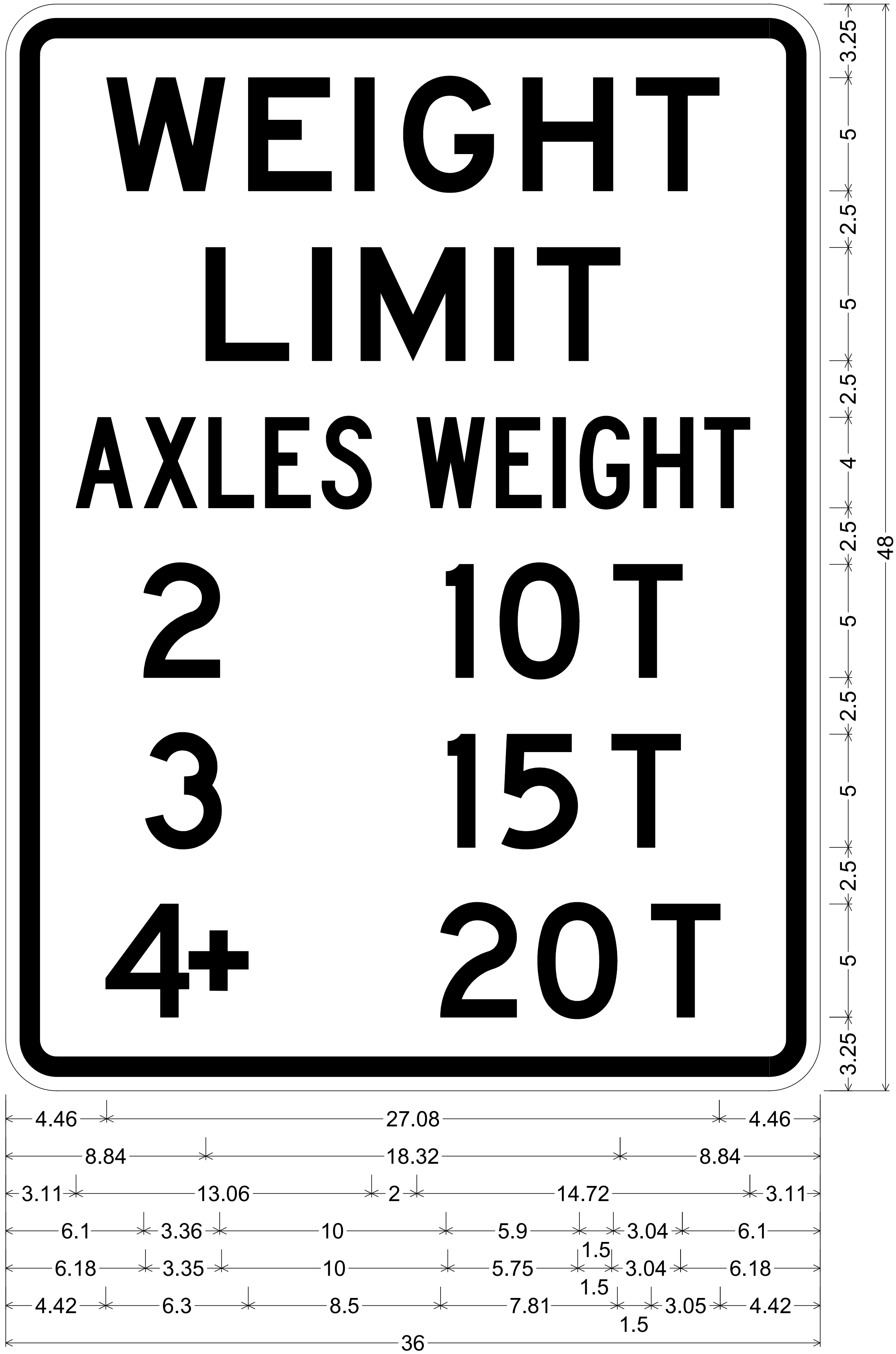
“4+” D; “20 T” D;

R12-Y5 30"x36"

R12-Y5 36"x48"



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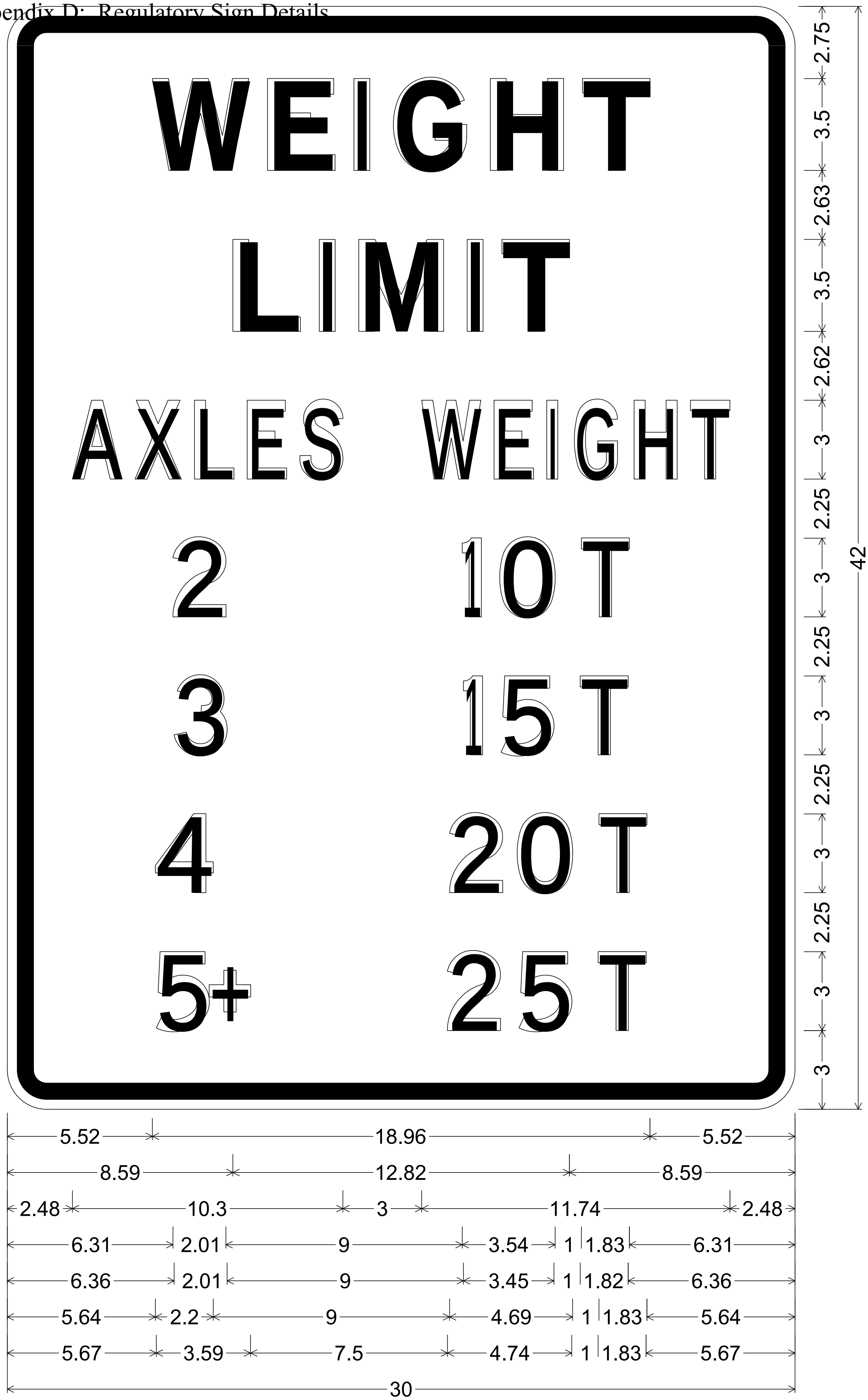

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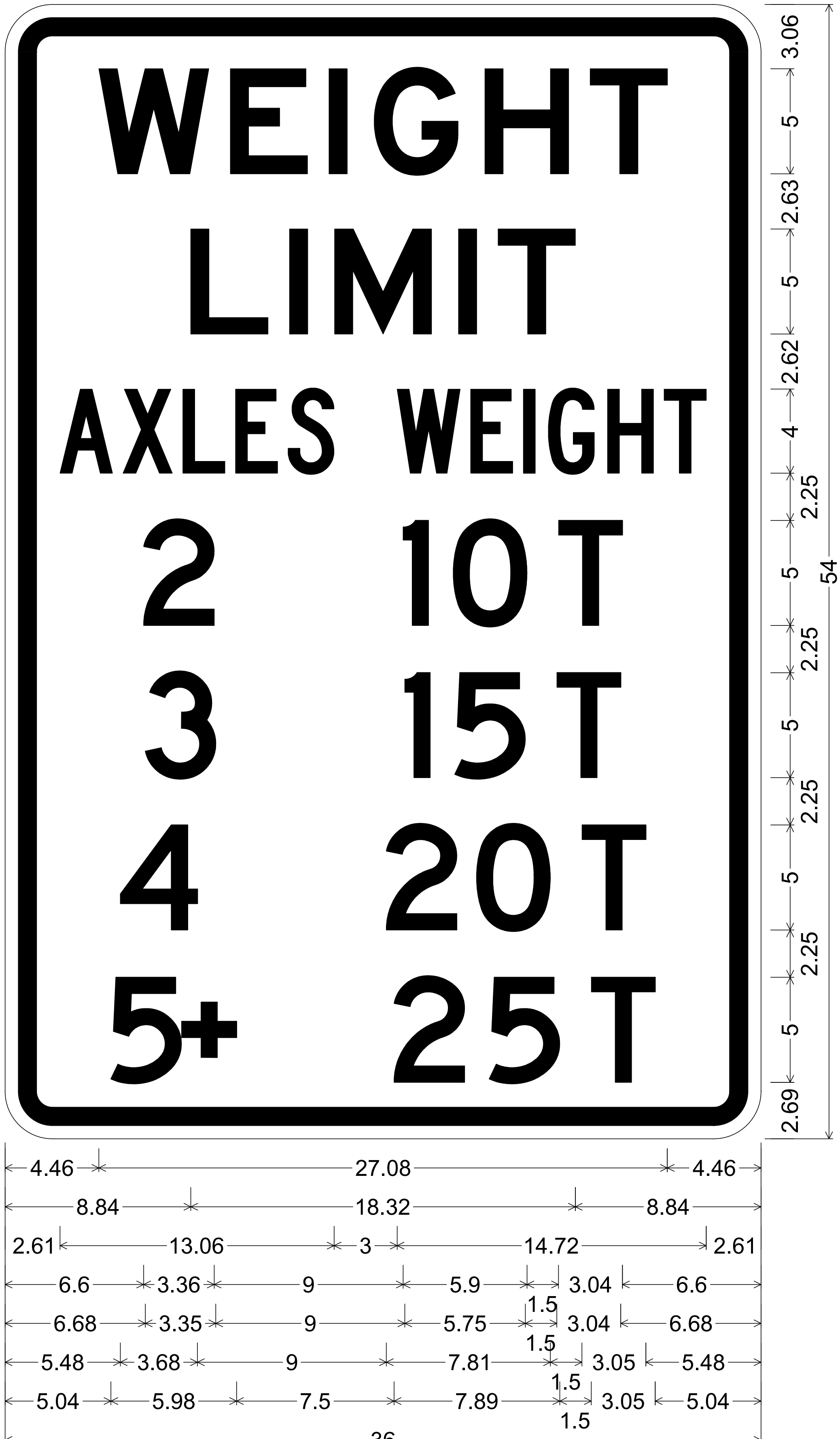

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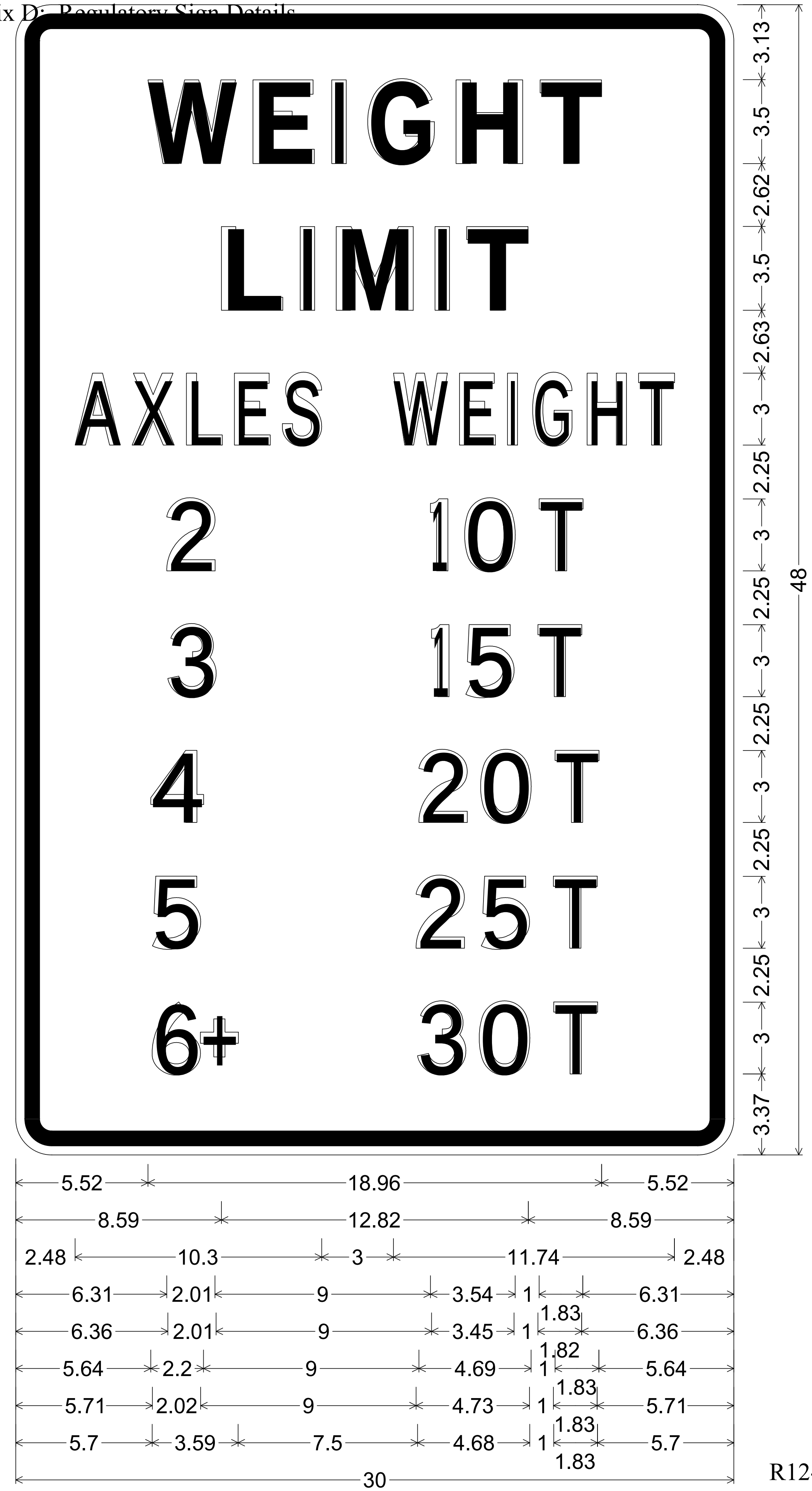

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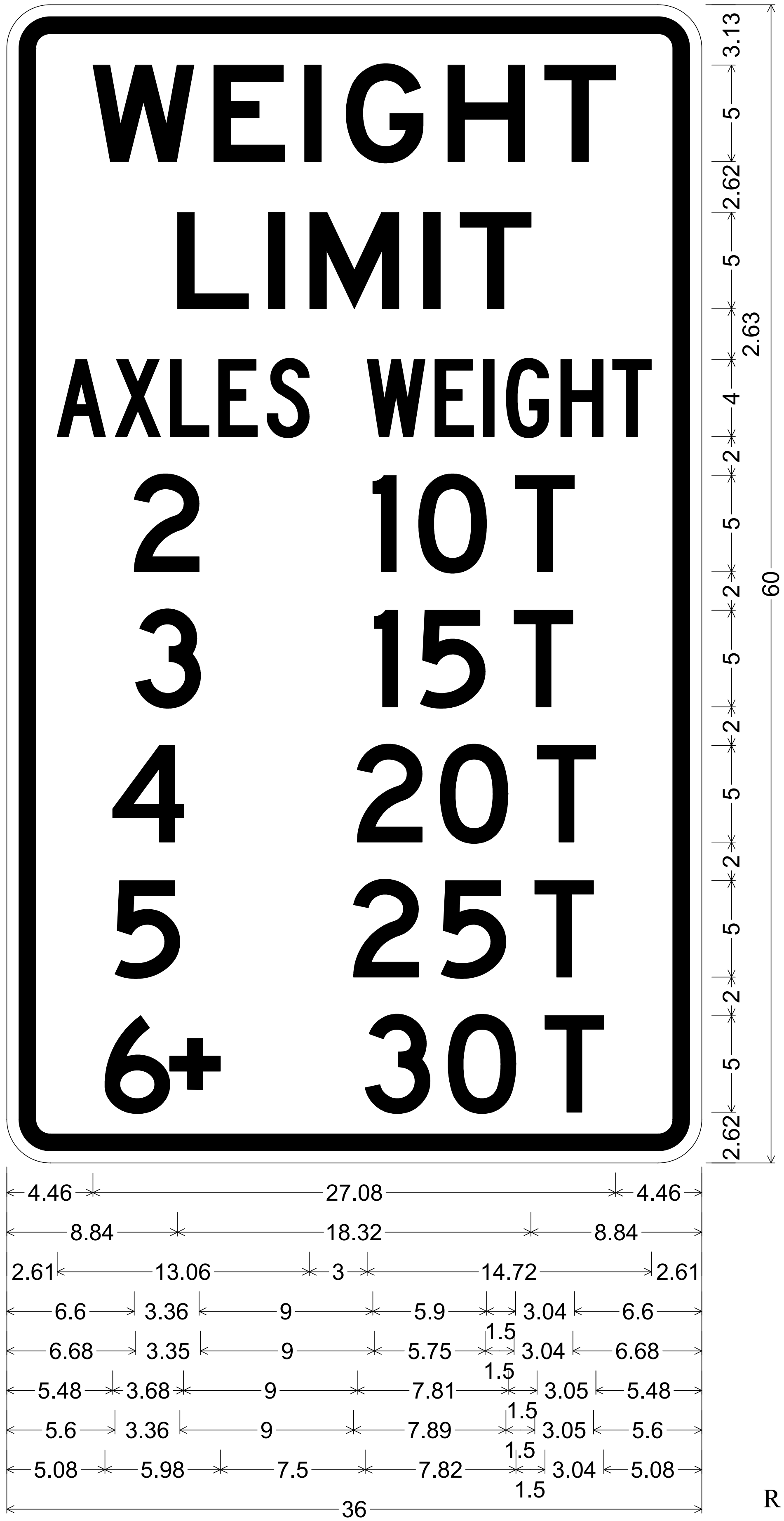

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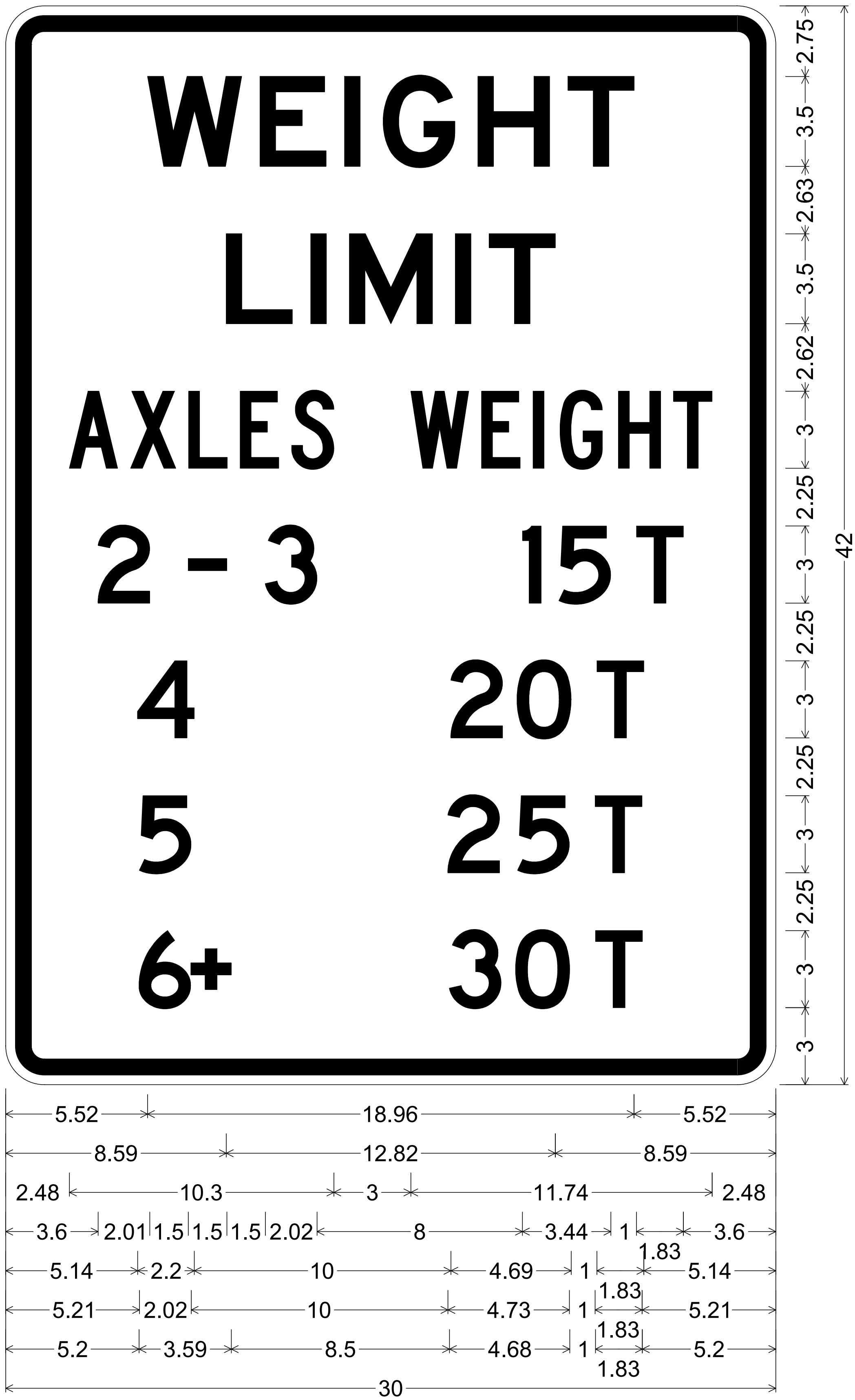

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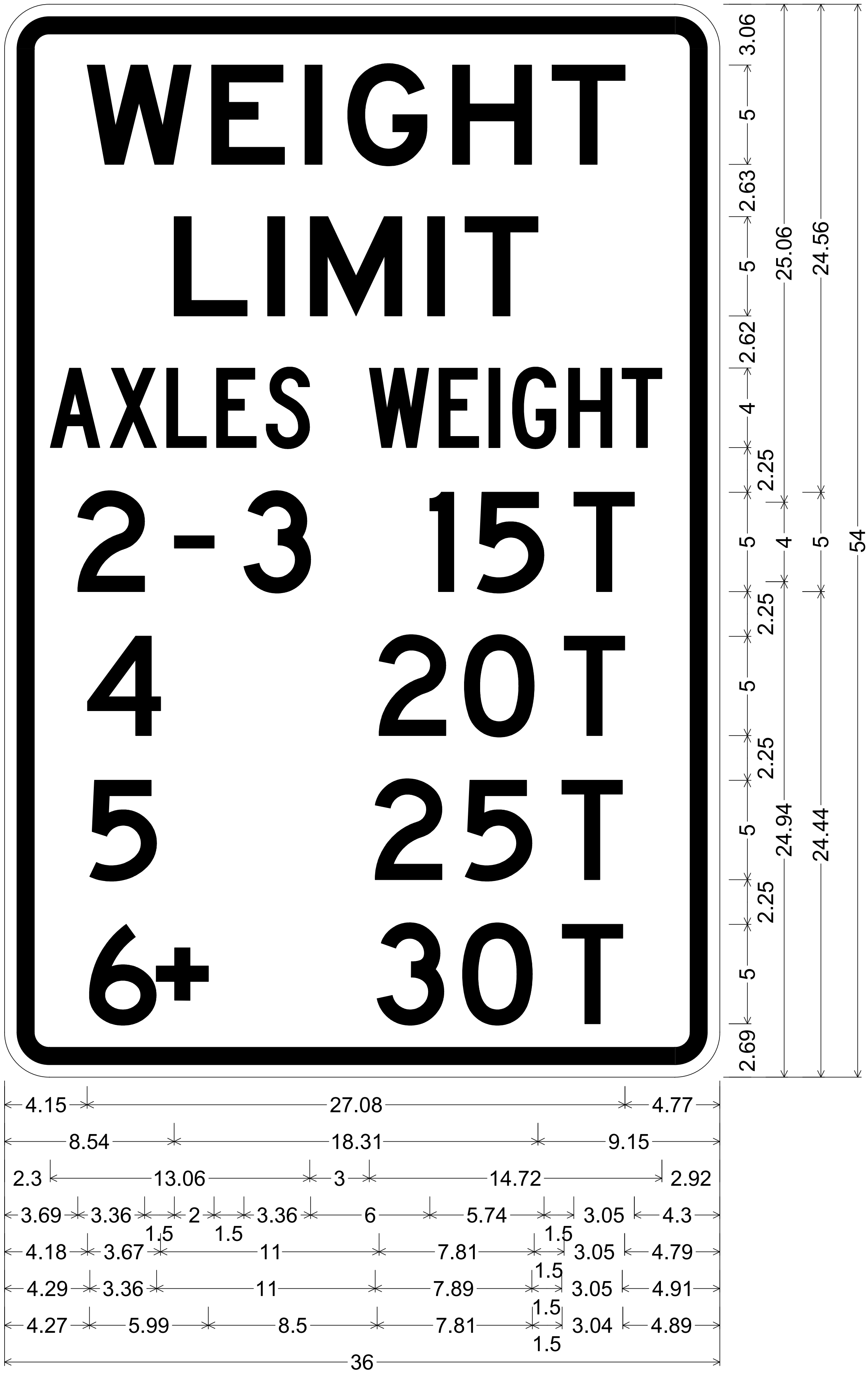
R12-Y5c 36"x54"



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"25 T" D; "6+" D; "30 T" D;

PART 4: ADDITIONAL INSPECTION GUIDANCE

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PART 4: ADDITIONAL INSPECTION GUIDANCE

INTRODUCTION

Part 4 of the Bridge Inspection Manual provides additional inspection guidance in the following four areas:

- Wearing Surface Ratings
- Scour
- Bats and Birds
- Fracture Critical Inspections

4-1.0 WEARING SURFACE RATINGS

4-1.01 Portland Cement Condition Ratings

All decks / slabs that have overlays with flexible, semi-rigid, and rigid materials are to be rated as outlined in this section.

The following general condition ratings shall be used as a guide in evaluating the wearing surface:

Condition Rating Guide for rigid Portland cement overlays:

Code	Description
N	**NOT APPLICABLE**
9	**EXCELLENT CONDITION**
8	**VERY GOOD CONDITION –** no problems noted
7	**GOOD CONDITION -** minor cracking with a crack width of 0.016” or less and less than 1% delamination
6	**SATISFACTORY CONDITION -** cracking width of 0.021” with a spacing of greater than 3 ft. Delamination less than 5%.
5	**FAIR CONDITION -** cracking width less than 0.021” with a spacing of between 1.0 – 3.0 ft. Delamination less than 10%.
4	**POOR CONDITION -** crack width greater than 0.05” or a spacing less than 1 ft. Delamination between 10% - 25%. Unpatched or unsound patching of spalled areas.

3	**SERIOUS CONDITION -** delamination greater than 25%. The wearing surface is no longer effective.

4-1.02 Epxoy Condition Ratings

The following general condition ratings shall be used as a guide in evaluating a semi-rigid (epoxy and polyester material) wearing surface:

Condition Rating Guide for Semi-Rigid Overlays

Code	Description
N	**NOT APPLICABLE**
9	**EXCELLENT CONDITION**
8	**VERY GOOD CONDITION –** no problems noted
7	**GOOD CONDITION -** minor cracking with a crack width of 0.016” or less.
6	**SATISFACTORY CONDITION -** cracking width of 0.016” with a spacing of greater than 10 ft. Delamination less than 0.5%. Minor wearing of the surface.
5	**FAIR CONDITION -** cracking width less than 0.016” with a spacing of greater than 5.0 ft. Delamination and loss of bond less than 1%. Minor wearing of the surface.
4	**POOR CONDITION -** crack width greater than 0.016” or a spacing less than 3 ft. Delamination and bond loss between 1% - 5%. Unpatched or unsound patching of spalled areas. Worn areas of the surface less than 5%.
3	**SERIOUS CONDITION -** delamination and bond loss greater than 5%. Worn areas of the surface greater than 5%. The wearing surface is no longer effective.

PART 4: ADDITIONAL INSPECTION GUIDANCE

4-2.0 SCOUR

4-2.01 Bridge Scour Evaluation Procedures For Local Public Agencies

4-2.01(01) Introduction

Several catastrophic bridge failures resulting from scour led to the development and initiation of the national bridge scour evaluation program in 1988. That program required each state to develop procedures to ensure each bridge over a waterway, whether existing or under design, was evaluated as to its vulnerability to scour in order to determine the prudent measures to be taken for its protection. INDOT's initial approach to this program for existing bridges was published in 1995. The approach was recently reviewed and due to inadequacies and limitations in the program, INDOT determined those evaluations were no longer acceptable. In addition, documents for many of the scour evaluations conducted during the initial program are no longer maintained in each bridge's bridge file. Therefore, the primary purpose of these revised scour evaluation procedures is: (1) to apply a risk-based approach to scour evaluations and the development and implementation of Plans of Action (POAs); and (2) to ensure those efforts are properly documented in each bridge file. The result of this effort will be that each bridge will be assigned a Scour Critical Evaluation Rating (Item 113) based on the following bridge scour evaluation procedures. Those bridges identified as scour critical or coded as U (unknown foundation) will require a Plan of Action (POA) to be developed and implemented.

The expected outcome of this process is to determine an accurate scour rating for each bridge based on existing documents, field conditions, and engineer judgement, or determine what documents are needed for an accurate scour rating. This process is to be completed utilizing an appropriate combination of office and field reviews. It is anticipated that the office reviews would include review of the online bridge files from INDOT and interviews with County staff. It may also include review of historical bridge files not available online from INDOT. It is anticipated the field reviews would be accomplished concurrently during an NBIS routine bridge inspection. The "Scour Evaluator" is responsible for the overall scour evaluation and is required to sign the forms. The "Scour Evaluator" must be a Professional Engineer that is a certified NBIS Team Leader in Indiana. It is preferred that these scour evaluation procedures be conducted by a multi-disciplinary team knowledgeable in hydraulic, geotechnical, bridge design, and bridge inspection procedures.

4-2.01(02) Initial Screening Process

Screen each bridge utilizing the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix A**. Bridges with multiple foundations should analyze the worst case. Answer each question and assign NA or a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file. If the assigned Scour Critical Evaluation Rating (Item 113) from the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES equals N, 9, or 8; the INDOT Scour Evaluation Procedure is complete for that bridge. If the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES equals NA, the Scour Critical

Evaluation Rating (Item 113) can't be determined through the INITIAL SCREENING PROCESS and the bridge must be assessed or analyzed per the SCOUR ASSESSMENT/SCOUR ANALYSIS Procedures.

4-2.03 Scour Assessment/Scour Analysis

Utilize the following guideline to determine whether the bridge will be assessed via the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** or analyzed in accordance with Hydraulic Engineering Circular 18 (HEC-18) in order to assign a Scour Critical Evaluation Rating (Item 113). See **Appendix C** for HEC-18 guidance.

1. For bridges with **KNOWN** foundations, identify each bridge as either Moderate Risk or Low Risk. Moderate Risk Bridges are those that cross the rivers and streams identified on the map in **Appendix D** or identified by the Inspection Team Leader. Low Risk bridges are all other bridges.
    a. Analyze each Moderate Risk Bridge by utilizing the procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C.**
    b. Assess or Analyze each Low Risk Bridge by either of the following methods:
        i. Utilize the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** in order to assign a Scour Critical Evaluation Rating (Item 113). Answer each question by circling the appropriate answer and, if applicable, assign a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file location. OR
        ii. Utilize procedures in HEC-18 to assign a Scour Critical Evaluation Rating (Item 113).
2. For bridges with **UNKNOWN** foundations, identify each bridge as either Moderate Risk or Low Risk. Moderate Risk Bridges are those that cross the rivers and streams identified on the map in **Appendix D** or identified by the Inspection Team Leader. Low Risk bridges are all other bridges. Use one of the following methods.

a. Assign a Scour Critical Evaluation Rating (Item 113) = "U" and develop a POA, OR
b. Analyze each Moderate Risk Bridges by utilizing the procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C.**
c. Foundations can be determined by either of the following methods:.
    i. Use NDE to determine foundation type, OR
    ii. Infer foundation information based on similar bridges in county built in similar timeframe or year of construction (see FHWA guidance: http://www.fhwa.dot.gov/unknownfoundations/); if using inference, document the methodology used.
d. Assess or Analyze each Low Risk Bridge by either of the following methods:
    i. Utilize the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** in order to assign a Scour Critical Evaluation Rating (Item 113).

       Answer each question by circling the appropriate answer and, if applicable, assign a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file location. OR

    ii. Utilize procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C.**

       Infer foundation information based on similar bridges in county built in similar timeframe or year of construction; if using inference, document the methodology used. The following assumptions can be used in lieu of inference:

        1. If rock is near surface, spread footings can be assumed
        2. If the top of the spread footing can be located for probing or other means, the bottom of the spread footing can assumed to be 3' lower than the top of the footing.
        3. If the foundation is unknown, and the pile length cannot be reasonably assured, then treat the bridge as if it is supported on spread footing.

PART 4: ADDITIONAL INSPECTION GUIDANCE

Bridges with Scour Critical Evaluation Rating (Item 113) = 0, 1, 2, or 3 are defined as Scour Critical. A Plan of Action (POA) is required to be developed and implemented for each bridge defined as Scour Critical or with a Scour Critical Evaluation Rating (Item 113) = U. Bridges not defined as Scour Critical are monitored for scour during routine inspections.

Definitions:

- **"No signs or history of scour":** in performing the office and field reviews outlined in the INTRODUCTION, scour was not reported.
- **"Significant scour on Spread Footings":** any portion of spread footing with more than 1' depth exposure.

  "Significant Scour on Piles":
  - **End bent/ Abutment with spillslopes:** any exposure of piles deeper than 4' below cap.
  - **Vertical faced abutments:** any exposure of piles.
  - **Interior pile bent/ drilled shaft:** any exposure of piles deeper than 3' below normal channel bottom.
  - **Interior bent/pier with footing or mudsill:** any exposure of piles.
- **"Appropriately sized scour countermeasures":** determination is based on existing study or an engineering judgement. The following should be considered:
  - If the current scour countermeasures are damaged, then they might not be appropriately sized.
  - Class I vs Class II or concrete underpin based on stream velocity.
  - Length of service.

- **"Stream banks unstable":** A stream bank is considered unstable when it is susceptible to erosion (the process by which the land's surface is worn away by actions of wind, water, ice, and gravity). If the bank is bare, or rills, gullies, or channels are forming, then the bank is considered unstable. Look for bank sloughing, undermining, evidence of lateral movement, or damage to bank stabilization measures. It is also important to look up and down the stream (approximately 200') for side channels feeding into the main stream below the bridge for bank stability. Consider NBIS Item 61 as a mean to confirm stream stability conditions.

PART 4: ADDITIONAL INSPECTION GUIDANCE

4-2.03 Scour Ratings During Field Reviews

The most recent Scour Critical Evaluation Rating (Item 113) from FHWA memo can be found on the FHWA website: http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm

PART 4: ADDITIONAL INSPECTION GUIDANCE

APPENDICES

A – Form - INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES B – Form - SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES

C – Form - SCOUR ANALYSIS SUMMARY (HEC-18) FOR LOCAL PUBLIC AGENCIES

D - MAP OF MODERATE RISK BRIDGES FOR USE WITH SCOUR EVALUATION PROCESS FOR LOCAL PUBLIC AGENCIES

E – Flowchart – OVERALL BRIDGE SCOUR EVALUATION PROCEDURES FOR LOCAL PUBLIC AGENCIES

APPENDIX A

DRAFT - FORM

Indiana Department of Transportation INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES

1. Is the bridge over a waterway? Yes/No
   - If No, complete the information at the bottom of this form and code Item 113 = "N"
   - If Yes, go to 2

2. Are all of the foundations on dry land well above flood water elevations or floodway? Yes/No
   - If Yes, complete the information at the bottom of this form and code Item 113 = "9"
   - If No **OR** Unknown, go to 3

3. Was the bridge designed and constructed to resist scour; and do plans show depth of foundation to be below the depth of Q100 scour (with sufficient length for friction piles)? Yes/No or Unknown
   - If Yes, complete the information at the bottom of this form and code 113 = "8"
   - If Unknown, **OR** the foundations are not below the Q100, go to 4

4. Are spread footings on erosion resistant rock or pile foundations of sufficient depth (20') below scour with no signs or history of scour**? Yes/No
   - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
   - If No **OR** Unknown, go to 5

5. Is the bridge a single span bridge that meets all following criteria? Yes/No
   i. Appropriately sized scour countermeasures in place**, AND
   ii. Elevation of stream bottom above bottom of footing/pile cap, AND
   iii. Does not have any signs or history of scour
   - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
   - If No, go to 6

PART 4: ADDITIONAL INSPECTION GUIDANCE

6. Is the bridge a 4-Sided Box Culvert or a Pipe Culvert with no signs or history of scour? Yes/No
   - If Yes, complete the information at the bottom of this form and code Item 113 = “8”
   - If No, go to 7

7. Is the bridge a single span concrete arch bridge with no signs or history of scour? Yes/No
   - If Yes, complete the information at the bottom of this form and code Item 113 = “8”
   - If No, complete the information at the bottom of this form, code “NA” on this form, and go to SCOUR ASSESSMENT PROCEDURES (Appendix B)

** See the “Definitions” section

To Be Completed by Scour Evaluator

Coding from INITIAL SCOUR SCREENING PROCEDURE: NA OR Item 113 = N, 9, 8

Coding by Scour Evaluator: NA OR Item 113 = N, 9, 8 Justification if different:

County: County Bridge#: NBI Bridge # Screening performed by:

Signed: Date:

PART 4: ADDITIONAL INSPECTION GUIDANCE

Appendix B

DRAFT - FORM

Indiana Department of Transportation SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES

1. CULVERTS: Is the bridge a 4-sided box culvert or a pipe culvert?
   - If Yes, go to 9.
   - If No, go to 2.a

2. HISTORICAL SCOUR PERFORMANCE:
   a. Has the bridge experienced a flood with a documented 100 yr. return interval which did not result in significant scour?
      - Yes, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113)
      - No, go to 2.b
      - Unknown, go to 2.b

   b. Is the bridge >50 years old with no signs or history of scour and not on granular or soft soil?
      - Yes, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113)
      - No, go to 3
      - Unknown, go to 3

3. SCOUR COUNTERMEASURES:
   a. Are scour countermeasures in place, functioning properly, and have minor to no damage?
      - Yes, go to 3.b
      - No, go to 4
      - Unknown, go to 4

   b. Are the scour countermeasures appropriately sized?
      - Yes, go to 3.c
      - No, go to 4
      - Unknown, go to 4

c. Has the bridge experienced a flood with a documented 50 year return interval with no damage to the installed countermeasures?
   - Yes, go to 3.d
   - No, go to 4
   - Unknown, go to 3.d

d. If scour countermeasures are present, were they installed to correct a previously existing problem with scour?
   - Yes, assign a rating of "7" to Scour Critical Evaluation Rating (Item 113)
   - No, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113)
   - Unknown, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113)

4. GEOMORPHIC CONDITIONS AFFECTING SCOUR RESISTANCE:

a. Is the stream bed degrading?
   - Yes, go to 7
   - No, go to 4.b
   - Unknown, go to 7

b. Is the channel meandering?
   - Yes, go to 7
   - No, go to 4.c
   - Unknown, go to 7

c. For natural streams, are there channel bends of greater than 30 degrees within 100 feet upstream of the bridge?
   - Yes, go to 7
   - No, go to 4.d
   - Unknown, go to 7

d. Are the stream banks unstable?
   - Yes, go to 7
   - No, go to 4.e
   - Unknown, go to 7

e. Are bridge substructure units skewed from the direction of flow?
   - Yes, go to 7
   - No, go to 4.f
   - Unknown, go to 7

f. Do ice jams or debris block more than 10% of the flow cross section?
    - Yes, go to 7
    - No, go to 5
    - Unknown, go to 7

5. SINGLE SPAN BRIDGE CONSIDERATIONS:
    a. Is the bridge is multiple-span?
        - Yes, go to 6
        - No, go to 5.b
    b. Is the bridge a single span and the Waterway Adequacy (NBI Item 71) is greater than 5
        - Yes, go to 5.c
        - No, go to 6
    c. Is the bridge supported by concrete abutments on piles?
        - Yes, assign a rating of “8” to Scour Critical Evaluation Rating (Item 113)
        - No, go to 5.d
        - Unknown, go to 5.d
    d. Is the bridge supported by timber abutment on piles?
        - Yes, assign a rating of “8” to Scour Critical Evaluation Rating (Item 113)
        - No, go to 5.e
        - Unknown, go to 5.e
    e. Is the bridge supported by end bent on piles with a spillslope at each end bent?
        - Yes, assign a rating of “8” to Scour Critical Evaluation Rating (Item 113)
        - No, go to 5.f
        - Unknown, go to 5.f
    f. Is the bridge on concrete abutments?

- Yes, go to 5.g
- No, go to 5.h
- Unknown, go to 6

g. Is the bridge over a waterway labeled as a “Ditch”?
- Yes, assign a rating of “8”
- No, go to 5.h
- Unknown, go to 5.h

h. Does the waterway have a slope of less than 0.5 feet per mile?
- Yes, assign a rating of “8” to Scour Critical Evaluation Rating (Item 113)
- No, go to 6
- Unknown, go to 6

6. REDUCED RISK BRIDGES:

a. Is the bridge programmed for replacement or rehabilitation within 5 years
- Yes, go to 6.c
- No, go to 6.b
- Unknown, go to 6.b

b. Is the bridge programmed to receive an installation of scour countermeasures within 2 years?
- Yes, go to 6.c
- No, go to 6.d
- Unknown, go to 6.d

c. Does the bridge have any signs or significant history of scour?
- Yes, go to 7
- No, assign a rating of “5” to Scour Critical Evaluation Rating (Item 113).
- Unknown, go to 7

d. Is the road classified as a "Rural Minor Collector or Local Road” (Item 26 - Functional Classification of Rural Minor Collector or Local)
- Yes, go to 6.e

- No, go to 7
- Unknown, go to 7

e. Is the estimated average daily traffic (ADT) over the bridge less than 200?
- Yes, assign a rating of “5” to Scour Critical Evaluation Rating (Item 113).
- No, go to 7
- Unknown, go to 7

7. FOUNDATIONS ON SPREAD FOOTINGS SCOUR RESISTANCE ASSESSEMENT: If the foundation is unknown, and the pile length cannot be reasonably assured, then treat the bridge as if it is supported on spread footing

a. Is the bridge supported on spread footings?
- Yes, go to 7.b
- No, go to 8
- Unknown, treat it as spread footing and go to 7.b

b. Is the spread footing on rock?
- Yes, go to 7.c
- No, go to 7.j
- Unknown, treat as granular or soft soil, go to 7.q

All of the following questions (7.c through 7.i) assume that the spread footing is on ROCK

c. …and footing socketed into rock, regardless of exposure?
- Yes, assign a rating of "8"
- No, go to 7.d

d. ...and top of footing is not exposed?
- Yes, assign a rating of "8"
- No, go to 7.e

e. ...and the top of footing is exposed?
- Yes, assign a rating of "5"
- No, go to 7.f

f. ...and the footing is fully exposed with no rock degradation?

- Yes, assign a rating of "4"
- No, go to 7.g

g. ... and the footing is fully exposed with rock degradation and less than 10% undermining?

- Yes, assign a rating of "3"
- No, go to 7.h

h. ...and the footing is fully exposed with rock degradation and more than 10% undermining?

- Yes, go to 7.i

i. ...and failure is eminent?

- Yes, assign a rating of "1" – Close the Bridge
- No, assign a rating of "2" – Create Critical Finding

j. Is the spread footing on stiff clays/clay till (Qu > 1.5 tsf)

- Yes, go to 7.k
- No, go to 7.q
- Unknown, treat as granular or soft soil, go to 7.q

All of the following questions (7.k through 7.p) assume that the spread footing is on stiff clays/clay till (Qu > 1.5 tsf).

k. ...and no observed scour?

- Yes, assign to rating of, "5"
- No, go to 7.l

l. ...and scour present and the footing not exposed?

- Yes, assign a rating of "5"
- No, go to 7.m

m. ...and scour present, < ½ of the top of the footing exposed and determined to be stable?

- Yes, assign a rating of "4"
- No, go to 7.n

n. ...and scour present, > ½ of the top of the footing exposed?

- Yes, less than 10% of footing undermined, assign a rating of "3"

- Yes, scour is adjacent to less than 25% of the face of the footing (below footing), assign a rating of “3”
- No, go to 7.o

o. ...and scour present and > ½ of footing exposed and determined unstable?
  - Yes, 10% or more of the footing is undermined, go to 7.p
  - Yes, Scour is adjacent to more than 25% of the face of footing, go to 7.p

p. …and failure is eminent?
  - Yes, assign a rating of "1" – Close the Bridge
  - No, assign a rating of "2" – Create Critical Finding

All of the following questions (7.q through 7.u) assume that the spread footing on granular or soft soils (Qu < 1.5 tsf).

q. Is there any observed scour on the spread footing?
  - Yes, go to 7.r
  - No, assign a rating of “5”

r. Scour present, however the footing is not exposed?
  - Yes, assign a rating of "4"
  - No, go to 7.s

s. Scour present and the footing exposed with less than 10% scour to the face of the footing?
  - Yes, assign a rating of "3"
  - No, go to 7.t

t. Scour present and the footing exposed with more than 10% scour to the face of the footing (below footing) or otherwise considered unstable?
  - Yes, go to 7.u

u. Is failure of the spread footing eminent?
  - Yes, assign a rating of "1" – Close the Bridge
  - No, assign a rating of "2" – Create Critical Finding

8. FOUNDATIONS ON PILES SCOUR RESISTANCE ASSESSEMENT: If the foundation is unknown, and the pile length cannot be reasonably assured, then treat the bridge as if it is supported on spread footing.

   a. Is the bridge supported on Pile Foundations?
      - Yes, go to 8.b
      - No, go to 7.a
      - Unknown, go to 7.a

All of the following questions (8.b through 8.p) assume that the bridge has a pile foundation.

   b. For any soil type, are the pile tips ≥ 40' below ground surface and piles not exposed by significant scour?
      - Yes, assign a rating of "8".
      - No, go to 8.c
   c. Are the piles socketed or driven into rock not exposed by "significant" scour?
      - Yes, assign a rating of "8"
      - No, go to 8.d
   d. Are the piles socketed or driven into rock and exposed by "significant" scour?
      - Yes, assign a rating of "5"
      - No, go to 8.e
   e. Are the bridge pile tips on rock but not socketed or driven into rock?
      - Yes, go to 8.f
      - No, go to 8.j

All of the following questions (8.f through 8.j) assume that the bridge has a pile foundation where the tips are on rock but not socketed or driven into rock.

   f. …and has minor/no existing scour present or has occurred previously with a 3-foot minimum thickness of cohesive soil in upper ½ of embedded pile length?
      - Yes, assign a rating of "8"
      - No, go to 8.g
   g. …and has minor/no existing scour present or has occurred previously with no layers of cohesive soil in upper ½ of embedded pile length?
      - Yes, assign a rating of "5"
      - No, go to 8.h

PART 4: ADDITIONAL INSPECTION GUIDANCE

h. …and has observed scour or erosion with a 3-foot minimum thickness of cohesive soil in upper ½ of embedded pile length?
   - Yes, assign a rating of "4"
   - No, go to 8.i

i. … and has no observed scour but a history of significant scour or erosion with no layers of cohesive soil in upper ½ of embedded pile length?
   - Yes, assign a rating of "3"
   - No, go to 8.j

j. and has observed significant scour with no layers of cohesive soil in upper ½ of embedded pile length?
   - Yes, assign a rating of "2"
   - No, go to 8.k

k. Are the bridge piles, friction piles in cohesive soils?
   - Yes, go to 8.l
   - No, assign a rating of “2”

All of the following questions (8.k through 8.r) assume that the bridge has a pile foundation are friction piles in cohesive soils.

l. … and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required, where minor/no existing scour is present or has occurred previously with Pile tips $\geq$ 15’deep?
   - Yes, assign a rating of “8”
   - No, go to 8.m

m. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required, where minor/no existing scour is present or has occurred previously with Pile tips <15’ deep?
   - Yes, assign a rating of “5”
   - No go to 8.n

n. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required with a history of significant scour/erosion with Plie tips $\geq$ 35’ deep?
   - Yes, assign a rating of “8”
   - No, go to 8.o

o. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required with a history of significant scour/erosion with Plie tips <35’ and $\geq$ 20’ deep
   - Yes, assign a rating of “5”
   - No, go to 8.p

p. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required with a history of significant scour/erosion with Pile tips < 20' deep without significant scour present
    - Yes, assign a rating of "4"
    - No, go to 8.q

q. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required with a history of significant scour/erosion with Pile tips < 20' deep with significant scour present but determined stable?
    - Yes, assign a rating of "3"
    - No, go to 8.r

r. …and a minimum 3-ft layer w/ Qu> 1.5 tsf in upper ½ of embedded pile length required with a history of significant scour/erosion with pile tips < 20' deep with significant scour present or piles otherwise determined unstable?
    - Yes, go to 8.s

s. Is failure of the pile eminent?
    - Yes, assign a rating of "1" – Close the Bridge
    - No, assign a rating of "2" – Create Critical Finding

9. CULVERT (STRUCTURES UNDER FILL)

a. What is the shape of the culvert?
    - Box
    - Pipe

b. Does the culvert have significant scour behind the ends of the box and the cut-off walls due to undermining of the wingwalls?
    - Yes, go to 9.b.i
    - No, go to 9.c
    - Unknown, go to 9.c

    i. Is the stream bed degrading?
        - Yes, assign rating of "4"
        - No, go to 9.b.ii
        - Unknown, assign rating of "4"

    ii. Is the channel meandering?
        - Yes, assign rating of "4"

- No, go to 9.b.iii
- Unknown, assign rating of “4”

iii. For natural streams, are there channel bends of greater than 30 degrees within 100 feet upstream of the bridge?

- Yes, assign rating of “4”
- No, go to 9.b.iv
- Unknown, assign rating of “4”

iv. Are the stream banks unstable?

- Yes, assign rating of “4”
- No, assign rating of “5”
- Unknown, assign rating of “4”

c. Does the culvert have scour adjacent to the cut-off walls?

- Yes, go to 9.c.i
- No, assign rating of “5”
- Unknown, go to 9.c.i

i. Is the stream bed degrading?

- Yes, assign rating of “2”
- No, go to 9.c.ii
- Unknown, assign rating of “2”

ii. Is the channel meandering?

- Yes, assign rating of “2”
- No, go to 9.c.iii
- Unknown, assign rating of “2”

iii. For natural streams, are there channel bends of greater than 30 degrees within 100 feet upstream of the bridge?

- Yes, assign rating of “2”
- No, go to 9.c.iv

- Unknown, assign rating of “2”

iv. Are the stream banks unstable?

- Yes, assign rating of “2”
- No, assign rating of “3”
- Unknown, assign rating of “2”

To Be Completed by Scour Evaluator

Scour Critical Evaluation Rating (Item 113) from SCOUR ASSESSMENT PROCEDURE: 8, 7, 5, 4, 3, 2, 1

Scour Critical Evaluation Rating (Item 113) by Scour Evaluator: 8, 7, 5, 4, 3, 2, 1 Justification if different:

County: County Bridge#: NBI Bridge # Foundation type:

Assessment performed by: Signed:

Date:

PART 4: ADDITIONAL INSPECTION GUIDANCE

Appendix C

Indiana Department of Transportation SCOUR ANALYSIS SUMMARY (HEC-18) FOR LOCAL PUBLIC AGENCIES

The scour analysis will be completed using HEC-RAS in accordance with HEC-18 and the INDOT Design Manual. Only Q100 will be used for the analysis. A summary of the scour parameters from the HEC-18 analysis will be uploaded to the bridge file (see below). A determination of the proper Coding for Item 113 will be made following the FHWA coding guide.

Scour Parameters

Q100 Discharge	=	cfs.
Elevation @ Q100	=	MSL
Velocity @ Q100	=	ft./sec.
Contraction Scour Depth	=	ft.
Total Scour Depth	=	ft.
Low Scour Elevation	=	MSL

PART 4: ADDITIONAL INSPECTION GUIDANCE

To Be Completed by Scour Evaluator

Scour Critical Evaluation Rating (Item 113) from SCOUR ASSESSMENT PROCEDURE: 8, 7, 5, 4, 3, 2, 1

Scour Critical Evaluation Rating (Item 113) by Scour Evaluator: 8, 7, 5, 4, 3, 2, 1 Justification if different:

County: **County Bridge#:**
NBI Bridge # Foundation type:

Assessment performed by:
Signed:

Date:

PART 4: ADDITIONAL INSPECTION GUIDANCE

Appendix D

DRAFT

Indiana Department of Transportation MAP OF MODERATE RISK BRIDGES FOR USE WITH SCOUR EVALUATION PROCESS FOR LOCAL PUBLIC AGENCIES

PART 4: ADDITIONAL INSPECTION GUIDANCE

4-2.02 Bridge Scour Plan Of Action (Poa) Procedures For Local Public Agencies

Bridge scour Plans of Action (POAs) are plans that document the action to be taken during a triggering flood event for scour critical bridges. Plans of Action are required for any bridge with a scour critical rating (item 113) of U, 3, or 2. Bridges with a scour critical rating (item 113) of 1 or 0 are closed and will require replacement or scour countermeasures depending on the condition of the bridge before they can be rerated and opened to traffic. If the rerating of these bridges results in a rating (item 113) of U, 3, or 2 a POA must be developed. Appendix A contains a POA form.

Bridge owners are encouraged to mitigate scour risk by installing properly designed countermeasures at bridges. The installation of properly designed scour countermeasures allows item 113 to be coded to reflect that the bridge is no longer scour critical and does not require a POA. FHWA Hydraulic Engineering Circular number 23 provides guidance to properly design scour countermeasures.

The minimum triggering event to implement the plan of action is when a flood warning is issued for the County. A flood watch or warning is announced by the National Weather Service which includes the county or drainage area tributary to the bridge (http://www.weather.gov/subscribe). If there is a USGS gaging station in or near the county, flood stage for the stream gage can be used as a triggering event. Waterways with stream gages can be found at: http://water.usgs.gov/wateralert/. Other triggering methods may be used as long as they can easily be determined.

A determination must be made if a monitoring plan can be used for the bridge during a flood event or if the bridge will be closed at the triggering event. The monitoring plan needs to include what will be monitored and the frequency that it will be monitored. The name of the responsible person monitoring and maintaining the log book must be included in the monitoring plan.

The closure plan needs to include what will trigger closure such as a flood warning, stream reaching bank full, water reaching the low structure, road overflow, signs of bridge movement, etc. It needs to include instructions on who to contact and how to get the closure implemented. At a minimum the County Engineer or County Highway Supervisor need to be notified. The plan needs to include the name and phone number of that contact person. The plan needs to include what needs to be inspected before reopening the bridge. It may require that the flood water recedes before the inspection can take place.

Appendix B contains the form that owners should use to document their actions to monitor or close scour critical bridges during notification events.

The POA and monitoring log need to be uploaded to BIAS as part of the bridge file.

The POA should be updated every 4 years or when personnel changes occur that affect the POA.

Appendix A

Indiana Department of Transportation
PLAN OF ACTION

Bridge Scour Plan of Action

Structure No.: ________________ Date: _____________
Triggering Event for Monitoring and Frequency:
Monitoring Plan:
Closure Plan:
Closure Notification:
Emergency Management Director: Phone:
Highway Engineer/Supervisor*: Phone:
* Responsible for completing the POA monitoring log
Secondary Highway Contact: Phone:
Reopening Inspection Requirements:
Written by: Signed:

Appendix B

Indiana Department of Transportation
BRIDGE SCOUR MONITORING/CLOSING REPORT FORM
POA MONITORING LOG BOOK

Structure Number: Road Number: Stream Name: Date	Type of Monitoring	Initials	Have Scour Conditions Worsened	Action

4-3.0 BATS AND BIRDS

4-3.01 Introduction

Some species of bats are listed as endangered or threatened under the federal Endangered Species Act , and many species of birds are protected under the Migratory Bird Treaty Act. Both federal laws prohibit actions that harm these animals. Bats and birds may use bridges for roosting or nesting, which means they could be harmed by construction activities. Inspectors must perform a preliminary screening for bats and cliff swallows as a part of each inspection for state-owned bridges.

Figure 4:3-1: Cliff Swallow Nests

Figure 4:3-2: Cliff Swallow Colony

4-3.02 Habitat Detection

Some species of birds nest under highway bridges on walls or beams, typically near waterways or reservoirs. In particular, inspectors should look for two types of swallow nests. Cliff swallow nests have a distinctive rounded top, as shown above in Figures 4:8-1 and 4:8-2. Cliff swallows are a colony nesting bird and there may be several to hundreds under one bridge.

Barn swallows do not nest in colonies. Their nests are generally found alone and the shape is indistinct, as shown in Figure 4:8-3. Barn swallows are not tracked by the Indiana State Department of Natural Resources, but are discussed here to highlight the differences between cliff swallows and barn swallows. Other bird nests, such as those of robins and warblers, may also be found and should be documented in the inspection.

:

Bats may roost in any dark, warm, quiet spot on a bridge, which makes them more difficult to see during an inspection. Most bats in Indiana are very small, about the size of an adult's thumb, and some species prefer to wedge into small crevasses to roost. Bats may leave signs of use, such as guano or staining, even if a structure is inspected during the bats' inactive season (mid-fall through mid-spring) or if the roosting bats themselves are not visible. Droppings are usually small and mouse-like, brown or black, and appear directly under the roost site. Urine stains are usually a few inches in size immediately below roosts, and may have a strong odor. Stains from fur oil may also be visible at the entrance to cavity roosts. INDOT's Environmental Services Division has developed a short online tutorial about investigating structures for bats. This tutorial is available through INDOT University.

Take care not to touch any bats or expose yourself to danger. If bitten, call the Department of Health at 317-233-1325 and record the incident immediately. Few bats have rabies; however, it is a deadly virus. If bitten by a bat, you will need rabies post-exposure shots.

In general, investigation of the structure should include the following:

1. Screen the entire structure for bird nests and provide photographs.
2. Look for roosting bats in sheltered features of the structure, including all protected joints, cracks, and small cavities.
3. Look for signs of bat use. Note the location of guano piles, urine stains, and fur stains.
4. Listen for squeaks or chirps and note location.
5. Photograph roosting bats, guano, urine, or fur stains.

Figure 4:3-3: Single Barn Swallow Nest

Figure 4:3-4: Bat Droppings

Figure 4:3-5: Bats Roosting Along Crack and Associated Staining

Figure 4:3-6: Bat Guano on Riprap

Figure 3:8-7: Bat

4-3.03 Coding

The presence of bats, birds, or signs of bat or bird use, are recorded in the inspection report. Follow the prompts in the fields on the inspection report data entry form and add photographs of what is found.

4-4.0 FATIGUE AND FRACTURE CRITICAL INSPECTIONS

4-4.01 The Fracture Critical Inspection

Proper identification, classification, inspection, and reporting of all fracture critical bridges and the subsequent members are crucial to the longevity of Indiana's bridges and the safety of the public. Uniformity in reporting permits the inspectors to accurately and closely monitor any problems throughout the life of the structure. Detailed and accurate reporting also permits the bridge owner to maintain and repair the bridge before major problems evolve.

4-4.01(01) Classification of Fracture Critical Members

The FHWA defines a fracture critical member as a steel member in tension, or with a tension element, whose failure would probably cause a portion of, or the entire, bridge to collapse. A fracture critical bridge is one that contains a fracture critical member. The FHWA presents two criteria for identifying a fracture critical bridge:

- Steel members must be in tension, or elements/fibers of the member must be in tension. These loading conditions may include tensile forces, shear, flexure, and torsion. Load analysis ratings may indicate some members experience a stress reversal (varies from tension to compression) under various loads. Such members are to be included under this criteria.
- There must be no load path redundancy of the bridge, in which no other structural elements are capable of carrying the load if a main load-carrying member fails. For a bridge to be defined as non-load path redundant, it must have two or less load paths.

Some typical bridges that may be considered fracture critical include, but are not limited to, these types:

- Truss bridges containing two main load-carrying members
- Through girder bridges
- Two-girder bridges
- Tied arch bridges
- Box girders
- Cable-stayed bridges
- Suspension bridges
- Steel rigid frame bridges
- Bridges containing steel cross-girders or steel pier caps

See Appendix B for examples of fracture critical bridges, components, bending diagrams, typical crack locations, and typical pin-and-hanger parts. Timber covered bridges (trusses) with steel vertical tension hangers are not coded as fracture critical (Item 92A). Unless a structural analysis indicates these are primary members, they are to be considered a secondary member (non-fracture critical).

Once a bridge is designated as fracture critical, each individual member and connection must be identified for the inspection. Any attachment connected to the tension area of a fracture critical member and having a length in the direction of the tension stress greater than four inches shall be considered part of the tension component and, therefore, shall be considered fracture critical. For definition purposes and uniformity in reporting, the portions of the fracture critical member within a minimum of 12 inches of the entire connection (gusset plates, connection plates, etc.) shall be considered a fracture critical connection, whereas the portion of the tension member beyond the 12-inch window shall be considered a fracture critical member. See Figures 4:11-14 through 4:11-16 for examples of this definition. The Inspection Team Leader shall use sound judgment to expand the minimum 12-inch criteria to include additional fatigue details, and also consider the scale of the bridge and associated members. Floor beam connections, lateral bracing connections, bearings, gusset plates, connection angles, pins, hangers, etc. are all typically considered as part of the fracture critical connection.

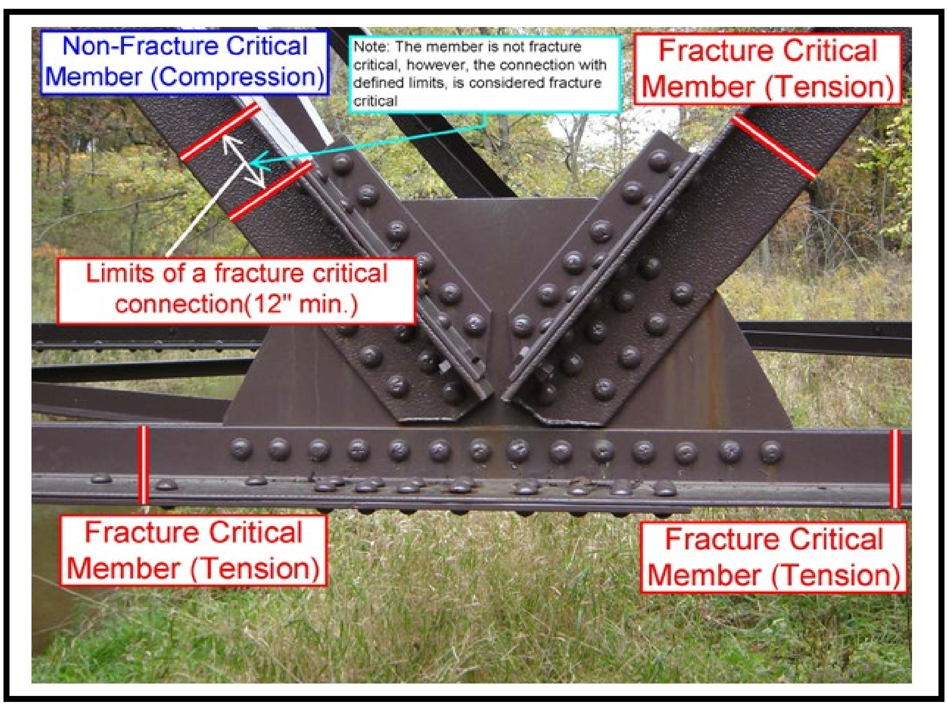


Figure 4:4-1: Fracture Critical Truss Connection

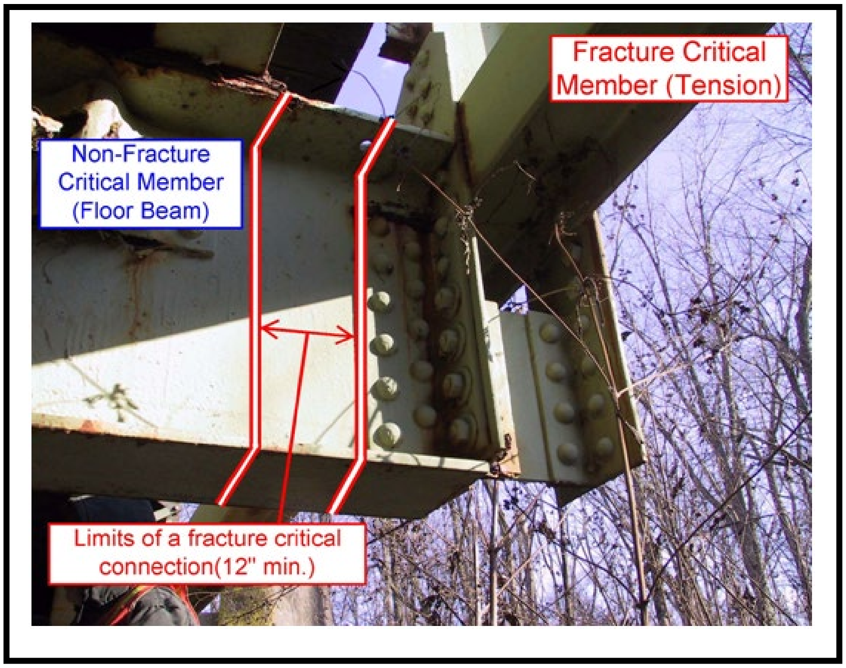


Figure 4:4-2: Fracture Critical Floor Beam Connection

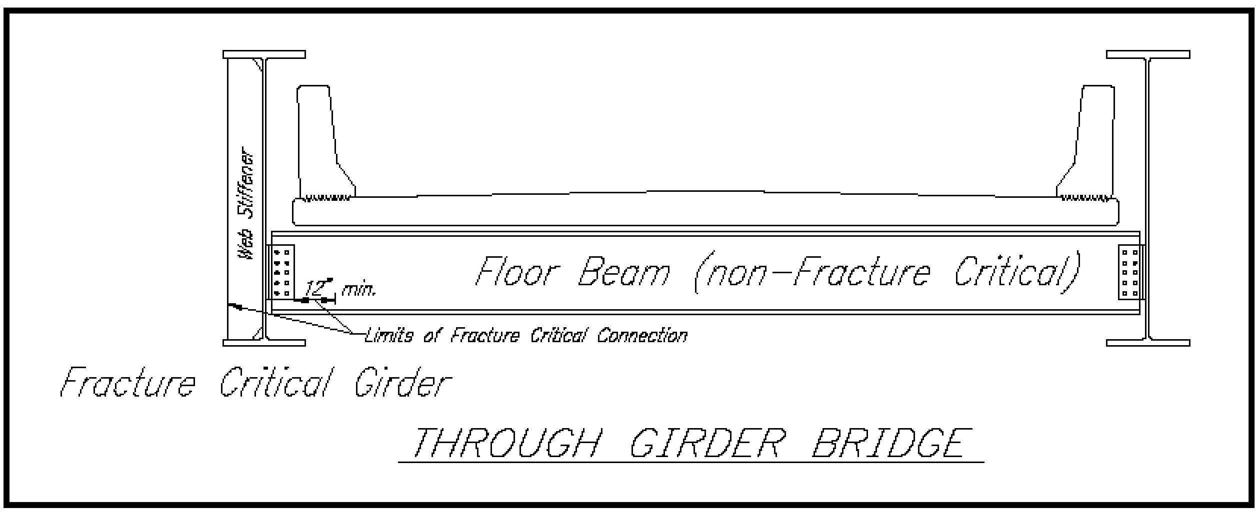


Figure 4:4-3: Fracture Critical Connection at Through Girder

In the event that original design plans of a fracture critical bridge clearly indicate that a tension member is not fracture critical due to internal redundancies within the bridge, these members will still require a detailed Fracture Critical Inspection. These tension members may only be omitted from the Fracture Critical Inspection if permission is given by the owner and the State Program Manager prior to the inspection.

4-4.01(02) Inspector Qualification

All Inspection Team Leaders for fracture critical bridges must:

1. Meet requirements in Part 1, Chapter 2
2. Possess adequate knowledge and understanding of how a fracture critical bridge functions, and where possible defects may occur
3. Possess suitable knowledge of the function of the specific bridge undergoing the inspection and, subsequently, the more complex bridges will warrant more knowledgeable, experienced inspectors; knowledge includes the understanding and ability to perform testing or recommend advanced testing procedures at problem areas; must be current on issues with the type of bridges being inspected
4. Physical ability to provide a hands-on inspection of all fracture critical members and connections in the individual bridge

4-4.01(03) Inspection Interval

Fracture Critical Inspections shall be performed at a regular interval not to exceed 24 months. If necessary, the inspection interval may be reduced. The inspection may be a supplemental inspection to the Routine Inspection.

4-4.01(04) Inspection Preparation

The fracture critical Plan of Action must be developed and/or reviewed and updated prior to performing a Fracture Critical Inspection. The inspection Plan of Action plays a crucial role in assisting all current and future inspectors at the bridge. The Plan of Action serves as an important first step in performing a thorough and complete investigation of all fracture critical members, while identifying necessary means, methods, and equipment required to perform this inspection. The inspection Plan of Action is a required element for every fracture critical report. These minimum requirements must be met for acceptance of the report by the Indiana Department of Transportation (INDOT. A full sample report, including the inspection Plan of Action is included in Appendix C.

At a minimum, the inspection Plan of Action shall include the following:

1. Sketch(es) of the superstructure with locations of all fracture critical members and connections clearly identified; primary members that are not fracture critical should be clearly identified, as well
2. An elevation view for trusses with locations labeled by letters and numbers similar to the nomenclature indicated in Figure 4:4-4
3. Use a framing plan and elevation view for a through girder with detail locations labeled by letters and numbers similar to the nomenclature indicated in Figure 4: 4-5

4. A north arrow
5. A general listing of all fracture critical members
6. A brief historical fact statement, such as a summary of repairs and rehabilitations or prior history of any problems
7. All inspection tools and access equipment required/used for the inspection
8. Traffic control requirements
9. Inspection frequency

Other items that should be reviewed and made available to the inspector, if available, prior to the inspection include the following:

1. Existing bridge plans and any repair/rehabilitation plans
2. Historical data and maintenance history of the bridge
3. Prior load ratings or a preliminary load rating (invaluable in determining fracture critical members)
4. Prior inspection reports

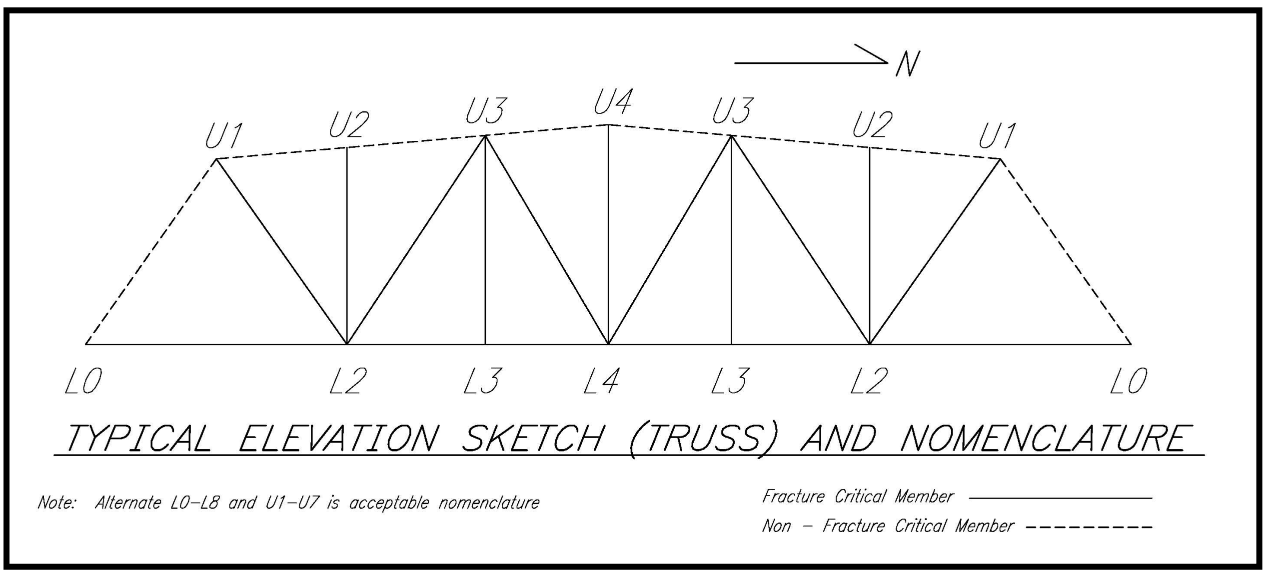


Figure 4:4-4: Typical Inspection Plan Sketch (Truss)

Note: Panel points are typically labeled beginning from South to North or from West to East in Figure 4:11-17.

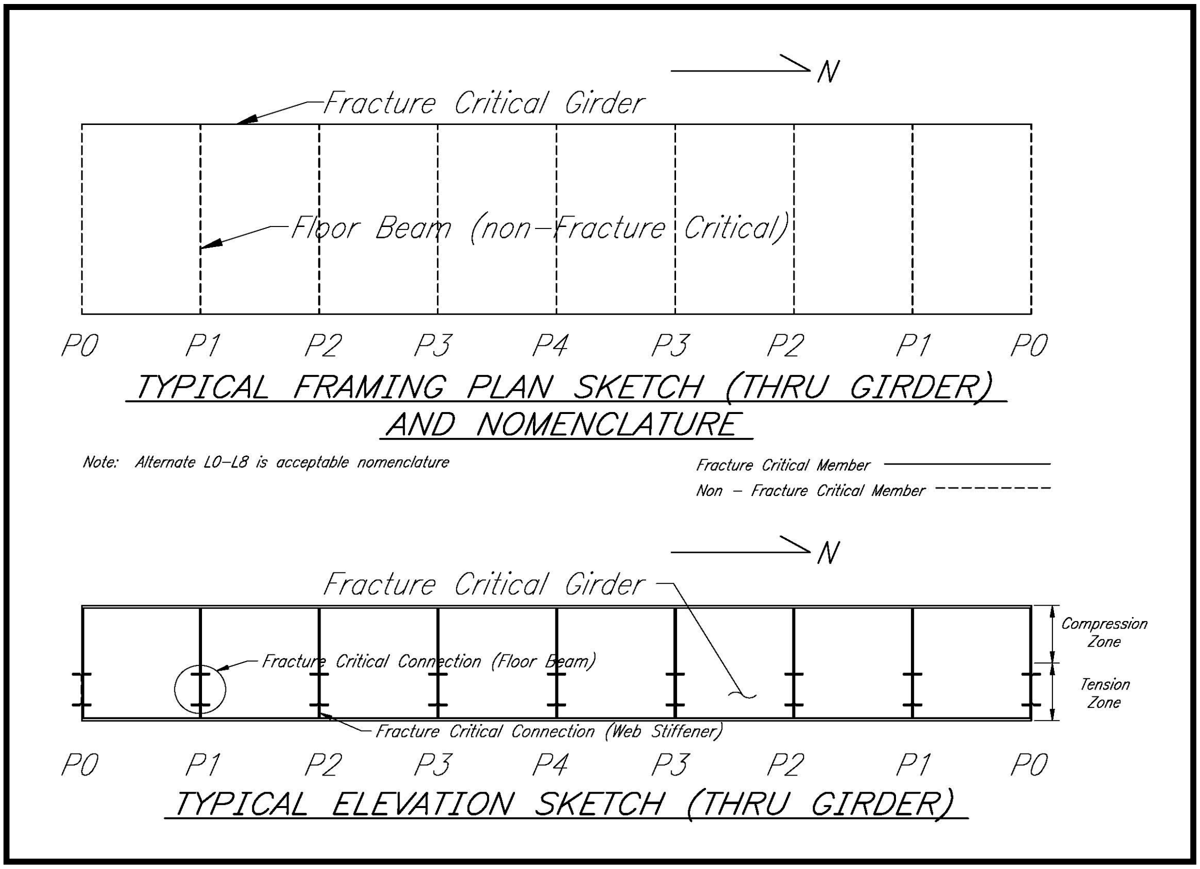


Figure 4:4-5: Typical Inspection Plan Sketches (Through Girder)

4-4.01(05) Field Inspection

The National Bridge Inspection Standard requires a hands-on inspection of all fracture critical members and/or components. Hands-on is defined as being within arm's reach (two feet) of these components. INDOT firmly enforces the hands-on requirement during inspections due to the relatively small size and difficulty in locating cracks and adequately inspecting fatigue and other details. The hands-on inspection requirement warrants the utilization of ladders, man lifts, climbing, and Under-bridge vehicles to inspect all fracture critical components and members. Cracks and other deficiencies cannot be adequately located and inspected with the utilization of binoculars or outside of the inspector's reach from the member.

Primary compression members, floor beams, and secondary members such as lateral bracing, portal bracing, etc. are not considered fracture critical. These items require inspection and reporting during the Routine Inspection cycle. However, special consideration should be given to ensure that all primary and secondary members are inspected during the Routine or Fracture Critical Inspection and that no members have been missed during the entire inspection cycle. At a minimum, the Inspection Team Leader should perform a brief walkthrough of all secondary and non-fracture critical primary members during the Fracture Critical Inspection as a simple means to ensure all members have been inspected. When expensive equipment such as an under-bridge vehicle or man lift is utilized during the Fracture Critical Inspection, the Inspection Team Leader should strongly consider and plan to utilize this equipment for the inspection of any difficult-to-inspect, non-fracture critical members or problem areas on the bridge.

It is imperative that the inspector adequately identify and inspect each fracture critical member and fatigue detail. The FHWA suggests inspection for fatigue cracks in welded bridges should be performed at, but not limited to, the following locations:

For out-of-plane distortion in welded bridges, inspect the following locations:

1. Girder webs at floor beam and diaphragm connections
2. Ends of diaphragm connection plates in girder bridges
3. Box girder webs at diaphragms
4. Lateral bracing gusset plates on girder webs at floor beam connections
5. Floor beam and cantilever bracket connections to girders
6. Pin-connected hanger plates and fixed-pin plates

For main members in welded bridges, inspect the following locations:

1. Ends of welded cover plates
2. Groove welds in flange plates
3. Butt welds in longitudinal stiffeners
4. Web plates with cut-outs and filler welds
5. Intersecting groove welds
6. Welded repairs and reinforcement
7. Back-up bar splices
8. Stress risers

For connections and attachments in welded bridges, inspect the following locations:

1. Cut short flanges
2. Coped beam ends
3. Blocked flange plates
4. Welded rigid connections of cross-girders at bents
5. Welded flange attachments
6. Intersecting welds at gusset plates and diaphragms

In general, the locations where fatigue cracks develop in riveted and bolted bridges are similar to those in welded bridges. The FHWA suggests inspection for fatigue cracks in riveted or bolted bridges should be performed at, but not limited to, the following locations:

1. Rivets/bolts at end connections (check for cracking and prying)
2. End connection angle
3. Girder webs at floor beam connections
4. Floor beam connections to girders
5. Diaphragm connections to girders
6. Cantilever bracket connections to girders
7. Truss hangers
8. Eyebars (see Figures 4:11-19 and 4:11-20)
9. Tack welds
10. Rivet heads and bolts made of certain types and ages of steel on older bridges may have fatigue issues, especially if pack rust has developed between connection members; additional stress may be placed on the nut or rivet head at these locations

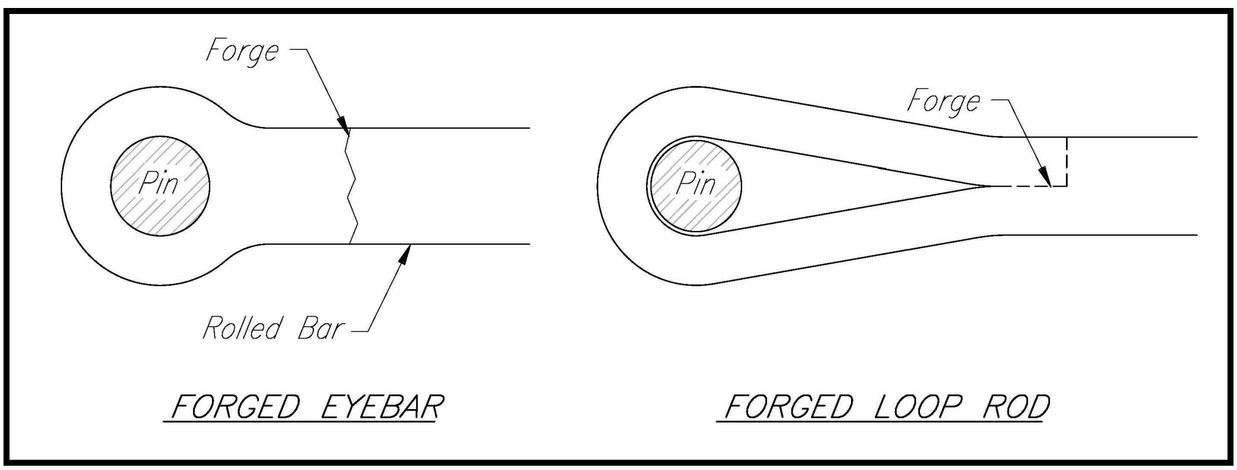


Figure 4:4-6: Typical Pin and Eyebar Details

The thickness of primary truss gusset plates should be measured as a part of a Fracture Critical Inspection. If the section cannot be adequately measured with traditional measurement devices, inspectors should use an appropriate NDT technology to assess the gusset plate condition and quantify the plate thickness.

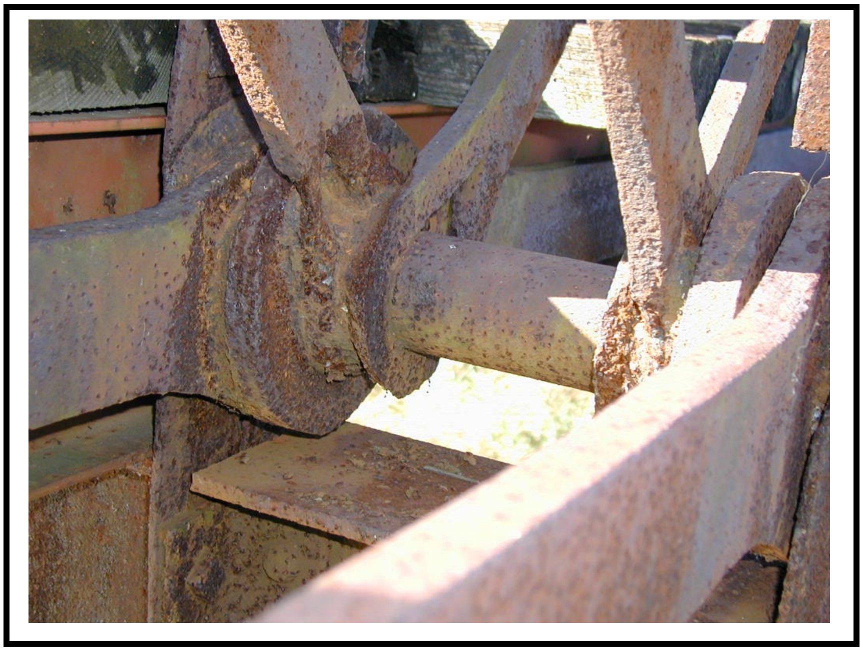


Figure 4:4-7: Forged Eyebar with Extensive Section Loss

4-4.01(06) Field Inspection Reporting

Each bridge owner has unique requirements and preferences for bridge reporting. The guidelines listed in this section are the minimum reporting requirements for acceptance of a fracture critical report. Although these minimum requirements must be met for acceptance of the report by INDOT, the inspecting agency may provide alternate report formats meeting internal guidelines, as long as the criteria set forth in this chapter are met. An example inspection report has been provided in Appendix C. The following are minimum requirements for a Fracture Critical Inspection report:

1) Inspection Plan of Action
2) General statement discussing inspection procedures
3) Date, temperature, and weather conditions of the inspection
4) Time duration of the inspection
5) Inspection Team Leaders and Inspection Team Members present at the inspection
6) General summary of inspection results
7) Testing performed, and locations of these tests
8) Recommendations for repairs and maintenance, highlighting urgent repairs and listing programmed repairs
9) Photographs of every fracture critical member, connection, or component assigned a

condition rating of 4 or less

10) Photographs of each fracture critical member at a frequency of not greater than 10 years (to be included in the bridge file)

11) Photographs of any cracks inspected or discovered

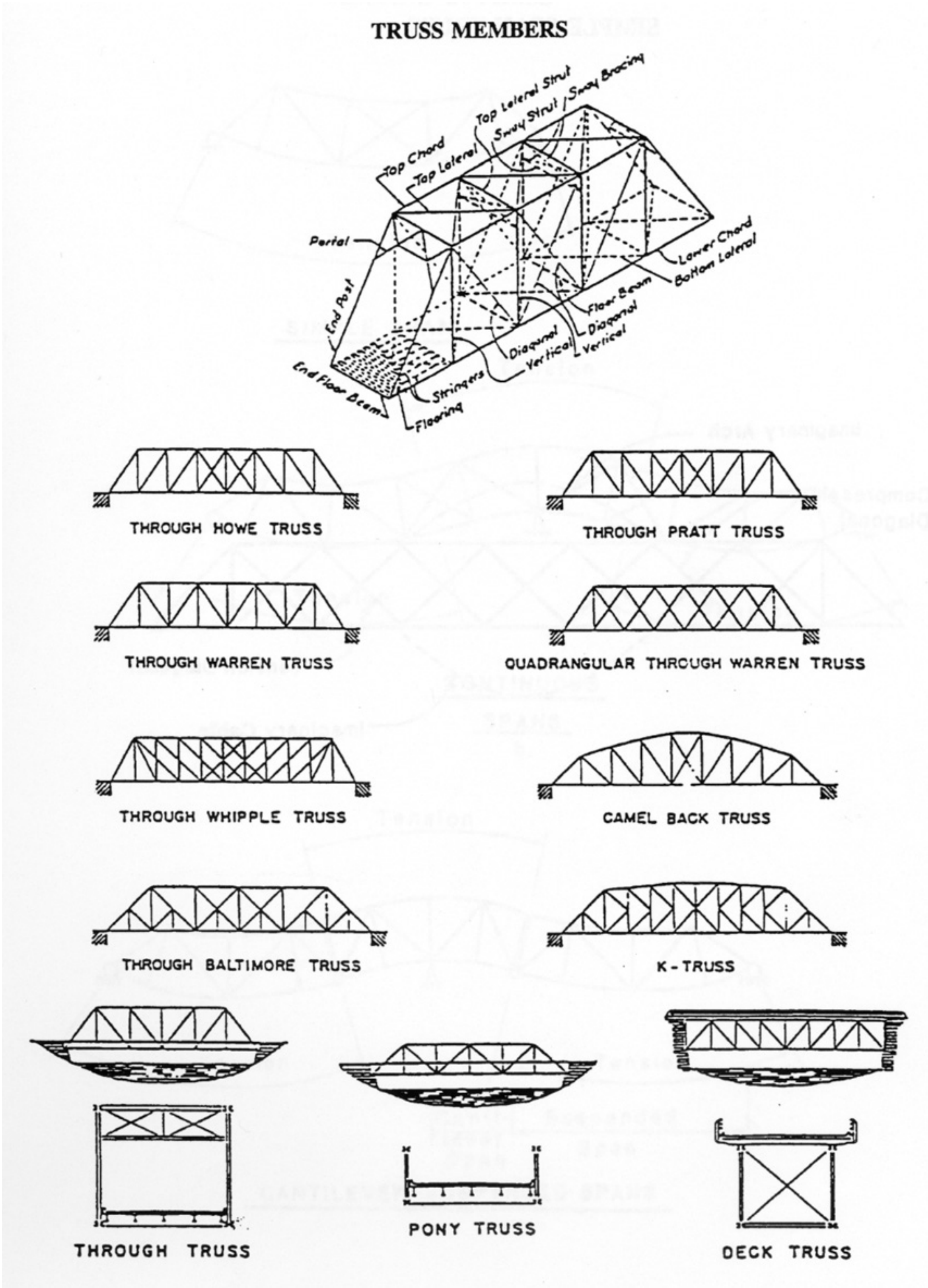
12) Recommended inspection interval

13) Documentation of inspection results for each individual member and/or component, including the following:

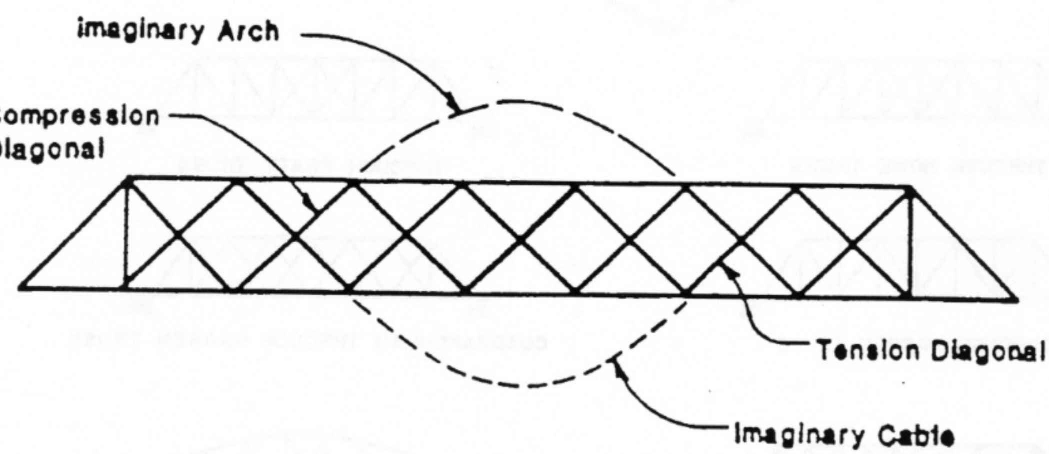
    a) Individual member rating
    b) Noted section loss
    c) AASHTO fatigue category
    d) Brief statement discussing the presence of cracks (or lack thereof)
    e) Adequate documentation of fatigue damage
    f) A table showing the primary truss gusset plates, thickness measurement taken, location of each measurement, and the inspection procedure used to take each measurement

APPENDICES

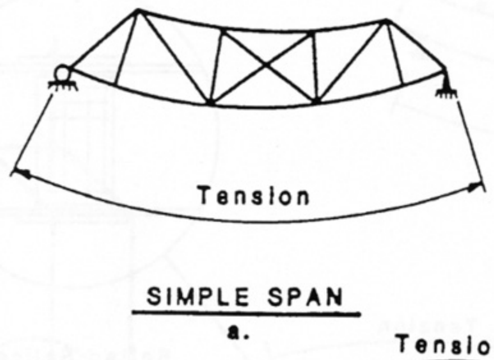
APPENDIX B FRACTURE CRITICAL DETAILS

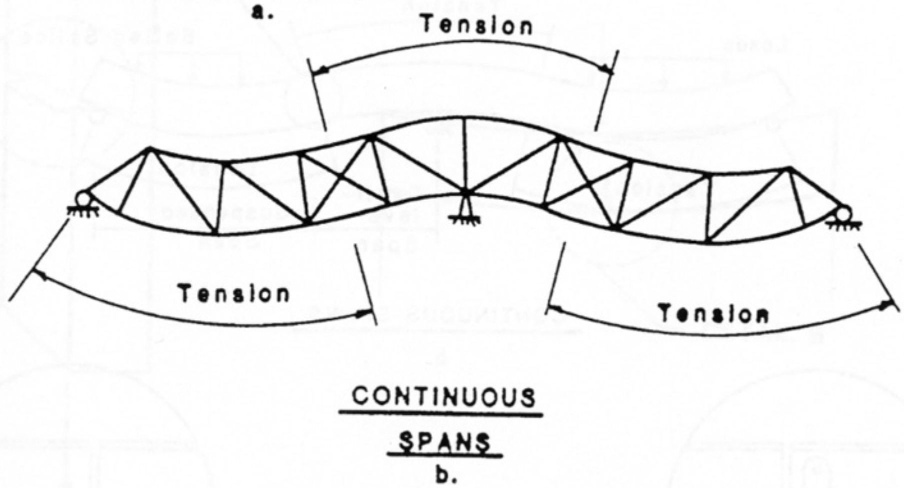


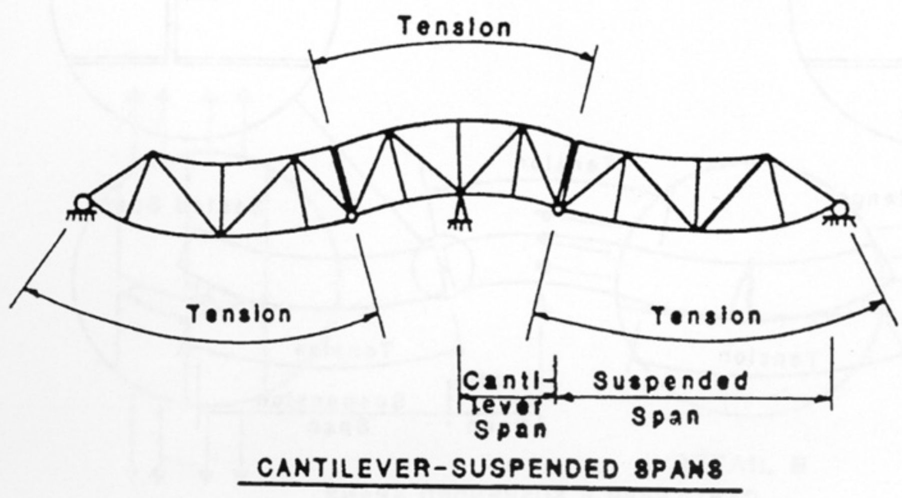
SIMPLE SPAN TRUSS



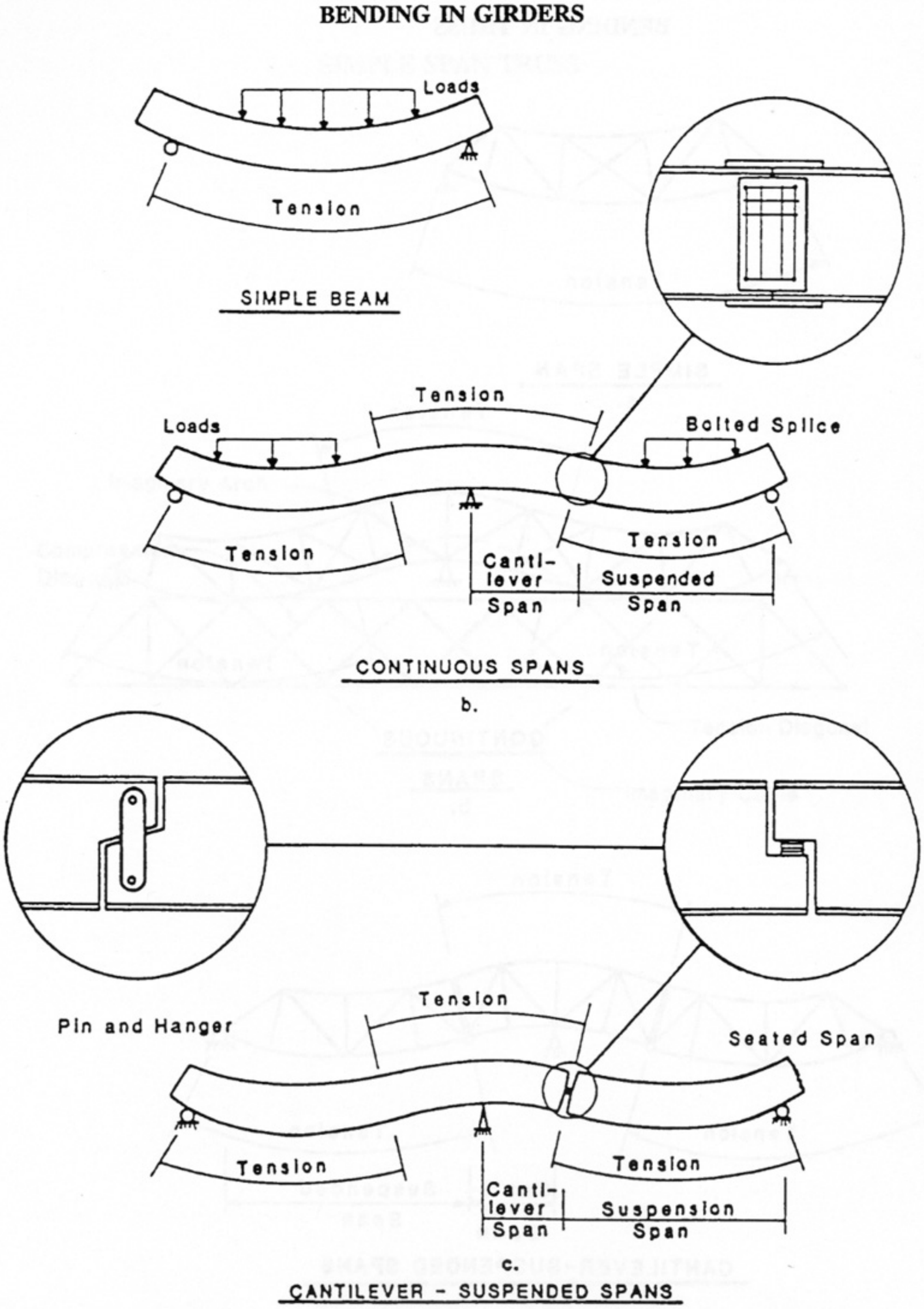
BENDING IN TRUSS

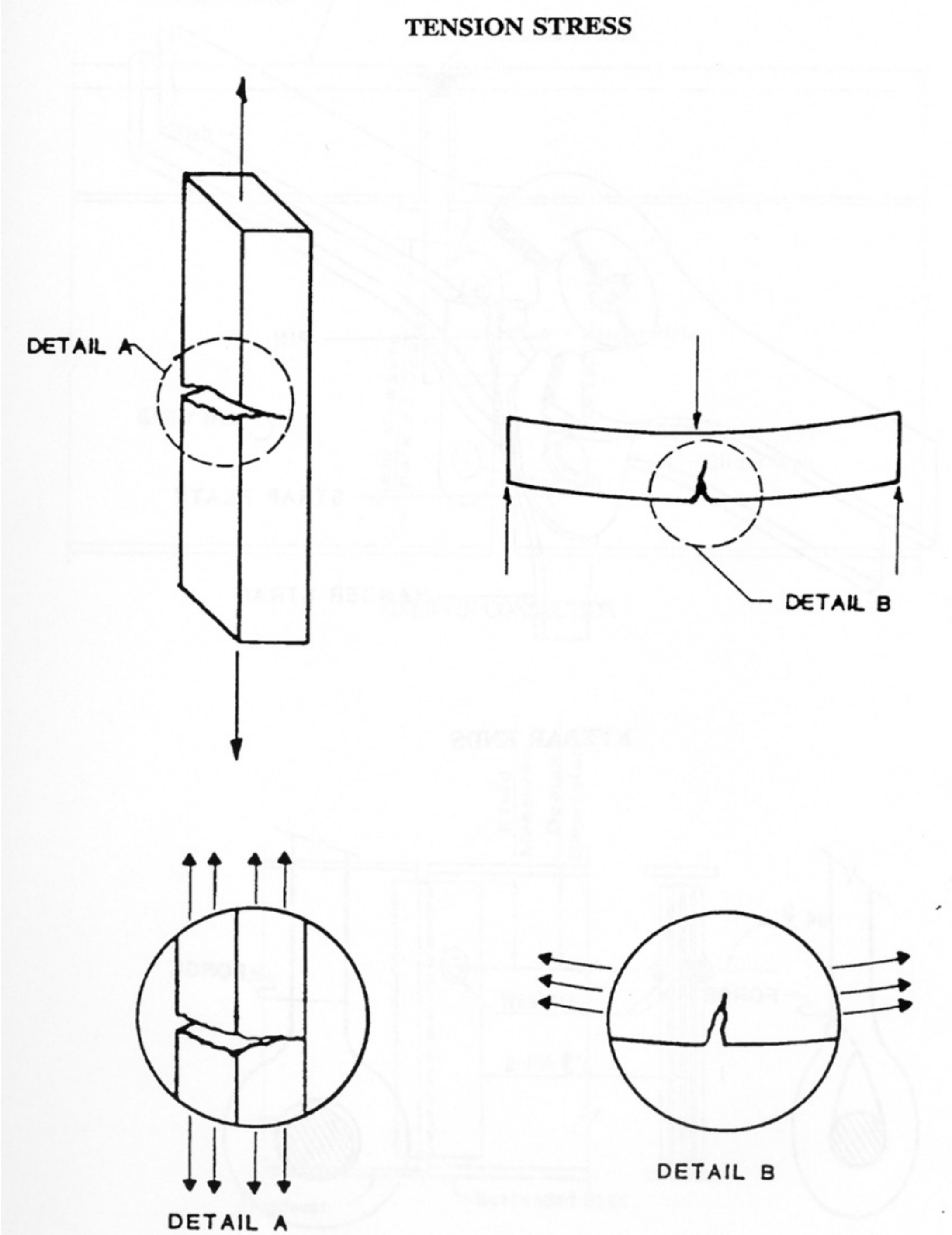






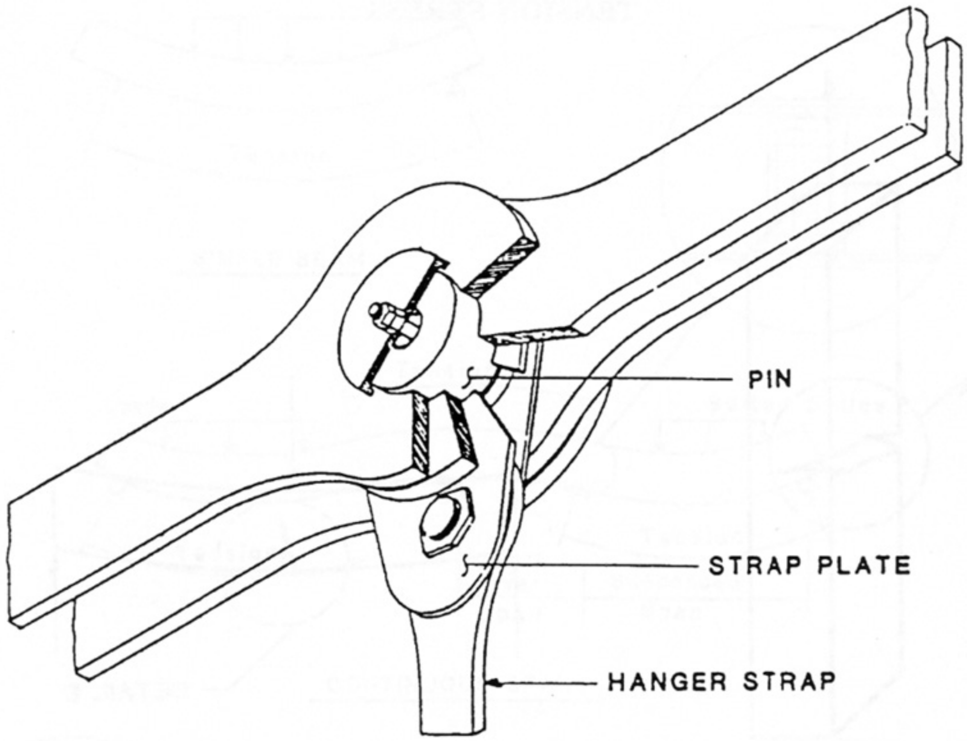
BENDING IN GIRDERS



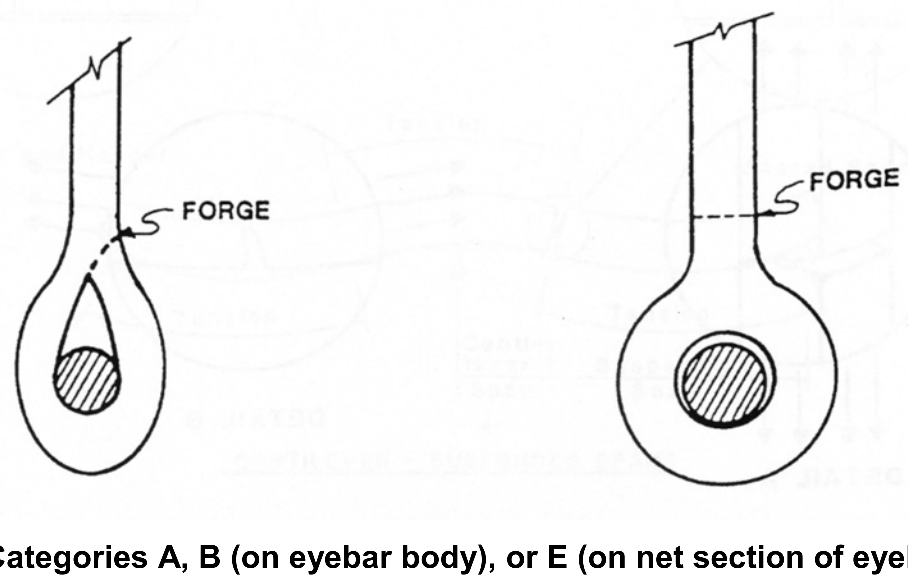


Cracks being pulled open by tensile forces.

EYEBAR HANGER CONNECTION

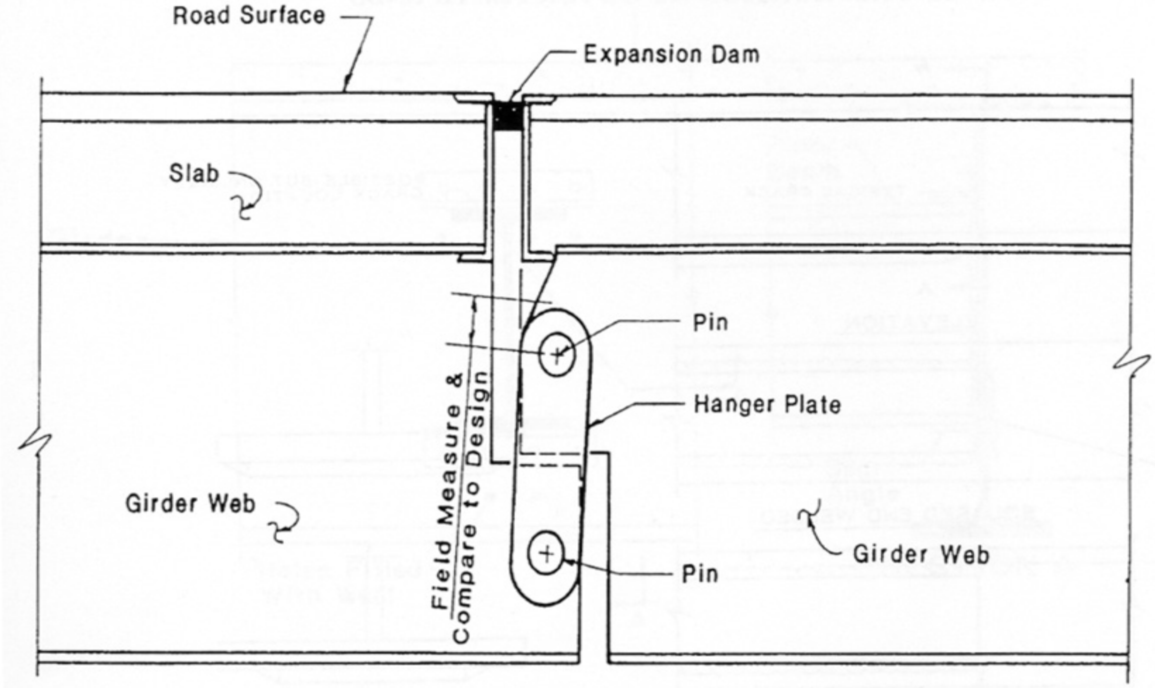


EYEBAR ENDS

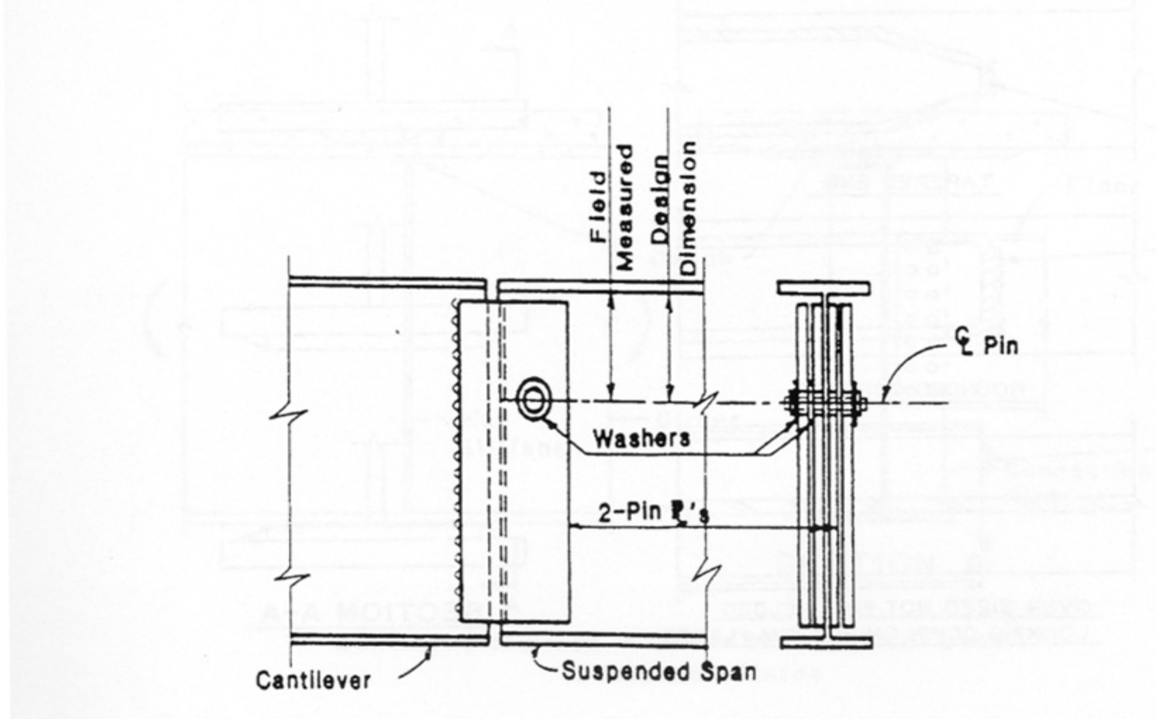


Fatigue Categories A, B (on eyebar body), or E (on net section of eyebar head)

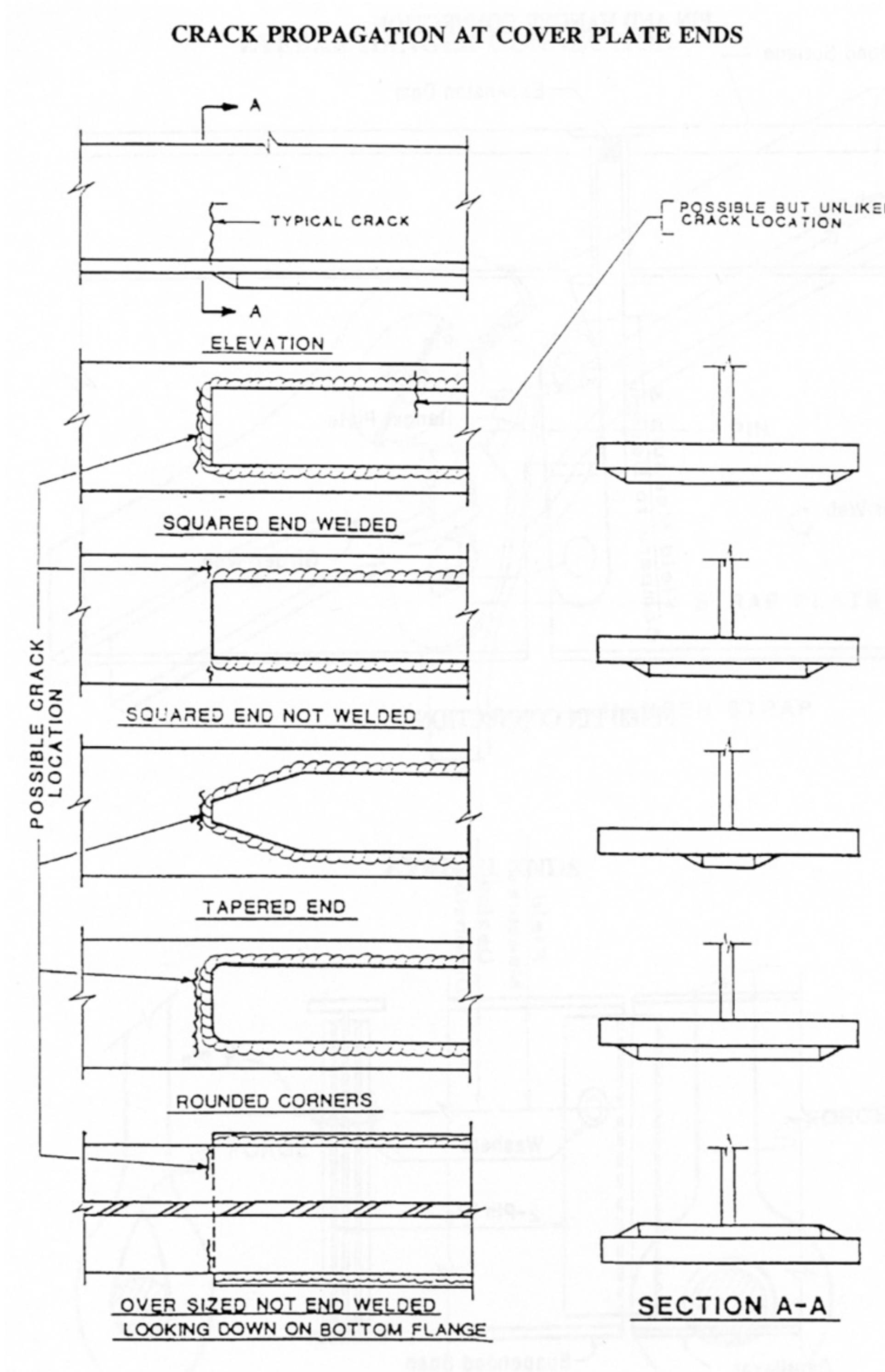
PIN AND HANGER CONNECTION



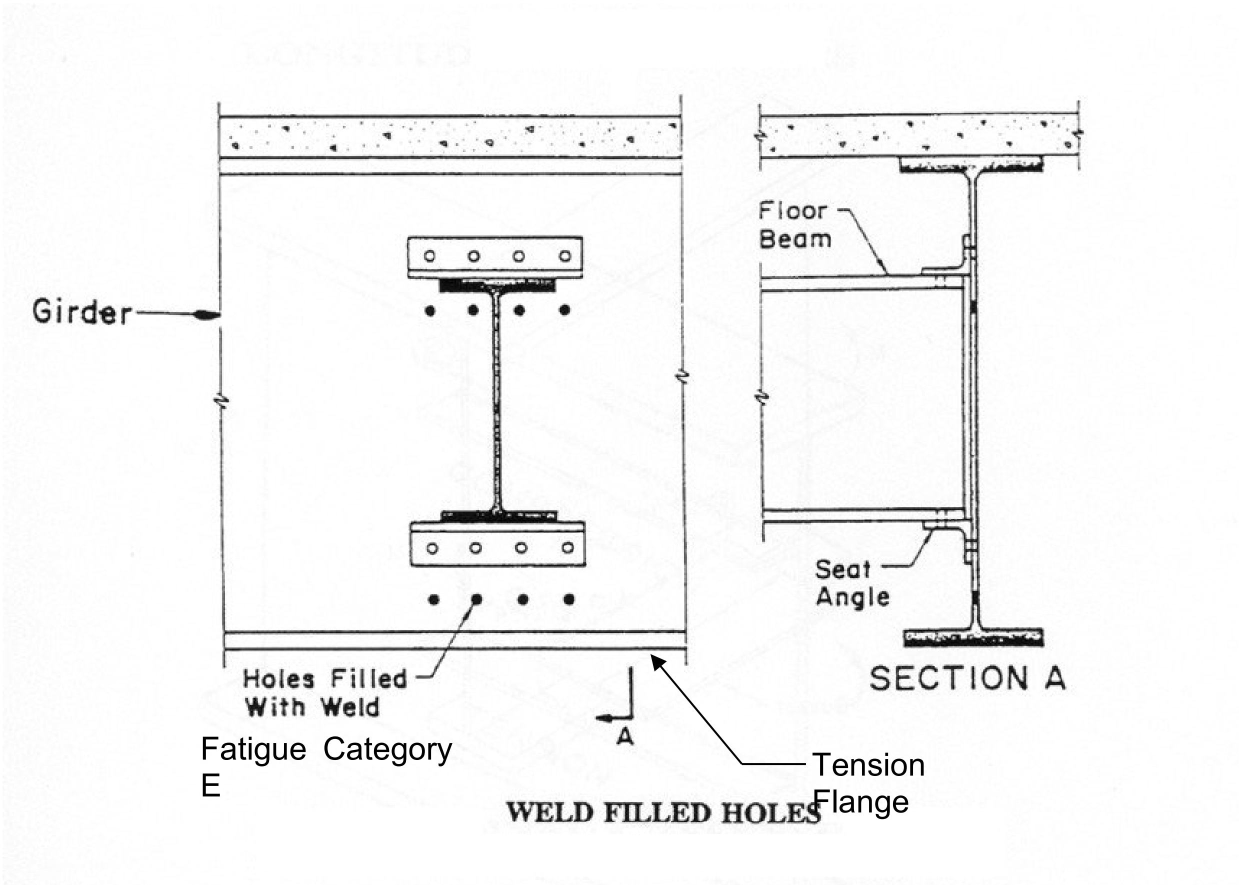
FIXED PIN CONNECTION

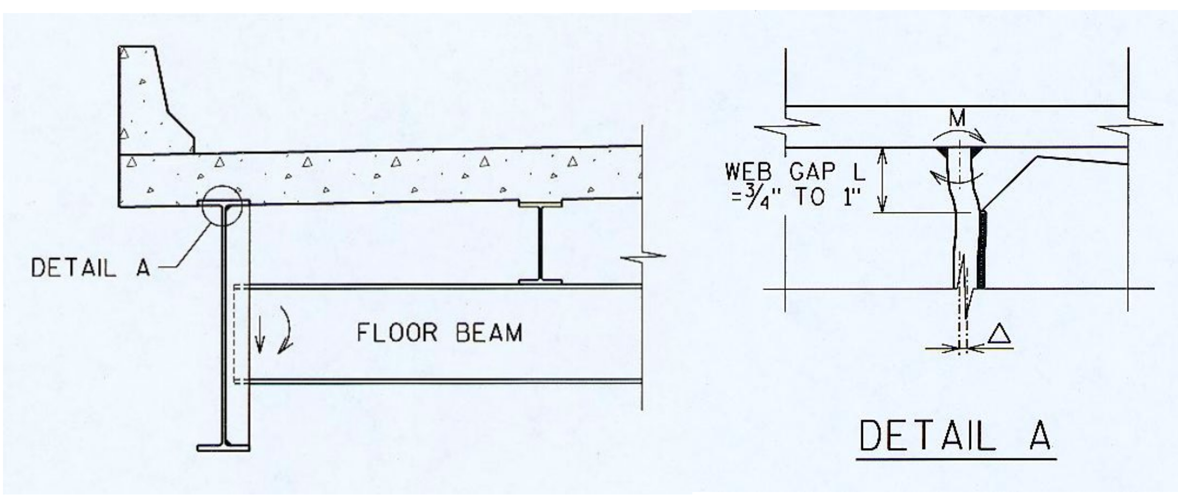


Fatigue Category A, B (on hanger plate body), or E (on net section of hanger or pin plate)



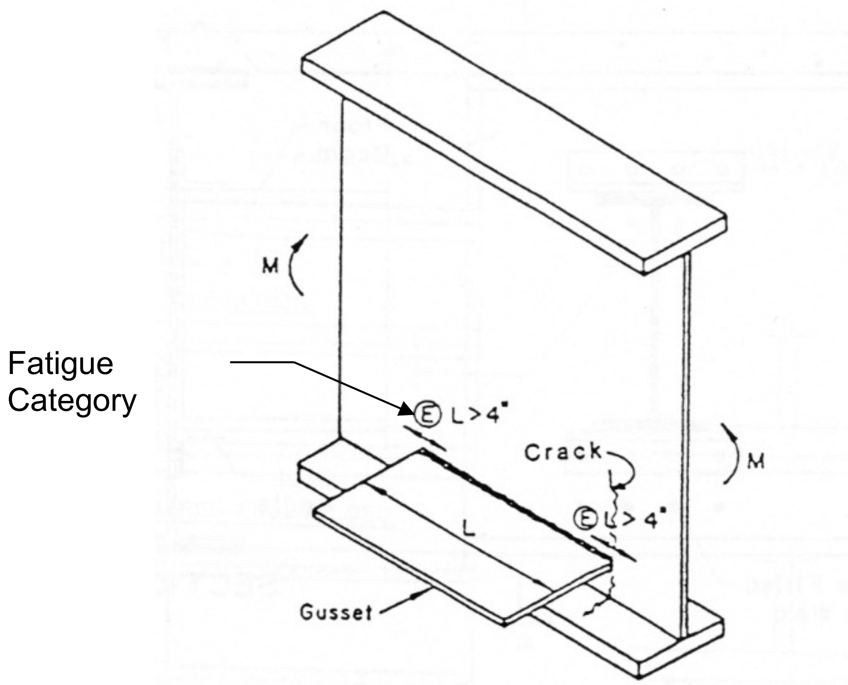
Fatigue Categories E and E'

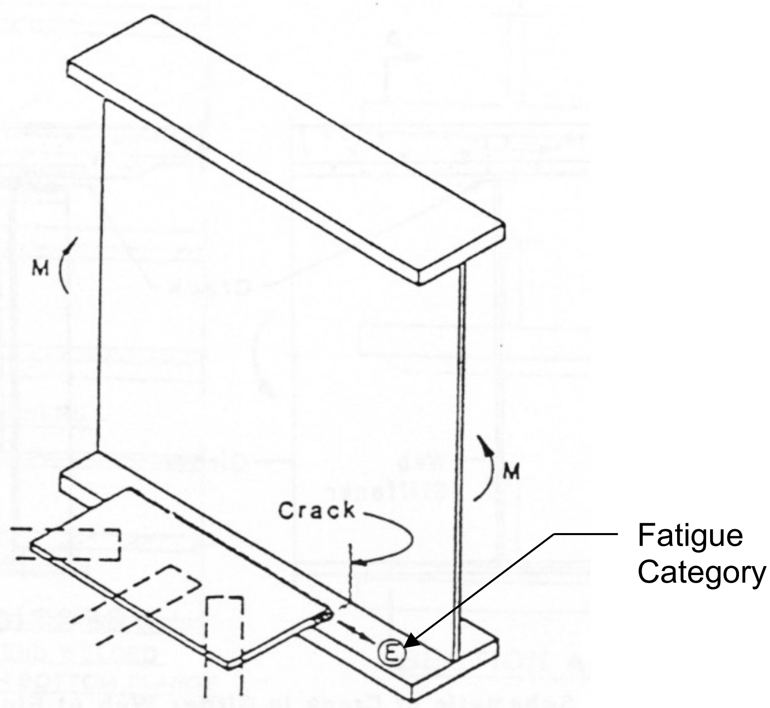




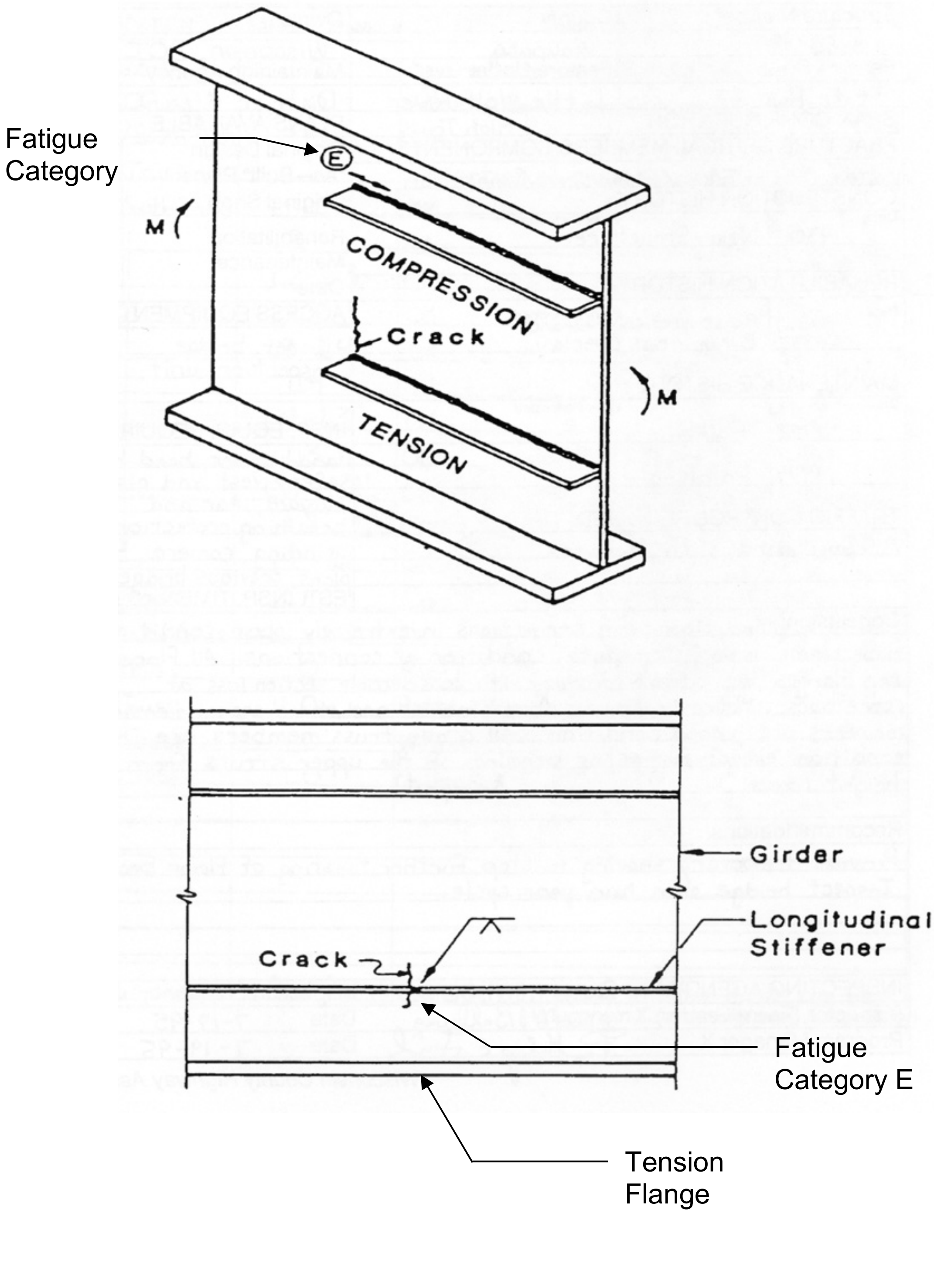
Web Out-of-Plane Bending at Floor Beam Connection Plate

FLANGE AND WEB ATTACHMENTS



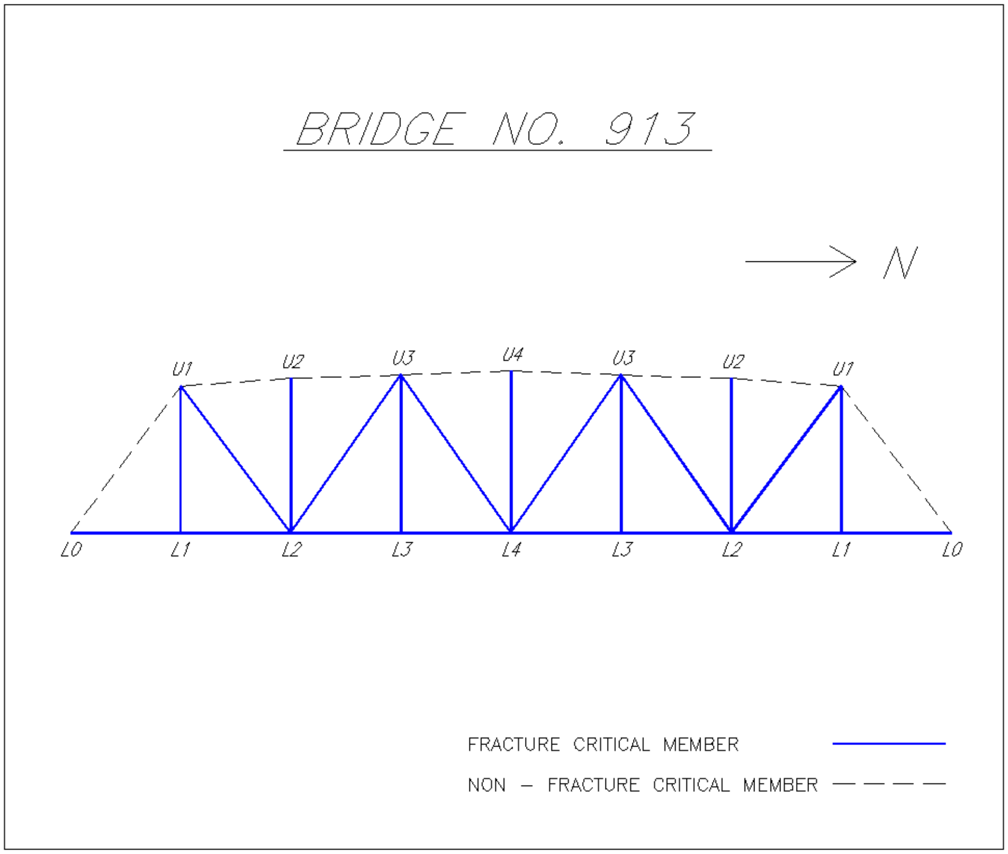


LONGITUDINAL STIFFENERS



APPENDIX A: SAMPLE REPORTS

SAMPLE FRACTURE CRITICAL INSPECTION REPORT – 2010



I. INTRODUCTION

A. Location and Description

Bridge No. 001 is located 0.1 miles south of State Road 99. The map location is at E-9. The bridge carries traffic on Main Street over Nameless Creek. The bridge is located at a latitude of N39°00’01.1” and a longitude of W86°00’01.1”.

Bridge No. 001 is a single span steel pony truss. The structure is on an approximate zero degree skew. The structure length is 127 feet with a maximum span length of 124.0 feet. The structure has a clear roadway width of 28.0 feet. The average daily traffic was estimated to be 11083 vehicles per day in 2008. The bridge has an H rating of XX tons.

B. History

The estimated year of construction for Bridge No. 001 is 1946. The bridge was reconstructed in 1986 and repaired in 1995.

II. FIELD INVESTIGATION

A. Members to be Inspected

The following truss tension members are considered to be non-redundant, fracture critical bridge members:

- lower chords and lower chord connections
- diagonals and diagonal connections in tension
- verticals and vertical connections in tension
- floor beam connections

B. Inspection Procedures

An up-close visual inspection was performed to locate possible problem areas in the fracture critical members.

If any suspect surface discontinuities were found, a dye penetration test would be performed. This test can help locate stringers (long, thin laminations), scams (shallow, thin voids), laminations (flat, subsurface discontinuities), and cracks in the base metal. It is also of use in checking for weld-related cracking and porous groove welds. This was not needed at this bridge.

C. Equipment Required for Inspection

Tools and equipment used to inspect each member or connection included a hard hat, safety glasses, chipping hammer, scraper, wire brush, feeler gauges, calipers, tape measure, flashlight, magnifying glass, swivel mirror, camera, and a punch.

A dye penetration kit was available for a more detailed inspection if needed.

A 20' extension ladder was used to inspect the upper chord connections and various members and lower chord connections and various members were inspected by free climbing with safety restraints.

D. Bridge Cleaning Requirements

The lower chord and bearings contained heavy dirt and roadway debris. The highway department power washed all lower chord members and bearings prior to the inspection. The highway department also removed heavy vegetation overgrowth around the bridge to assist in the inspection. Hand brushes and a scraper were utilized by the inspector to clean individual locations.

E. Traffic Maintenance Requirements

All lower chord members and connections were accessible without roadway restrictions. The highway department provided temporary roadway closures at each end of the bridge for the portions of the inspection requiring the utilization of a ladder.

F. Date and Conditions of Inspection

Date : 5/29/10

Temperature : 55° F

Conditions : Overcast

Inspection Duration: 5 hours

G. Other items

Original bridge plans were available to the inspector dated July 1945, as well as rehabilitation plans dated 1986 and repair plans dated 1995. The previous inspection consultant provided copies of load ratings as well as previous inspection reports. Field notes tracking several deficiencies were made available by the previous inspection consultant in order to monitor the development of several deficiencies at the bridge.

III. SUMMARY OF INSPECTION RESULTS

A. Connections

All of the connections were in satisfactory to good condition with the exception of NE L1U1 which is in fair condition. No deterioration or section loss was found that would affect the load capacity of any fracture critical connections. Debris has accumulated at the lower chord connections. No cracks were found.

B. Members

All of the members are in satisfactory to good condition, with the exception of SW L1U1 which is in fair condition. No deterioration or section loss was found that would affect the load capacity of any fracture critical members. Debris has accumulated on the lower chord. No cracks were found.

IV. NBIS CODING INFORMATION

ITEM	CODE	DESCRIPTION
92A: Fracture Critical Details Inspection (Non-Redundant)	Y24	Fracture critical inspection every 24 months
93A: Fracture Critical Details Inspection Date	05/29/2010	Inspection date, May, 2010

V. SUMMARY OF RECOMMENDATIONS

Programmed Repairs: The lower chord should be cleaned regularly to remove debris.

Urgent Repairs: None

VI. FIELD NOTES

The following rating system was used to rate the fracture critical members and connections:

9 Excellent Condition

8 Very Good Condition - No noteworthy deficiencies

7 Good Condition - Some minor problems

6 Satisfactory Condition - Minor structural deterioration

5 Fair Condition - Minor section loss

4 Poor Condition - Advanced section loss, deterioration

3 Serious Condition - Local failures are possible

2 Critical Condition - Advanced deterioration of primary elements

1 Imminent Failure Condition - Major deterioration - Structure should be closed

0 Failed Condition - Out of service - Bridge condition beyond corrective action

Connection at Southwest L0:

MEMBER	FATIGUE CAT.	RATING	REMARKS
Lower Chord	D	6	Light surface rust and moderate pitting. Minor expansion rust at floor beam connection angle. Areas of heavy pitting with minor section loss on inside flanges and top and bottom of web. No cracks evident.
Bearing	D	7	Light surface rust and minor pitting. Minor expansion rust between angles and plates and between gusset plates and lower chord flanges. Bearings near limit of rotation. No cracks evident.
Floor Beam	B	7	Light surface rust on repairs and bolted connection. No cracks evident

Connection at Southwest L1:

MEMBER	FATIGUE CAT.	RATING	REMARKS
Lower Chord	E	6	Light surface rust and minor pitting. Areas of heavy pitting with minor section loss on inside flanges and top of web. One rivet head is missing on each angle. Expansion rust between gusset plate and flange with minor section loss. Welded repairs to member have created a fatigue prone detail however no cracks evident.
Vertical (L1U1)	D	6	Light surface rust and minor pitting. Minor expansion rust and section loss at floor beam connection on inside flange. 20% section loss at inside flange at plate connection. No cracks evident.
Floor Beam	D	6	Light surface rust, minor section loss, and minor pitting. Minor expansion rust at floor beam connection on inside flange. No cracks evident.

Connection at Southwest L2:

MEMBER	FATIGUE CAT.	RATING	REMARKS
Lower Chord	D	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges, top of web, and on rivets. 15-20% section loss of flange at gusset plate and flange connection. Expansion rust between splice plates at the lower chord web. No cracks evident.
Vertical (L2U2)	D	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flange under railing connection, on web at lower chord splice and on vertical connection plates. Minor out of plane distortion from impact damage below rail. No cracks evident.
Diagonal (L2U1)	D	7	Light surface rust and minor pitting. Areas of heavy pitting, expansion rust and minor section loss on inside flange at gusset plate connection. No cracks evident.
Diagonal (L2U3)	D	7	Light surface rust and minor pitting. Areas of heavy pitting, expansion rust and minor section loss on inside flange at gusset plate connection. No cracks evident.
Floor Beam	B	7	Light surface rust on repairs and bolted connection. No cracks evident.

Connection at Southwest L3:

MEMBER	FATIGUE CAT.	RATING	REMARKS
Lower Chord	D	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges, top of web, and on rivets. No cracks evident.
Vertical (L3U3)	D	6	Light surface rust and minor pitting. Areas of heavy pitting and on inside flange and web. Heavy expansion rust at inside flange and lower chord connection. No cracks evident.
Floor Beam	D	6	Light surface rust and minor pitting. Minor expansion rust at floor beam connection angles and lower flange connection. No cracks evident.

In order to avoid redundancy, several pages of the Sample Report have been deleted.

West Truss Lower Chord Members:

MEMBER	FATIGUE CAT.	RATING	REMARKS
Lower Chord (Southwest L0L1)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Lower Chord (Southwest L1L2)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Lower Chord (Southwest L2L3	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Lower Chord (Southwest L3L4)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. Heavy section loss of rivet heads (50-75%) at splice in web only. No cracks evident.
Lower Chord (Northwest L3L4)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. Heavy section loss of rivet heads (20%) at splice in web only. No cracks evident.
Lower Chord (Northwest L2L3)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Lower Chord (Northwest L1L2)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Lower Chord (Northwest L0L1)	A	6	Light surface rust and minor pitting. Areas of heavy pitting and minor section loss on inside flanges and on top of web. No cracks evident.
Vertical (Southwest L1U1)	A	5	Light surface rust and moderate pitting. Areas of heavy pitting on inside of south web with 20% section loss on web. No cracks evident.
Vertical (Southwest L2U2)	A	7	Light surface rust and minor pitting. Localized areas of surface rust and moderate pitting. No cracks evident.
Vertical (Southwest L3U3)	A	6	Light surface rust and minor pitting. Areas of heavy pitting, surface rust and minor section loss on inside flanges and on north face of web. No cracks evident.
Vertical (West L4U4)	A	7	Light surface rust and minor pitting. No cracks evident.
Vertical (Northwest L3U3)	A	7	Light surface rust and minor pitting. No cracks evident.

Vertical (Northwest L2U2)	A	7	Light surface rust and minor pitting. No cracks evident.
Vertical (Northwest L1U1)	A	7	Light surface rust and minor pitting. No cracks evident.
Diagonal (Southwest L2U1)	A	7	Light surface rust and minor pitting. No cracks evident.
Diagonal (Southwest L2U3)	A	7	Light surface rust and minor pitting. Localized areas of surface rust and moderate pitting. No cracks evident.
Diagonal (Southwest L4U3)	A	7	Light surface rust and minor pitting. Localized areas of surface rust. No cracks evident.
Diagonal (Northwest L4U3)	A	6	Light surface rust and minor pitting. Areas of web with heavy pitting and section loss. No cracks evident.
Diagonal (Northwest L2U3)	A	7	Light surface rust and minor pitting. No cracks evident.
Diagonal (Northwest L2U1)	A	7	Light surface rust and minor pitting. No cracks evident.

Note: Heavy debris accumulation on lower chords. Large areas of paint are beginning to peel on members.

West Gusset Plates with Corrosion and Requiring Non-Destructive Evaluation:

CONNECTION	THICK.	LOCATION/METHOD OF MEASUREMENT
Southwest L0	½”	Ultra-sonic Testing. Dimension taken 3” past the end of the interior lower chord.
Northwest L2	¾”	Ultra-sonic Testing. Dimension taken between lower chord Northwest L1L2 and Diagonal Northwest L2U3.
Northwest U3	½”	Ultra-sonic Testing. Dimension taken between vertical Northwest L3U3 and Diagonal Northwest L2U3. A man-lift was required for testing

In order to avoid redundancy, several pages of the Sample Report have been deleted.

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CHAPTER 1 GENERAL

SECTION 1.1 INTRODUCTION

A movable bridge is a bridge across a navigable waterway that has at least one span which can be temporarily moved in order to increase the vertical clearance for vessels in the channel. Such a bridge is built where site conditions preclude constructing a fixed-span bridge with an acceptable vertical profile.

In the second half of the 19th century, the U.S. Congress prohibited the construction of bridges or other obstructions over navigable waterways. Only bridges authorized by an act of Congress could be constructed over a navigable waterway, and these had to be movable or have sufficient height to allow the passage of vessels. To this day, water traffic has the primary right of way at intersections of land and water traffic. Although an act of Congress is no longer required for the construction of a bridge, a rigorous permitting process is in place.

As of 2010, there are three movable highway bridges in the state of Indiana. Two are in East Chicago. The Indianapolis Boulevard Bridge is owned and maintained by the Indiana Department of Transportation (INDOT), and the bridge on Dickey Place is owned and maintained by Lake County. The third bridge, on Franklin Street in Michigan City, is owned and maintained by LaPorte County.

Movable bridges should receive the same inspections mandated for fixed bridges, including applicable specialized inspections such as Fracture Critical, Special, and Underwater Inspections. In addition, the operating systems need to be inspected on a routine basis. Inspection of the structural components is addressed in Part 4. Part 5 of this manual outlines the requirements for a Moveable Bridge Inspection, which is primarily concerned with the electrical and mechanical machinery for operating and stabilizing the movable span. The interaction between the movable bridge and the machinery will also be addressed here because an understanding of the mechanical/structural interaction is important for adequate inspection and maintenance of the machinery.

SECTION 1.2 INSPECTION DETAILS

Subsection 1.2.1 Inspector Qualifications

Movable bridges are large, complex, pieces of machinery. Each part of a movable bridge has a relationship to, and must interact with, many other parts. All functional systems must be inspected and evaluated by personnel experienced in that line of work.

Inspectors for movable bridges should have experience beyond that required for the inspection of fixed bridges. As with a fixed bridge, the structural members of a movable bridge must safely withstand the stresses imposed by the dead loads, live loads, and other loads typically encountered. In addition, many of the structural members must withstand the stresses imposed by the operating equipment and the movement of the bridge. It takes significant experience on movable bridges and with the applicable codes to adequately understand these relationships, evaluate the conditions of the various components, and recommend appropriate action.

The Inspection Team Leader for a Movable Bridge Inspection should be trained in the inspection of fixed bridges and all of the functional systems. He/she must be a Professional Engineer registered in the state of Indiana with experience in the inspection, design, maintenance, or construction of movable bridges. The Inspection Team Leader’s experience must understand the inter-relationships inherent in these bridges.

The inspection team for a Movable Bridge Inspection should include structural, electrical, hydraulic, and mechanical lead inspectors. A single individual may serve as lead inspector in more than one of the areas if he/she has the necessary experience. Each lead inspector should have experience in the inspection, design, maintenance, or construction of movable bridges, including the inspection of at least three such bridges within the last five years. The experience should be in the specific systems for which the individual is leading the inspection. Each lead inspector must supervise and monitor any work performed by anyone assisting in the efforts. All inspectors assisting with the inspection should, as a minimum, have experience in the inspection of fixed bridges.

The Lead Structural Inspector must have completed Fracture Critical Inspection Techniques for Steel Bridges (FHWA-NHI-130078) class and must be a Professional Engineer registered in the state of Indiana.

Subsection 1.2.2 Operating and Maintenance Manual

Every movable bridge should have its own Operation and Maintenance Manual, although these documents may not be readily available at the bridge site. If the Operation and Maintenance Manual is available, the inspection team should review the manual to determine if there are any special conditions that should be addressed at the bridge. A copy of the Operation and Maintenance Manual should be scanned into the Central Database. If there is no Operation and Maintenance Manual, the inspection of a movable bridge must be in accordance with this *Bridge Inspection Manual* and sound judgment should be used where specific conditions are encountered that are not covered by this manual.

Subsection 1.2.3 Precision

Movable bridges are considered complex structures in Indiana and require a Special Inspection, described in Part 1, Chapter 3 of this manual. The Plan of Action for each inspection required for a movable bridge (Routine, Movable, Fracture Critical, and Special) should be written with enough detail to provide guidance on the frequency and specific requirements for each inspection.

The Plan of Action must include the following:

- A timetable for conducting each inspection
- Personnel requirements for each portion of each inspection
- A list detailing what is required to be inspected under each inspection
- Required access and testing equipment needed for each inspection
- Required traffic control for each inspection
- Required type and level of nondestructive testing (NDT) that may be needed for each inspection

Movable Bridge Inspections typically require that a high level of precision be taken with measurements. Mechanical tolerances should be obtained with feeler gauges. Electrical data is typically obtained with specialized devices. The measurement locations and the precision required should be clearly called out in the Plan of Action.

Subsection 1.2.4 Frequency

Movable bridges are normally inspected prior to the start of the navigation season in the spring so that any problems can be corrected before the bridge returns to normal operations. Annual maintenance functions are generally performed at this time, as well. This is a good time to flush the bridge with high-pressure water to remove the previous year’s accumulation of dirt, road salt, and debris. Cleaning the bridge in this manner makes the inspector’s job easier and makes it more likely that small defects will be found.

Various systems, subsystems, and components are normally inspected on a frequent basis to ensure their continued operation and reliability. Some of these inspections may be performed on a daily basis by the bridge operators, while other inspections may be performed by maintenance personnel as a part of normally scheduled maintenance. Operators should be trained to observe the indicators located on the console during each bridge operation. They should be able to recognize if any of the readings are changing over time and, if so, report the changes to supervisory personnel. Any changes in the way the bridge handles should also be reported. Maintenance personnel should be trained to observe the equipment and recognize basic indicators of wear, misalignment, and malfunctioning equipment.

Movable bridges should be thoroughly cleaned prior to any of the required inspections.

Subsection 1.2.5 Bridges Closed to Traffic

If a bridge is closed to traffic, the inspection team shall follow the steps outlined in Part 1, Section 3.3 of this manual.

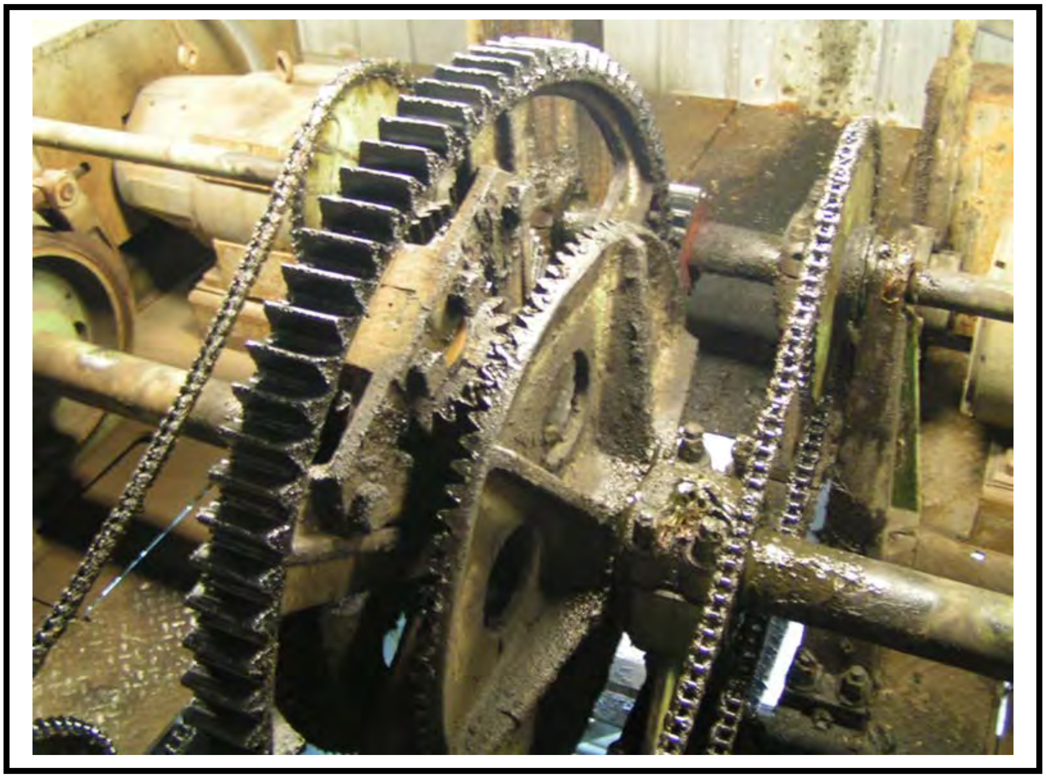

Figure 5:1-1: Movable Bridge Gearing

Figure 5:1-2: Rolling Lift Gears

SECTION 1.3 INSPECTION SAFETY

Nothing is more important during a bridge inspection than the safety of the public, the bridge operating and maintenance staff, and the bridge inspection team. The inspectors need to be alert and aware of the safety issues in the work environment. They should not rely solely upon bridge operating and maintenance staff to create a safe environment. The Inspection Team Leader should take an active role in arranging pedestrian and vehicular traffic control and de-energizing electrical equipment. For basic safety requirements, refer to Part 1, Chapter 4. Potential personnel and public safety hazards are also discussed in Chapter 1.3 of the American Association of State Highway and Transportation Officials (AASHTO) *Movable Bridge Inspection, Evaluation, and Maintenance Manual*.

The traveling public must be prevented from accessing any movable bridge that is not in a stable, closed position. All warning devices must be operating. Ensure that no one can access the moving parts during the inspection.

Figure 5:1-3: Franklin Street Bridge in Partially Open Position

Perform a test opening before beginning the bridge inspection to determine if the movable span is operable and if there are any serious defects which need special consideration, or that would preclude a safe inspection. Such issues should be resolved with the bridge maintenance and design groups if possible.

Following the test lift, the inspection team should:

- Meet with the bridge operation crew to ascertain any scheduled opening times and to establish direct communications with the operating staff.
- Tag and lockout the electrical service to the lift motors. If it is not possible to tag and lockout the electrical service, one member of the inspection crew should remain with the operator and have direct communication with the inspectors working on the bridge to ensure that all inspection crew members are clear of any movable parts prior to initiating a bridge opening.
- Upon completion of the inspection, meet again with the bridge operation crew to inform them that all inspection crew members are in the clear and that bridge operations may resume without interruption. If electrical tags and lockouts have been placed, the person placing the tag and lockout shall remove the tag and lockout and restore the power to the lift motors.

Inspectors must be cognizant of the mechanisms which are intended to move and stabilize the movable span. Do not disconnect any components that would create an unsafe condition. After completion of the inspection, the Inspection Team Leader should check the operating equipment to make certain that it is energized and ready for operation. A test opening should then be made to verify that the bridge condition has not been compromised.

Figure 5:1-4: Movable Bridge Span Accessible From the Bank

The inspector should verify that a panel or device is not powered from a second utility source or standby generator. Under this circumstance, removing power from a single source may be insufficient to de-energize a panel. An inspector should always test the equipment with a voltmeter or similar power detector to determine whether the equipment is safe to inspect.

Give special attention to all rotating or moving machinery. Portions of the inspection will require the inspector to observe the machinery and equipment while in operation. Be very careful not to come into contact with the machinery or let hair or loose clothing be caught in the machinery. Strict notification and communication procedures between the person performing the inspection and the bridge operation staff should be implemented to ensure that inspectors are in the clear when bridge operations are observed.

The inspection of a bridge should not be destructive and the inspector should always take care to seal all panels and equipment properly to prevent later damage. Before attempting to open any panel, the inspector should determine if the panel is warped or damaged. If the equipment is damaged, do not inspect it unless there is a maintenance crew readily available to repair or replace the damaged equipment. Otherwise, the inspector should note in his/her report that the equipment is inaccessible due to damage. Open or cracked panels can expose the bridge wiring to corrosion or damage and expose people to electrical contact. This could lead to permanent injury, disability, or death.

Inspectors should not attempt to repair or modify any bridge equipment. Accurately recording any deficiencies and notifying the appropriate maintenance authority immediately will enable the repairs to be made in a documented and orderly manner.

Inspectors should always use appropriate personal protective equipment while performing the inspection. This includes, at a minimum, the use of a hard hat, safety glasses, safety reflecting vest, appropriate footwear, and clothing that is not loose. Life vests and safety harnesses shall be used when inspecting over the water or areas with a fall hazard, as required by the Occupational Safety and Health Administration (OSHA) and U.S. Coast Guard regulations. Each inspector is responsible for his/her own safety and should take all necessary actions required to minimize risk.

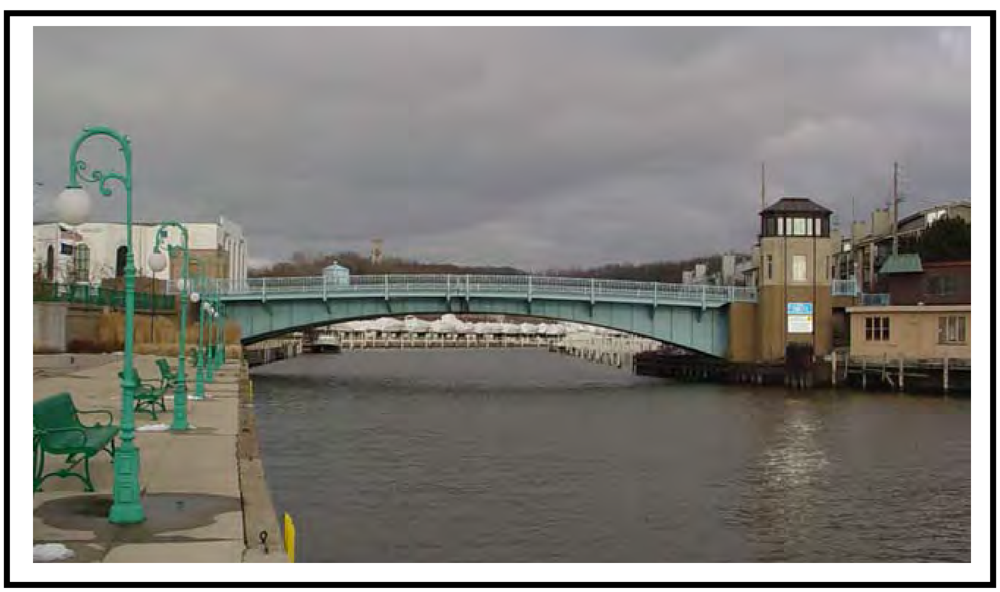

Figure 5:1-5: Franklin Street Bridge

SECTION 1.4 EMERGENCY NOTIFICATION

Structural deficiencies may lead to localized failures or collapse of a bridge. Similarly, mechanical and electrical defects can cause a movable span to become unstable in the closed position, the open position, or both. In Part 1, Chapter 7, procedures are detailed for reporting serious structural defects and the actions to be taken to limit traffic or temporarily close the bridge.

The lead inspector must immediately report any defects of the span drive or stabilizing machinery that would render the operation of the bridge unsafe or leave the bridge in an unsafe condition for motor traffic or pedestrian use. If necessary, the lead inspector shall take all such actions as is necessary to prevent the operation of the bridge until emergency repairs are made. Such defects include cracked or damaged drive gears and pinion shafts, loose or missing keys, improperly operating tail locks, and improper balance. A movable span may be unstable in any position due to defects in the span drive or stabilizing machinery. Much depends on the type of bridge and the redundancy of the overall system. Because of the variations in movable bridge design, the lead inspector must rely on his/her experience when assessing the suitability of the bridge for continued operation.

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CHAPTER 2 BASCULE BRIDGES

SECTION 2.1 INTRODUCTION

Bascule bridges are modern versions of the medieval draw bridge. These medieval draw bridges had no counterweights so their size and utility was limited. Modern bascule bridge design can be traced to about 1893 with the construction of the Van Buren Street Bridge in Chicago, a rolling lift bascule, and the Tower Bridge in London, a roller-bearing trunnion bascule.

Bascules are often selected for narrow to moderately wide channels where unlimited vertical clearance is required for navigation. They have been built in many configurations. Usually, a bascule leaf is comprised of two longitudinal bascule girders, or trusses, which support the roadway deck framing. A wide leaf may be supported by multiple girders.

A bascule leaf is usually nominally balanced by a counterweight, which is fixed to the girders and located below the roadway. Counterweights reduce the size of the mechanical systems required to operate the bridge and provide an increased margin of safety in the event that a control system failure leads to a runaway condition.

Bascule bridges can be constructed with one or two leaves spanning the channel. Indiana’s three highway bridges all have two leaves. A bridge with two leaves is called a double-leaf bascule. The two leaves usually meet at the center of the navigation channel. A span drive and stabilizing machinery is required for the moving of each leaf. A shear transfer device is provided between the leaves of the bridge to allow both leaves to share live load.

On a deck bascule bridge, the deck is located above the girders or trusses. Indiana’s bridges are all deck bascules.

All movable spans utilize a combination of rotation and translation. Rolling lift bridges utilize rotation about a horizontal axis with simultaneous translation. Indiana’s three highway bridges were all designed using the concepts in patents granted to William and Albert Scherzer starting in 1893. The Franklin Street Rolling Lift Bridge in LaPorte County, a double-leaf rolling lift bridge, is shown in Figure 5:2-1 below.

Figure 5:2-1: Franklin Street Rolling Lift Bridge

Figure 5:2-2: Rolling Lift Bridge Teeth

SECTION 2.2 ROLLING LIFT BASCULES – SCHERZER-TYPE

Scherzer-type bascules are characterized by cylindrically curved parts of the bascule girders or trusses at the ends over the bascule piers. Because of their large size, the girders or trusses of the early Scherzer bridges were assembled from segments and the girders were called segmental girders. Each segmental girder may be viewed as a segment of a wheel, rigidly attached to the bascule leaf. As the wheels roll along the tracks, the bascule leaf rotates to open or close the bridge.

Figure 5:2-3 depicts this movement for a double-rolling leaf deck type Scherzer bascule. As the curved ends of the girders roll away from the channel, the leaf tilts open to clear the channel. Slippage between the segmental girder treads and the tracks on which they ride is prevented by lugs or teeth that mechanically engage sockets. Typically, the protruding lugs are located on the track and the receiving holes or notches are in the segmental girder treads. Treads and tracks are described in more detail in Part 5, Chapter 3, Section 3.3. The rack is shown located above the pinion, as is common on many newer Scherzers, and is found on all of Indiana's rolling lift bridges. The tracks on which the bascule leaf rolls may be mounted directly on the substructures, as is the case for the Indiana movable bridges, or they may be mounted on flanking spans. Span locks (also called center locks) are required to transfer vertical shear between the two leaves of a double-leaf bridge and to assure proper lateral and vertical alignment. Span locks are discussed in Part 5, Chapter 3, Section 3.3.

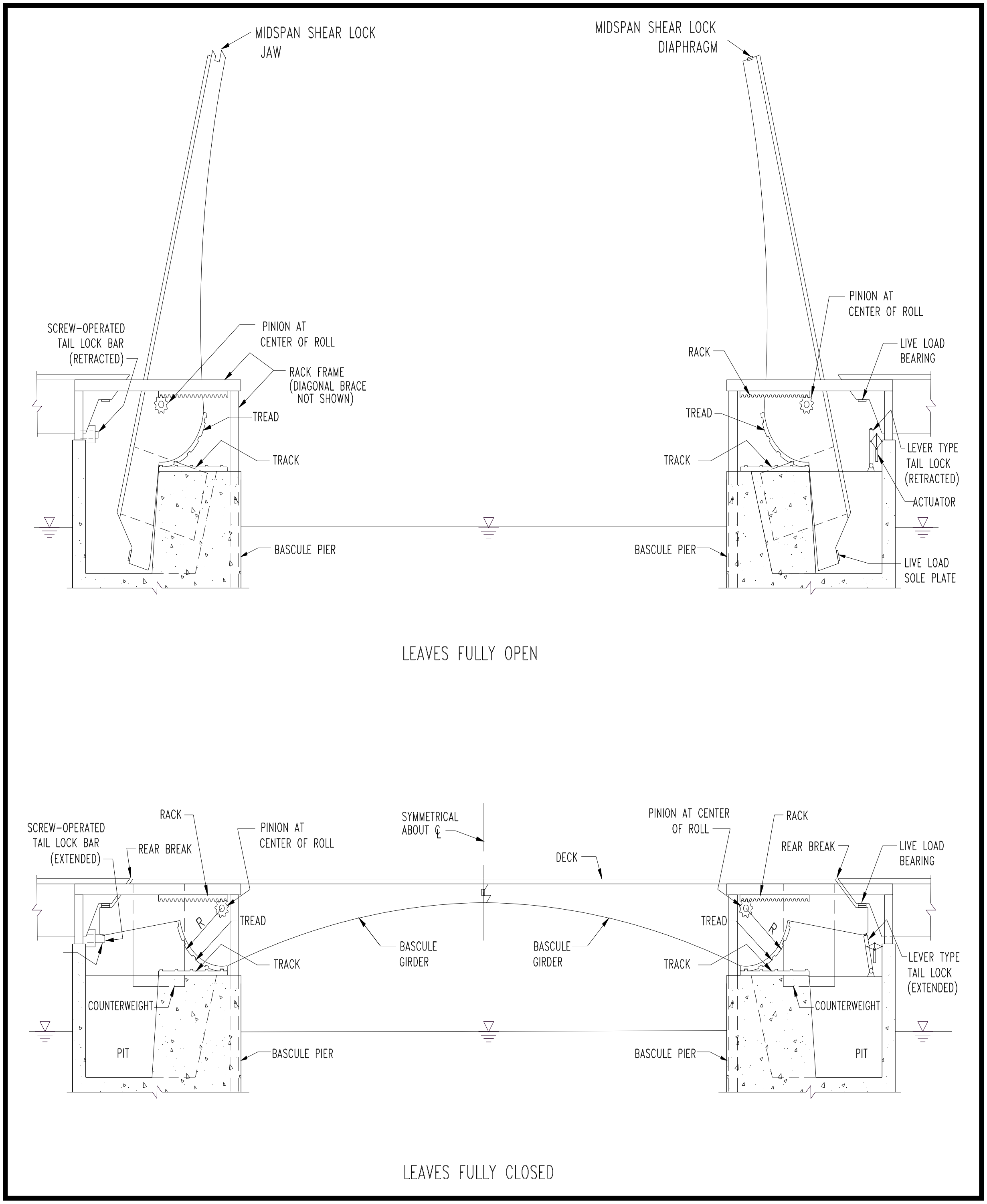

Figure 5:2-3: Motion of Rolling Lift Bridge

SECTION 2.3 BRIDGE WATERWAY PROTECTION

As with all bridges over navigable waters, the movable bridge structure must be protected from water traffic. The movable bridge piers are protected with a combination of protection cells, typically referred to as dolphins, and fenders. The protection cells are located immediately outside of the navigable channel and protect the bridge from direct hits by vessels. Along the face of the bridge piers, fenders are typically installed. The fenders protect the bridge from vessels as they pass through the bridge draw.

Navigation lights are provided on the movable leaf. These indicated whether the bridge is open or closed. The protection cells will also have lights installed to delineate the limits of the navigable channel. Properly operating navigation lights are critical to the safety of the water traffic.

The protection systems must be inspected as part of a Moveable Bridge Inspection.

Figure 5:2-4: Dickey Road Pier Protection Cell

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CHAPTER 3 FUNCTIONAL SYSTEMS

SECTION 3.1 INTRODUCTION

The functional systems of a movable bridge are classified as span drive machinery and span-stabilizing machinery. Span drives are the machinery needed to move the span. They also serve to stabilize the span when it is not in the fully closed position. Span drive machinery varies little with movable bridge types because the objective is the same: to convert the low-torque rotation of a motor (electric or hydraulic) to the high-torque or force required to move the span. In electro-mechanical drives and hydraulic drives, gearing is used to convert the low-torque, high-speed rotation of the motor to high-torque, low-speed rotation required to move the span.

Stabilizing machinery consists of the electro-mechanical and hydraulic components that support and restrain the span when it is in motion and when it is at rest. Some stabilizing components may be used to decelerate the span under certain conditions, but they do not accelerate the span.

This chapter describes the span drive and stabilizing machinery arrangements utilized on Indiana’s rolling lift bascule bridges.

SECTION 3.2 SPAN DRIVE MACHINERY

The span drive is the combination of electrical or hydraulic motors and mechanical components used to open and close a movable bridge. This can be accomplished in many ways. In this section, we describe the electro-mechanical or hydraulic-mechanical drives found on the Indiana rolling lift bascule bridges.

Subsection 3.2.1 Type 1 Span Drives

Span drives in which the motor outputs are connected mechanically to the drive gear are denoted as Type 1 Span Drives. Indiana's Franklin Street Bridge span drive is designated as a Type 1 Active Differential (AD) span drive and is described in greater detail below. In all Type 1 arrangements, a motor is connected directly to the primary speed reduction gearing, usually through a shaft with a slip clutch to prevent damage to the gearing. On this bridge, all gearing is fully open. Power from the motor is distributed from the primary reduction gearing to two or more sets of secondary reduction gearing located at the sides or ends of the movable span. Through a series of progressively fewer gear teeth, the mechanical leverage is provided to move the span. The point of interface between the drive gears and the bridge is at the rack which is mounted to the bridge girder.

An active differential span drive is designated as Type 1 AD. On the Franklin Street Bridge, the motor drives a main gear from which planetary gears are driven. The arrangement is similar to that of the rear axle differential of a car. The arrangement of the planetary gears around the main drive gear from the motor permits the output shafts to rotate at slightly different speeds, but transmit equal torques. The active differential is located at the center of the machinery room of the Franklin Street Bridge. The active differential is shown on Figure 5:3-2.

Each side of the active differential has a drive shaft that extends to the gear train on each half of the bridge leaf. The shaft drives are attached to a large gear, which in turn drives a smaller gear with fewer teeth, which in turn drives another large gear, which in turn drives a smaller gear with fewer teeth than the first small gear, etc. This is the gear that engages the rack and provides the torque to raise and lower the bridge. Figure 5:3-1 illustrates the general arrangement of a Type 1 span drive system.

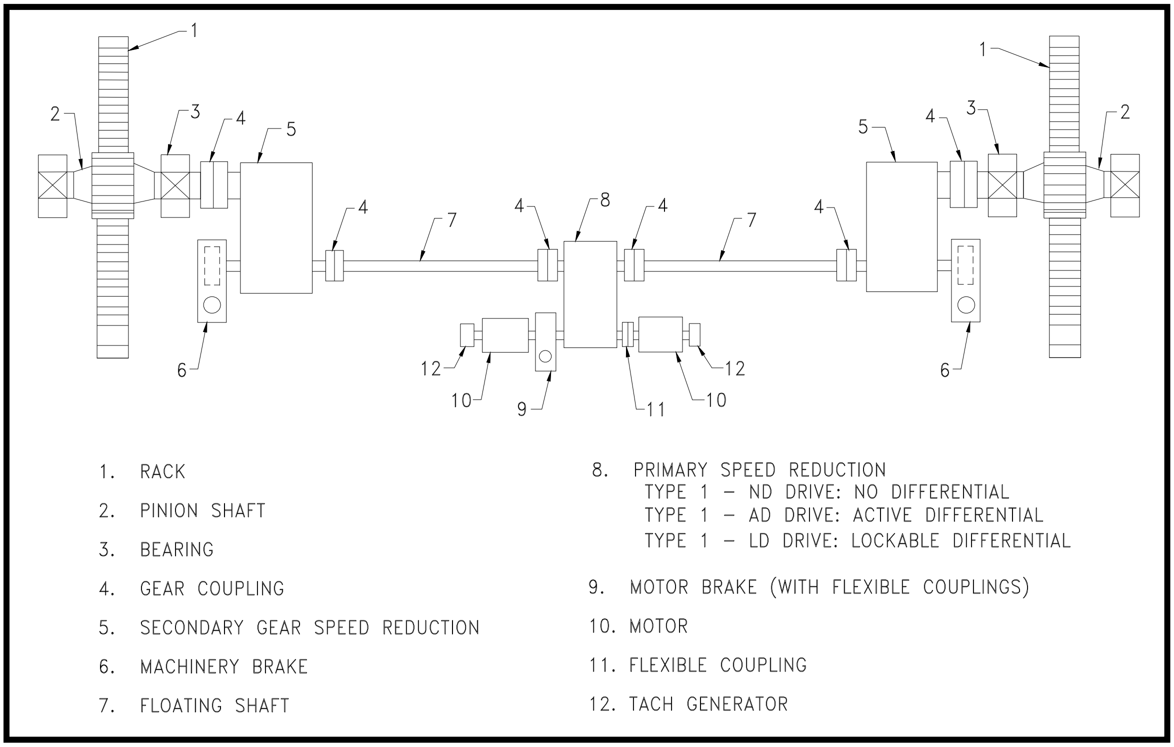

Figure 5:3-1: Type 1 Span Drive With Two Low-Speed, High-Torque Final Outputs

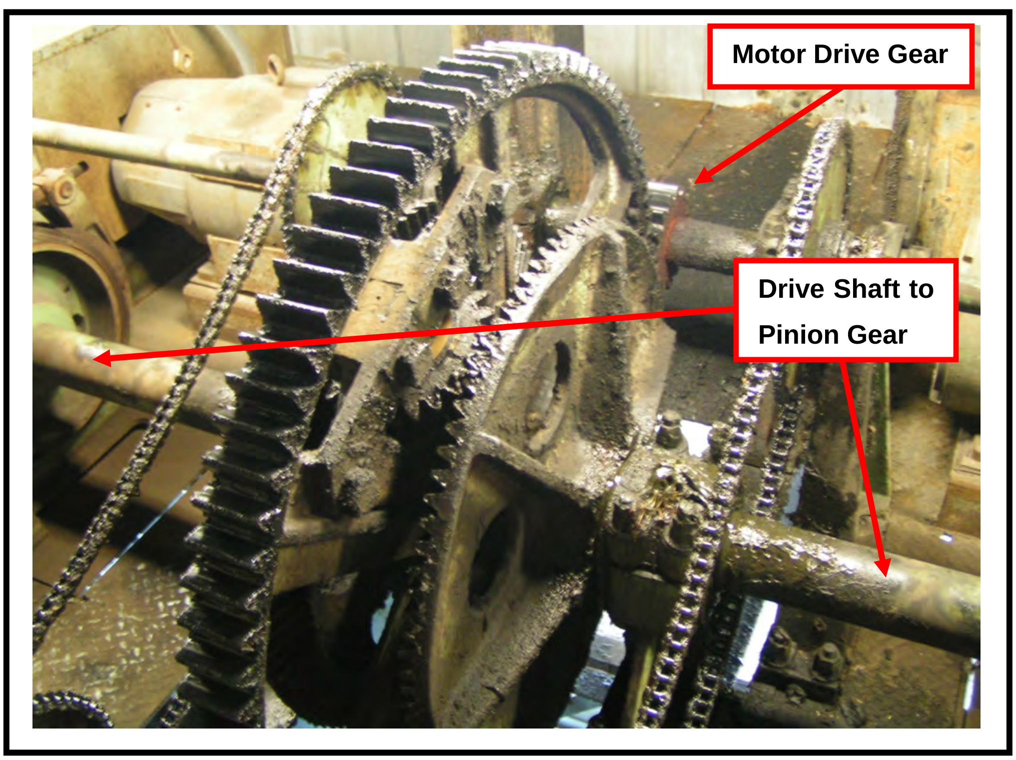

Figure 5:3-2: Type 1-AD Span Drive

Subsection 3.2.2 Type 2 Span Drives

When each drive pinion gear is separately powered on a bascule bridge, the span drive is called Type 2. The Indianapolis Boulevard and Dickey Place rolling lift bascule bridges have Type 2 span drives. In the case of these bridges, hydraulic motors are directly connected to the various gears that drive each half of the leaf. The motors are connected to a small gear, which in turn drives a large gear, which drives a small gear, etc. With each transfer there are fewer teeth on the gears. This creates the mechanical leverage needed to move the bridge. The Indianapolis Boulevard and Dickey Place bridges also have a shaft that connects the two gear trains. This shaft is used to apply braking forces to control the up and down speed of the bridge. Figure 5:3-3 illustrates the general arrangement of a Type 2 span drive system. Figures 5:3-4, 5:3-5, and 5:3-6 illustrate the motor, gearing, and brakes used on these bridges. Also illustrated is the hydraulic pump used to drive the hydraulic motors.

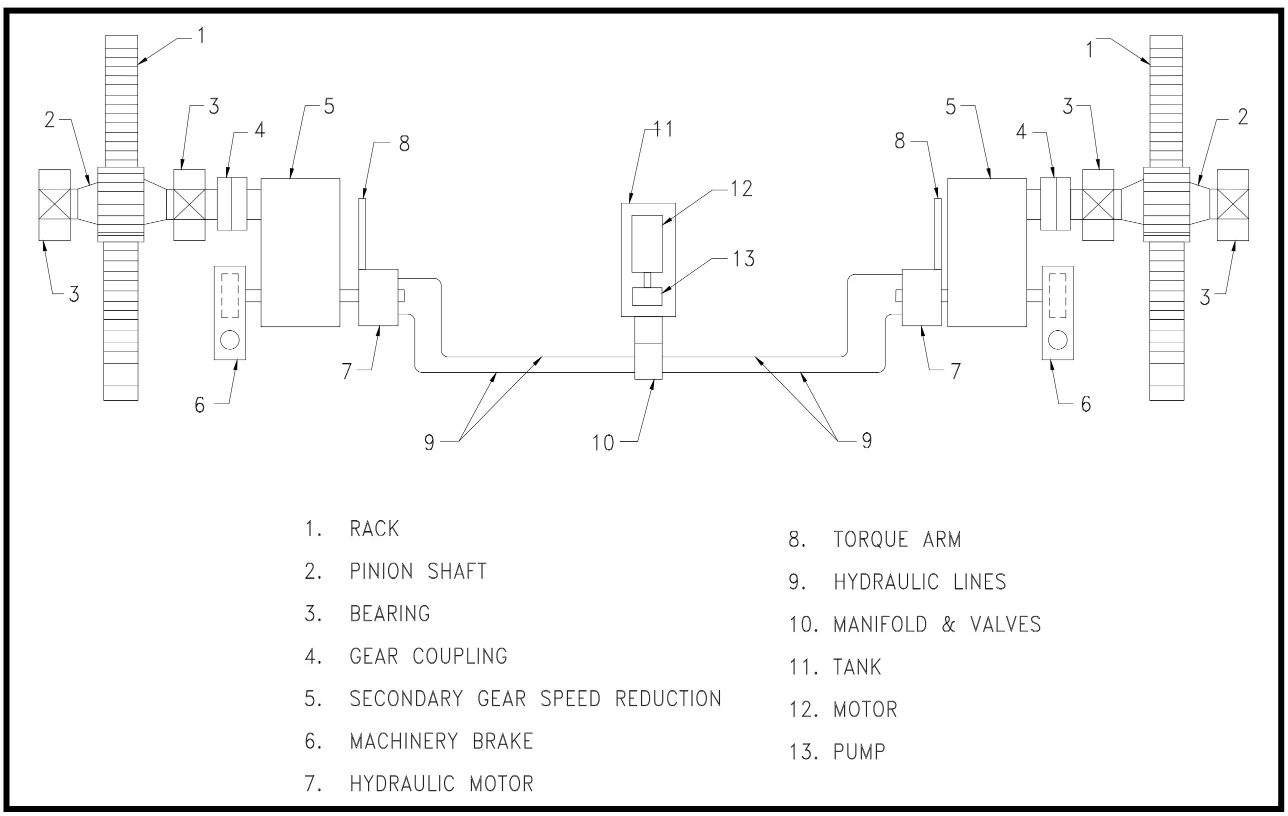

Figure 5:3-3: Type 2 Span Drive

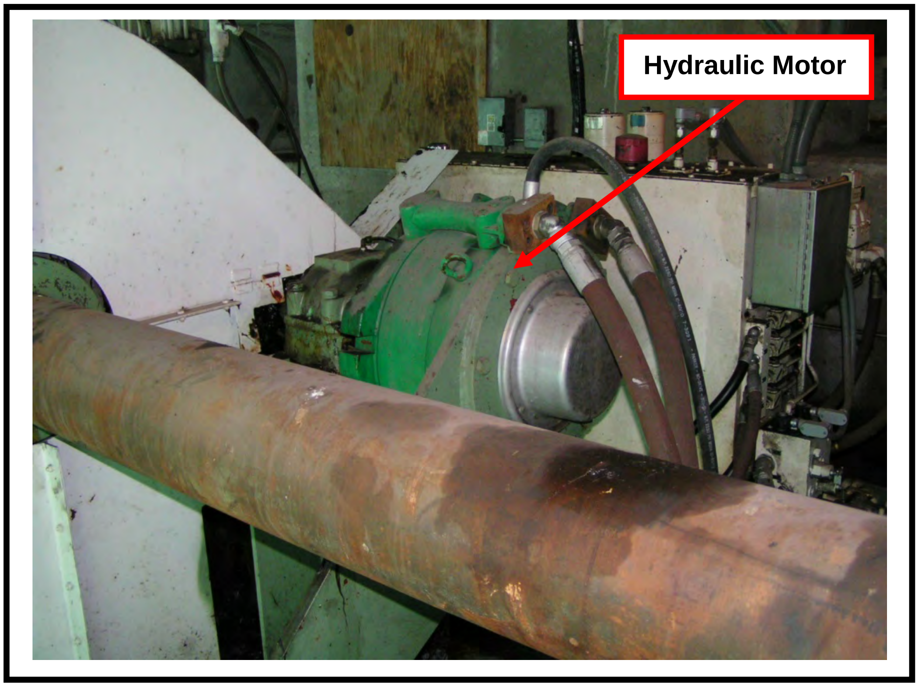

Figure 5:3-4: Hydraulic Drive Motor

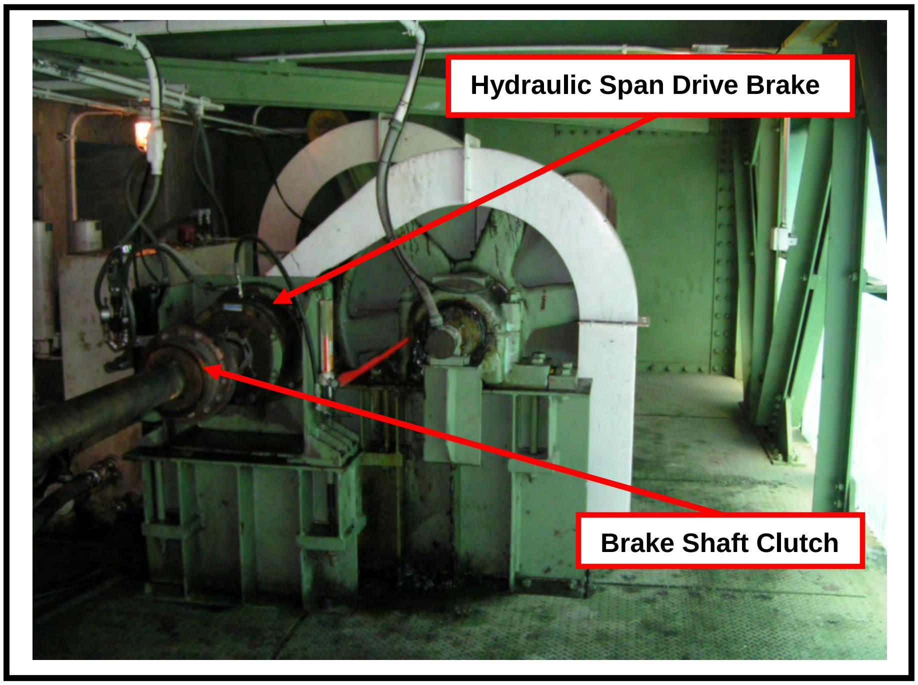

Figure 5:3-5: General Gearing Arrangement With Brake

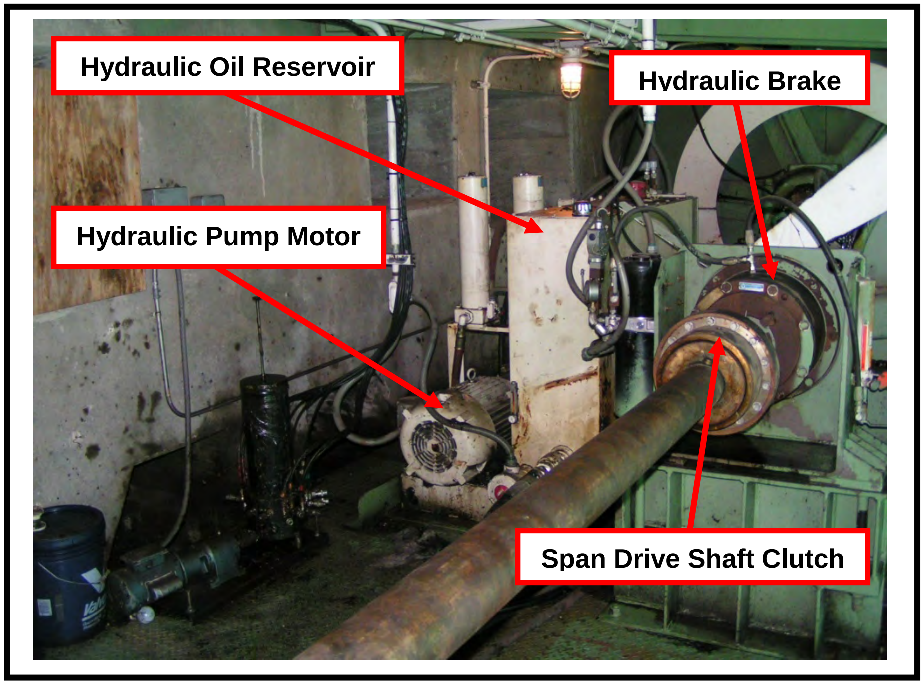

Figure 5:3-6: Hydraulic Pump, Reservoir, and Span Drive Brake

SECTION 3.3 STABILIZING MACHINERY

Stabilizing machinery supports the span when it is in motion and at rest. The machinery components and assemblies are usually mechanical, but fluid power (air and liquid) components are also utilized. Stabilizing components on rolling lift bascule bridges include treads mounted on segmental girders, tracks, live load bearings, tail locks, mid-span locks, centering devices, and buffers. Components found on Indiana rolling lift bridges are explained below. Additional details are discussed in Chapter 4, Electrical Systems, and Chapter 5, Mechanical Systems. Stabilizing machinery includes the following:

- **Tracks and Treads:** Each rolling lift bridge segmental girder rolls on a track which has upward projecting lugs equivalent to gear teeth. The lugs are usually rectangular protrusions of the steel casting, spaced from about 10 to 25 inches apart, depending on the radius of roll. Lugs are staggered in two lines along the edges of the track. Figure 5:3-7 depicts the lugs on the edges of a track of a rolling lift bridge. The gear segments are then bolted to the sides of the tread. The tracks and treads guide the segmental girder as it rolls forward and backward, closing and opening respectively.

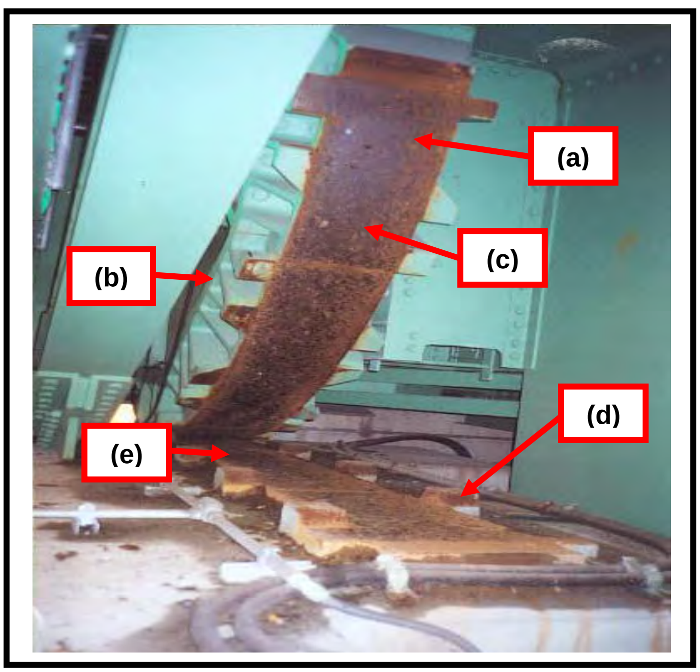

Figure 5:3-7: Segmental Girder and Track

(a) Tread
(b) Socket
(c) Joint Between Segmental Tread Castings
(d) Track
(e) Lug

- **Live Load Bearings:** The live load bearing supports the live load, a positive dead load from a desired span heavy imbalance, and the force due to residual torque in the span drive machinery. The live load bearings are found at the tail of the movable span and engage the roadway overhead. The live load bearings prevent the rolling lift span from literally "falling into" the draw. The live load bearings prevent excess force in the gear train from the vehicular loads on the bridge. When properly adjusted, the live load bearings should be nearly touching the reaction bearing of the overhead roadway.

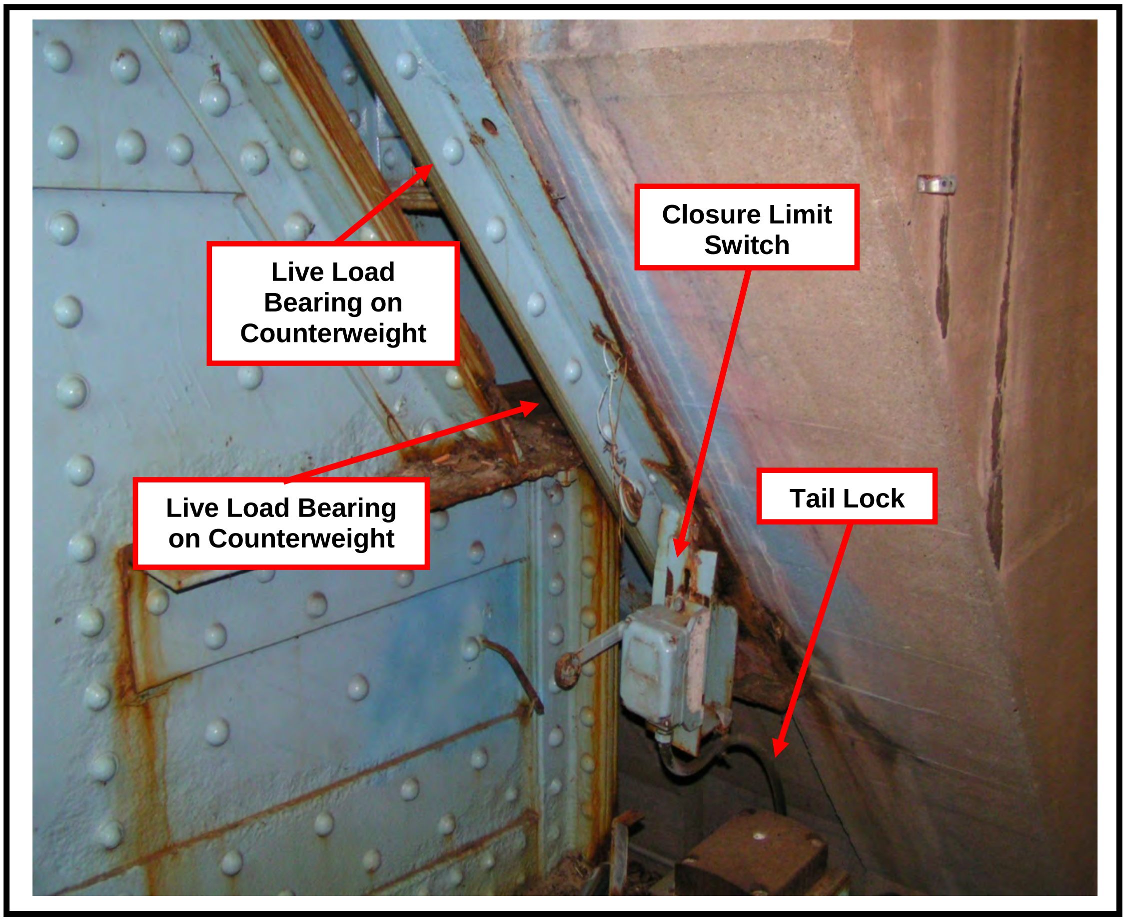

Figure 5:3-8: Live Load Bearing at Rear of Counterweight

- **Span or Shear Lock (also called Center Lock):** This lock is intended to maintain the toes of both leaves at the mid-span of the bridge, at the same elevation, and in proper lateral alignment when the bridge is in the closed position and subjected to live load. In order to accomplish this, the shear lock must transfer live load shear between the leaves. All Indiana rolling lift bridges employ a jaw-type lock. As the bridge closes, the jaw, shown in Figure 5:3-9, enters between the diaphragm side plates and the diaphragm casting is engaged between the upper and lower jaws. With time, the top and bottom edges of the sliding surfaces of the jaw strike plates wear. The rate of wear depends on the number of bridge openings and the amount of traffic passing over the bridge. Shims are provided under the jaw plates in order to permit adjustment. Figure 5:3-11 is a detailed drawing of the mid-span lock parts shown in Figure 5:3-9 and Figure 5:3-10. In order to inspect the mid-span shear locks, the bridge must be in the partially open position. Special care is needed to be able to access the locks for full inspection.

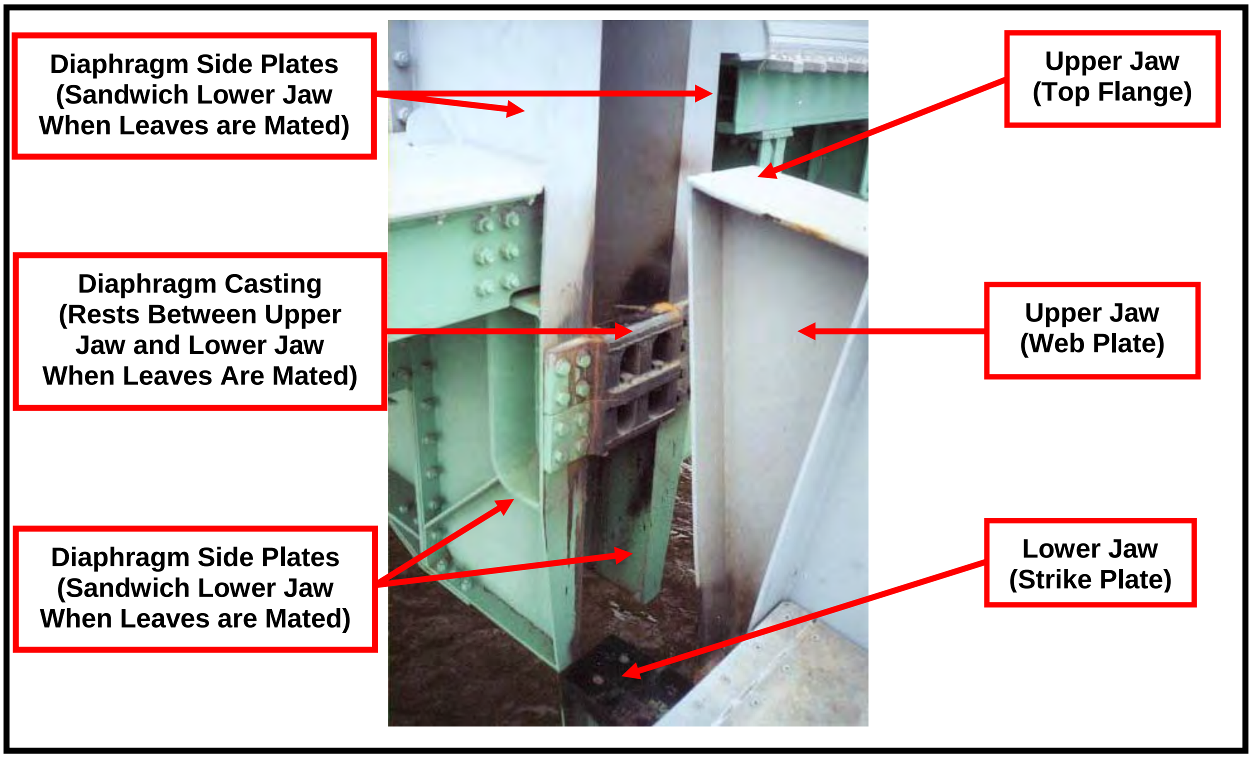

Figure 5:3-9: Span Lock

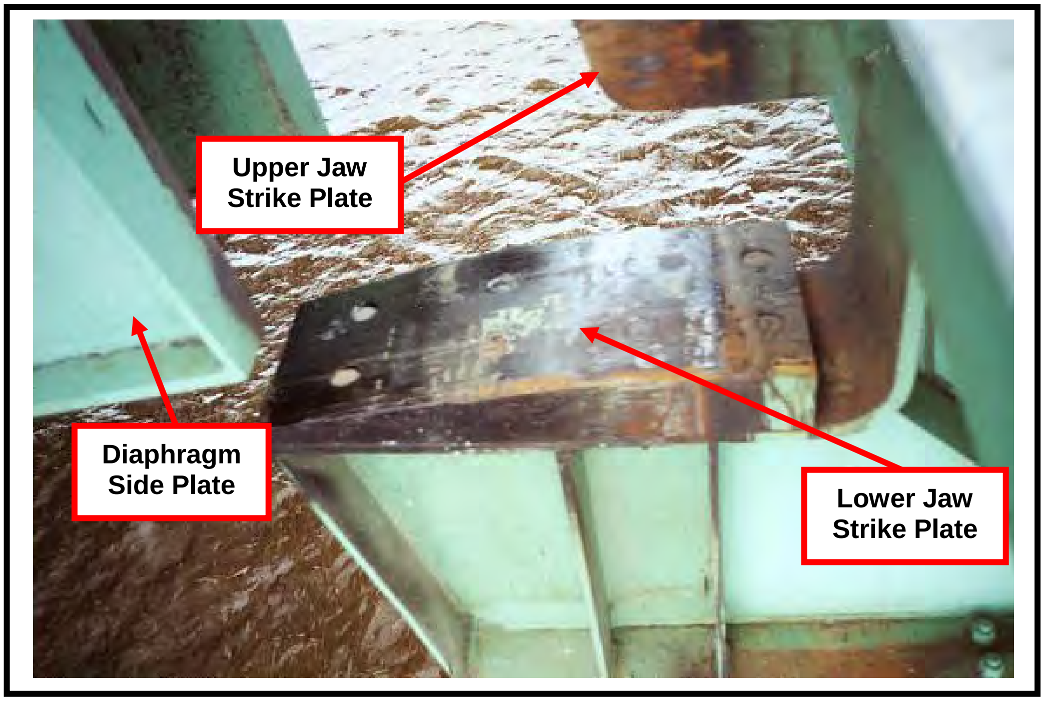

Figure 5:3-10: Span Lock Jaw

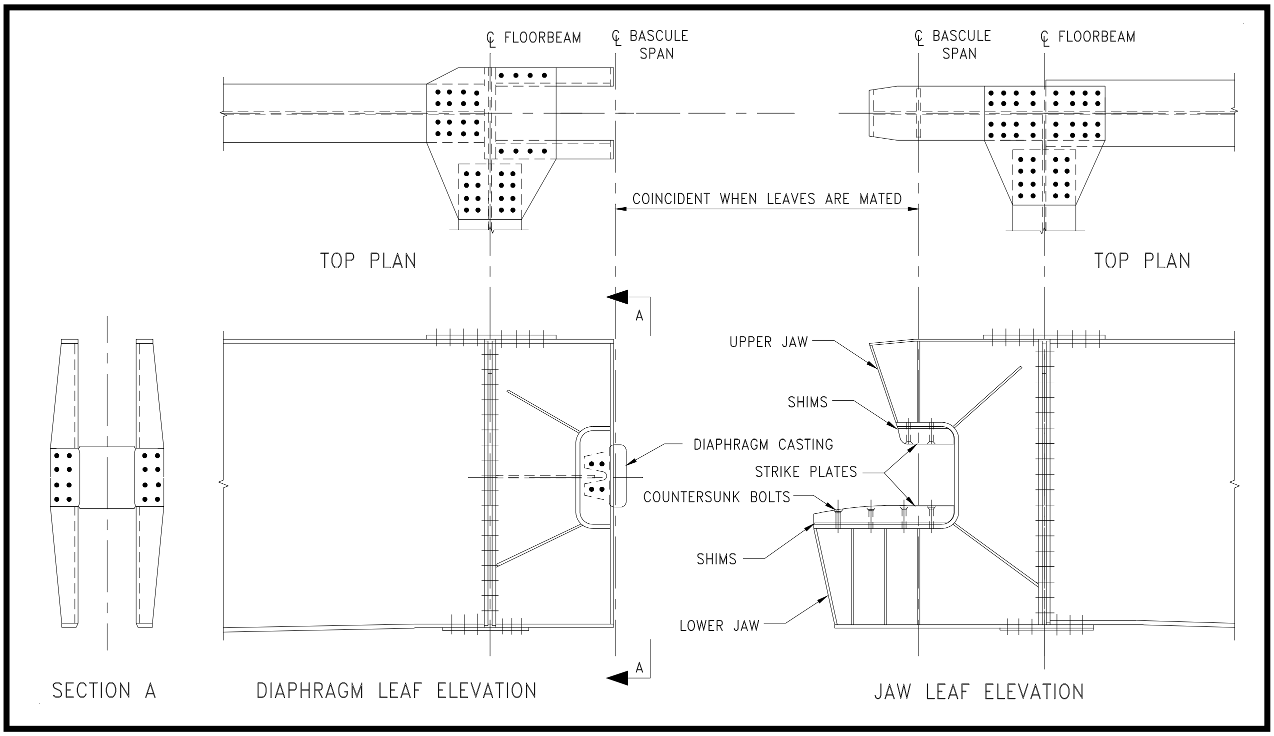

Figure 5:3-11: Detail of Mid-Span Shear Lock

- **Tail Locks:** Tail locks provide for the upward reaction that occurs when the live load is located between the center-of-roll and the rear floor break. The tail lock must be retractable to accommodate the motion of the leaf. All Indiana rolling bascules have tail locks, although they do not appear to be used at the present time.

  Indiana bridges use a retractable lock bar for the tail lock. The tail lock is mechanically withdrawn prior to the start of the opening sequence of the bridge. It is mechanically inserted under the counterweight at the end of the closing sequence of the bridge. Tail locks reduce wear on the gears of the movable bridge by preventing movement of the leaf under live loads.

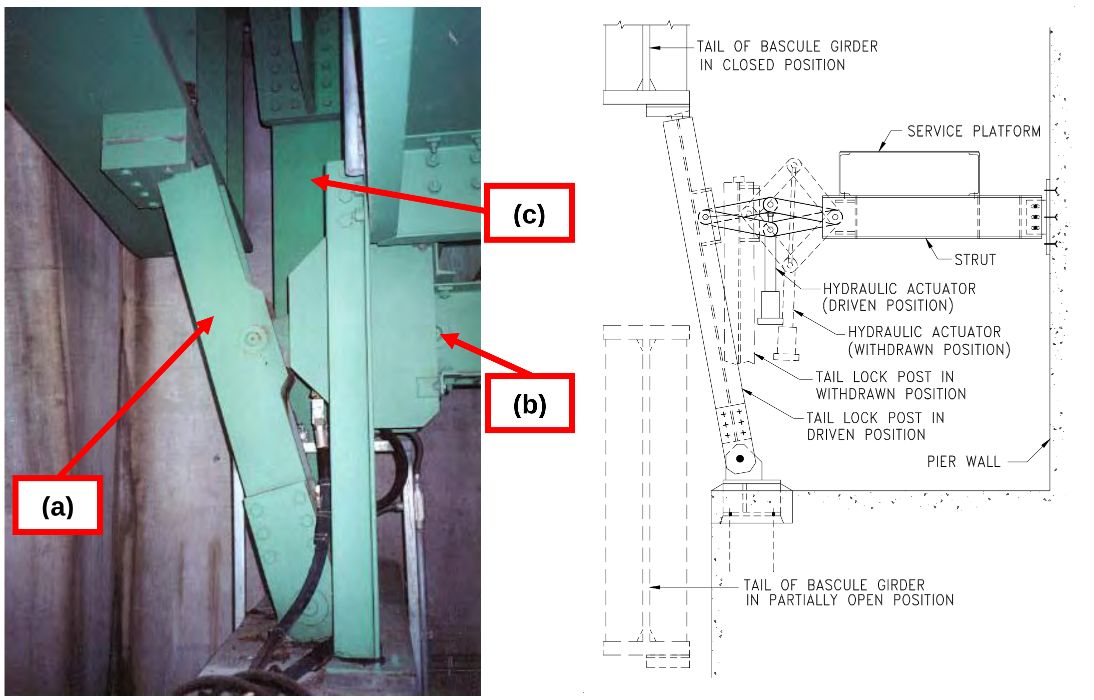

Figure 5:3-12: Lever Tail Lock

(a) Tail Lock Post in Driven Position
(b) Actuator (Hidden by Enclosure)
(c) Live Load (Uplift)
Anchor (right)

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CHAPTER 4 ELECTRICAL SYSTEMS

SECTION 4.1 INTRODUCTION

All Indiana rolling lift bascules have relatively modern electrical equipment. These electrical systems are also in generally good condition, although some functionality has been lost, including the tail locks which are no longer operating.

A typical electrical system for a movable bridge includes four major groups of equipment:

- Power Distribution Equipment
- Electrical Machinery
- Control System
- Lighting Systems

Conduits, flexible cables, junction boxes, electrical cabinets, and other components common to electrical systems are found on these bridges. An indispensible tool for the inspection of the bridge electrical system is the wiring or circuit diagram. These diagrams allow the inspector to determine the function of various components and what circuits control which functions. Common electrical systems and the tools unique to these inspections are discussed in this chapter.

SECTION 4.2 INSPECTION TOOLS AND INSTRUMENTS

Tools that are necessary for an electrical inspection include a megohmmeter, a voltmeter, a live power indicator, an ammeter, a thermometer, and a receptacle tester. The megohmmeter is a cable voltage insulation tester used to inspect bridge wiring, cables, and specialty cables. A voltmeter can be used to check the voltage on equipment and help verify equipment is de-energized. An ammeter can be used to verify the current and direction of phasing to motors, and verify desk indicators.

The inspector should note all equipment on the bridge and the state of the equipment. Each piece of equipment should have a unique identifier. This name should be used to track the status of the equipment from inspection to inspection.

An Electrical Inspection should be done in accordance with the recommendations listed in this manual, the American Association of State Highway and Transportation Officials (AASHTO) *Movable Bridge Inspection, Evaluation, and Maintenance Manual* and the National Electric Code (NEC). Part 5 of the Indiana *Bridge Inspection Manual* is intended to augment the inspector's prior knowledge of the NEC by providing bridge-specific equipment information.

SECTION 4.3 POWER DISTRIBUTION EQUIPMENT

The power distribution equipment consists of electric power sources, protective devices, and distribution equipment.

The primary power source for movable bridges is a three-phase electric service from a local utility company. The typical three-phase electric service voltage used on the Indiana rolling lift bridges is a 277/480-volt, four-wire system.

The electric service from the utility company is delivered from pole-mounted or pad-mounted transformers typically owned and maintained by the utility. Feeders from the transformers extend to the service disconnect. The service disconnect is a circuit breaker or fused switch, owned and maintained by the bridge owner, which provides overload and short-circuit protection of the bridge electrical system. A utility energy consumption meter is located in the vicinity of the service disconnect or at the utility transformers.

A movable bridge electrical system may be provided with a secondary source of electric power should the primary electric source fail. To provide this redundancy in electric supply, a second electric service derived from a utility source independent of the primary electric service may be provided. The second electric service will be furnished with its own service disconnect and utility meter.

Electric power is supplied to the various motors and electrical equipment through protective devices, namely fuses and circuit breakers. Fuses and circuit breakers provide overload and short circuit protection to the electrical equipment they serve. These protective devices are typically housed in panel boards, motor control centers, and/or enclosed panels. Typically, fuses are cylindrical devices that prevent fault currents by melting and preventing any current flow. They are single use items and must be replaced when they have been used. Circuit breakers are used to protect the electrical equipment from a fault condition. Circuit breakers have elements that sense the current and are set to open the breaker if a certain limit is reached. Once tripped, the circuit breaker can be reset and used again.

A panel board contains a group of circuit breakers to distribute power to various electrical devices. Motor control centers house circuit breakers, fuses, motor starters, motor controllers, and other equipment required to control and distribute power to motors and other equipment. Motor control centers are modular in construction. In lieu of panel boards and motor control centers, circuit breakers, fuses, motor starters, motor controllers, and other motor control equipment may be installed on an enclosed, custom-built panel.

Transformers are commonly installed on movable bridges. Transformers convert voltage from one level to another, usually to serve lighting loads or to isolate electrical noise in the electrical system.

Electrical circuits are carried from panel boards, motor control centers, enclosed panels, and transformers to the electrical devices they supply power to through a raceway system. A raceway system typically consists of rigid, metal conduit and junction boxes. Electrical wires, or conductors, carry electrical current and are installed inside the conduit and boxes that make up the raceway system.

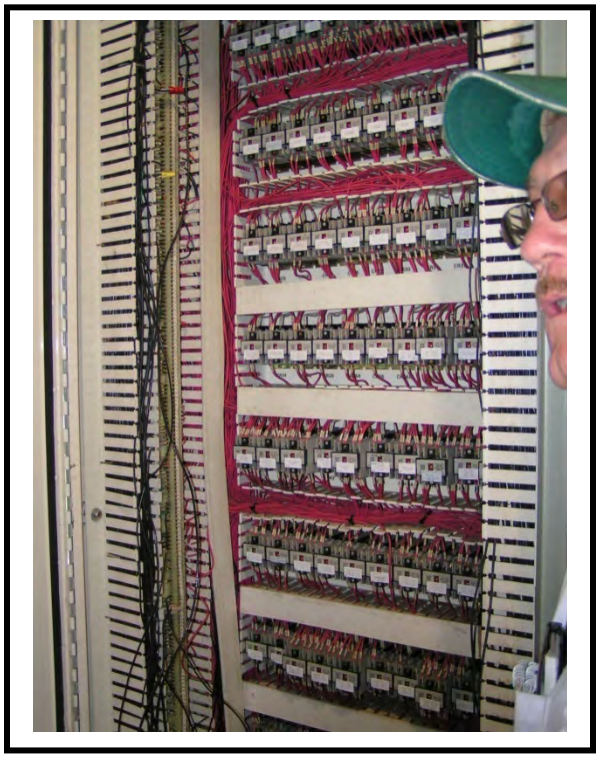

Figure 5:4-1: Dickey Road Panel Board

SECTION 4.4 ELECTRICAL MACHINERY

Electrical machinery refers to electro-mechanical devices that operate the movable span and auxiliary devices such as locks and traffic control equipment. For the Indiana rolling lift bridges, the electrical systems are designed with interlocks that prevent bridge operation without completing a pre-programmed sequence of operation. This fact must be kept in mind when inspecting the electrical systems for these bridges.

Subsection 4.4.1 Span Motors

The movable span is provided with one or more span motors that serve either as the prime mover for the span or provide the power to operate hydraulic pumps that are used to move the span. Span motors are the alternating current (AC) type on all Indiana bridges. Depending on the type of motor control equipment employed, the operating speed of the span motors is governed by the bridge operator or by a motor controller. A motor controller provides controlled motor speed and torque to ensure smooth movement of the movable span. The span motor and motor controller combination is commonly referred to as the electrical part of a span drive.

In an electro-mechanical drive system, the movable span is provided with electrically actuated span brakes to stop and hold the movable span. With modern motor controllers, the majority of braking during operation is accomplished by the span motor and motor controller. Thus, span brakes are typically utilized for holding the movable span and stopping it during emergency conditions.

Subsection 4.4.2 Auxiliary Motors

Some movable spans are equipped with a back-up motor for operation in the event the span motors fail or are out-of-service. These motors, called auxiliary motors, are generally smaller motors that take longer to open or close the span because of additional speed reduction gearing. The motor controller for an auxiliary motor is typically an across-the-line contactor.

The auxiliary motor will either be directly coupled to the main span machinery, or separated by a clutch. The auxiliary motor will either be selected by the operator at the control desk, or operated locally. The clutch, if present, will then be operated manually or electrically to connect the auxiliary motor.

Subsection 4.4.3 Locks

Locks are described in detail in Chapter 3, Section 3.3, Stabilizing Machinery. The electrical equipment is similar in each type, consisting of a motor directly coupled to the machinery and a series of limit switches to monitor the machinery. The motor controllers for locks are typically across-the-line contactors.

Subsection 4.4.4 Warning Gates and Barrier Gates

Traffic signals, lights, and gates are used to warn approaching cars and pedestrians and to provide physical protection, when required. Traffic signals, or red flashing lights, are used to initially stop the traffic. Once the traffic has come to a complete stop, the warning gates are lowered to indicate that no vehicles may enter. Gates are usually equipped with flashing lights.

Subsection 4.4.5 Gongs, Horns, Bells, or Sirens

Gongs, horns, bells, or sirens are used to alert traffic to changing conditions. They are sounded at the beginning and end of any bridge operation and used in tandem with flashing lights and warning signs.

SECTION 4.5 CONTROL SYSTEMS

The control desk is where the bridge operator controls the operation of the bridge and its associated equipment. There are push buttons, control switches, indicating lights, meters, and indicators on the desk, and often a foot pedal switch mounted on the floor at the control desk. Mirrors, cameras, and binoculars are used to help the operator see motor, pedestrian, and water traffic.

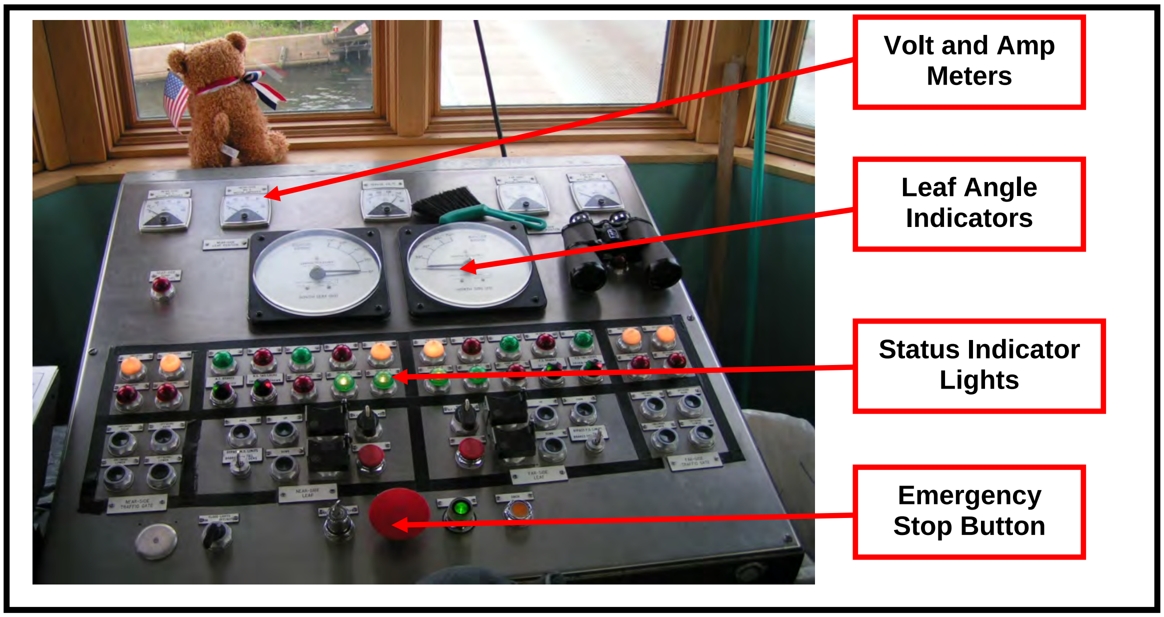

Figure 5:4-2: Franklin Avenue Control Desk

There are many types of motor controllers, ranging from simple contactors to motor drives. The equipment may be installed in a panel or motor control center.

A standard motor controller consists of a motor protector, a contactor, and a motor overload device. A motor circuit protector is either a circuit breaker or a fuse that has a trip setting to protect the motor controller and motor. Contactors are devices that make or break current to the motor. When the motor is connected to the current, it will operate, and when the current is removed, it will stop. Contactors can operate the motor in a single direction, or forward and reverse directions. An overload device is a sensitive, quick-acting device that will sense when the motor is drawing too much current and open the contactor to stop the motor. Motor overloads are intended to be faster in reacting to a motor fault than a circuit breaker or fuse, and more sensitive to minor faults that would not trip a circuit breaker.

Many specialty controllers, called motor drives, provide the same functions listed above, as well as speed, torque, and/or counter torque control of the motor. Motor drives use circuit boards and capacitors to generate a specific current amplitude and/or frequency to control the motor.

Limit switches provide an electrical signal to stop or change operation. There are several types of limit switches: lever arm, plunger-type, rotary, and proximity.

Relays are low-current switching devices that provide logical control of a bridge. They can be used independently or with a programmable logic controller (PLC). In order to provide control for an entire bridge, multiple relays are required. They are generally located in a panel or enclosure. When relays are used with a PLC, they are generally interposing relays. These relays are located between the PLC outputs and the equipment being controlled and serve as a means of isolation. Relays are also used as part of auxiliary systems, such as traffic gates, or control of local equipment.

Machine relays are larger relays that can be repaired and modified for various logical configurations. They are bolted to panel back plates and the terminals of the relay accept wire. “Ice cube”-style, plug-in relays are smaller relays covered with a clear plastic cover. They cannot be modified or repaired and must be replaced when damaged. They are plugged into a mounting strip and wires to the electrical equipment are terminated on the mounting strip.

Check all contact surfaces for signs of pitting or flashing. Contacts should not make any sounds.

PLCs are computers that provide the logical control of the bridge. They are generally rack-mounted in cabinets in the control room. There may be multiple PLCs in the cabinet and multiple input/output (I/O) cards in the rack. There may be multiple remote I/O drops. A remote I/O drop will consist of I/O cards and communication cards rack-mounted in a panel. PLCs processors can use communication networks to transmit information from a remote drop to the main processors.

The PLC generates electrical control signals through the PLC output cards. These output signals interface with the motor electrical controllers and equipment to control bridge equipment. PLC input cards supply the PLCs with information on the state of the equipment and provide the necessary interlocks for the processors to start and stop the bridge equipment.

Figure 5:4-3: Control Relay Labeling on Dickey Road Panel Board

SECTION 4.6 LIGHTING SYSTEMS

Service lighting and receptacles are provided throughout the bridge to enable work and inspection in dark areas or at night. Check that receptacles exposed to the elements are provided with covers and have ground fault circuit interrupters (GFCIs) as part of the outlet.

Navigation lighting and signals are provided to guide and alert the channel water traffic. Red lights mounted on the piers or fenders mark the channel for the boats. Alternating red and green lights mounted on the span notify the boat operator of the status of the bridge opening. When the light is red, the span is not fully open. When the light is green, the span is fully open. Navigation lights are installed in accordance with U.S. Coast Guard standards and guidelines. Proper maintenance of these lights is essential for the safety of the waterway traffic.

An air horn or similar audible device is used to warn the water traffic that a bridge operation is about to start.

SECTION 4.7 INSPECTION OF POWER DISTRIBUTION EQUIPMENT

Inspection of the electrical service should include the following:

- Locate all points of electrical service. Some bridges may have separate points of service on each side of the bridge, or separate services for special equipment such as roadway lighting.
- Contact the utility and arrange for power to be disconnected. Have the utility verify, in the presence of the inspector, that electric power is removed.
- Perform a visual inspection of the incoming feeders. If the feeders are from overhead transmission lines, they can be easily viewed. Underground feeders will not be visible except at the point of entry.
- Check for damaged wires and missing or broken supports.
- Verify that all equipment is firmly mounted.
- Check for blown line jacks.
- Inspect the panels where service is terminated for damage, rust, debris, or fluid build up.
- Check the wiring and terminations.
- Check the insulation resistance of the cables while they are de-energized.
- Look for any scorch marks or evidence of faults in the panel.
- Inspect the main ground terminal. Request that the utility take a measurement of the resistance to ground to verify that the incoming service is solidly grounded.
- Inspect the bridge grounding system thoroughly if the grounding at the utility is not acceptable.

Inspection of the transformers should include the following:

- Inspect the exteriors for damage, corrosion, lost paint, or scratches.
- Verify that the hinges and latches of panel doors or bolt on covers operate properly, are sufficiently lubricated, and make a tight seal when the doors/covers are sealed.
- Verify there is a gasket between the door/cover and the panel. The gasket should be continuous, springy, and compressible to the touch. Note if the gasket is brittle, permanently deformed, or missing in areas.
- Verify that the panel mount is secure and vibration-resistant. The panel may be free-standing and bolted to the floor, wall-mounted and bolted to the wall, or wall-mounted and mounted to a metal strut support.

- Note any loose bolts or other deficiencies.
- Listen to the transformer for any unusual noises during bridge operations. Transformers normally have a low, quiet, buzzing sound.
- Take the temperature of the transformer and compare it to the specified normal range. Record the operating temperature.
- Inspect oil-filled transformers for leakage.
- Test older transformers for polychlorinated biphenyls (PCBs).

Motor control centers (MCCs) are cabinets where electrical power is controlled and distributed to end devices. Equipment is arrayed in units called buckets. Each bucket will contain one or more of the following: an overcurrent protection device, a motor controller, an overload relay, or metering equipment. Inspect the panel, motor controllers, circuit breakers, fuses, and wiring.

Panel boards are panels with distribution circuit breakers and, on older bridges, relays. Inspection of the panels should include the following:

- Inspect the panel, circuit breakers, and wiring.
- Inspect the exterior of all panels for damage, corrosion, lost paint, or scratches. Inspect panel doors or bolt-on covers to verify that the hinges and latches are properly lubricated and make a tight seal when the door or cover is sealed.
- Verify there is a gasket between the door/cover and the panel. The gasket should be continuous, springy, and compressible to the touch.
- Note if the gasket is brittle, permanently deformed, or missing in areas.
- Verify the panel mount is secure and vibration-resistant. The panel may be free-standing and bolted to the floor, wall-mounted and bolted to the wall, or wall-mounted and mounted to a metal strut support. Note any loose bolts.
- Determine if any temperature control equipment, such as a heater, ventilation grate, and/or fan is operating properly. Verify that the ventilation grate filter is clean and free of dust and debris.
- Check that each panel is solidly grounded by a conduit fitting or ground bar located in the panel.
- Inspect other equipment located within the panel.

The raceway system consists of conduits, conduit fittings, junction boxes, and terminal boxes. Conduit is used to protect wire and route it from one location to another. Typically these are 10- or 20-foot sections of rigid galvanized steel (RGS) conduit, polyvinyl chloride- (PVC-) coated RGS conduit, and PVC nonmetallic conduit. Inspection of the raceway system should include the following:

- Ensure raceways are properly coupled and supported.
- Ensure all conduit is tightly connected. If a coupling becomes loose, the conduit sections may separate, and the wires inside may become damaged.
- Verify that required supports are present and securely mounted. Check each support for loose screws or bolts. RGS conduit should have secure support at intervals not exceeding 10 feet. Nonmetallic conduit should have a support every three to seven feet.
- Check the wall-mounted conduit runs for dirt and debris between the conduit and the walls. Dirt and debris should not be allowed to build up on any conduit runs.
- Note any areas that require cleaning.
- Check that conduit fittings are in good condition. Conduit fittings are in-line enclosures in conduit that provide bends or taps in conduit runs. Check the gaskets for a tight seal. Check the conduit fitting for any debris or fluid.
- Check that junction and terminal boxes (enclosures for the routing of wires) are in good condition. The boxes will be rated by the National Electrical Manufacturers Association (NEMA) for various exposure conditions, including watertight, dust-proof, and corrosion-proof. For all junction and terminal boxes:
    - Inspect the wires and terminals.
    - Verify that that seals around the access panels provide a watertight seal.
    - Check the boxes for debris or fluids.
    - Check that the drain and breather valves are operational.
    - Check the exterior of the boxes for rust or chipped paint.
    - Check the conduit bushing and fittings to verify a solid and tight fight.
    - Verify that any grounding fittings are properly installed and the ground wire is bonded to the fitting.

Bridge wires are copper conductors that carry electrical power and control to the electrical devices. Occasionally, aluminum is used in lieu of copper. Wires are either solid cylindrical shapes, or composed of several strands. Conductor sizes are based upon the amount of electrical current, or ampacity, of the load device. The more current required, the larger the conductor. The wire is covered with insulation, rated for electrical voltage, and jacketed to protect the wire. A cable contains several insulated wires within the same outer jacket. The insulation and jacket are selected based upon the electrical voltage of the system and the environmental conditions to which the wire/cable will be exposed. Inspection of the wire and cable should include the following:

- Confirm that the bridge is wired in accordance with the as-built documents of the electrical system. Each wire should be designated with a wire number that is referenced on the as-built drawings.
- De-energize high- and medium-voltage cables before inspecting. Only personnel trained on such equipment should perform the inspection.
- Check for insulation failure when the jacket and insulation of the conductor wears away, causing electrical faults or wire failure. Failure may be caused by overloading, physical wear and tear, exposure to water or corrosive materials, or age.
- Note any signs of abrasion or cracking over the entire length of the cable.
- Note any signs of discoloration and overheating.
- Note any signs of excessive bends or kinks in the wire.
- Note any signs of water or other moisture on the cables.

Wires and cables are usually installed in conduits. The conduits provide additional protection for the cables. When the cable is inside conduit, it cannot be visually inspected for the entire run. The wire and cable should then be inspected at accessible points, such as conduit fittings, terminal and junction boxes, and equipment panels.

Wires and cables are terminated at terminal strips in panels and lugs on equipment. There are three types of terminations to terminal strips: compression, fork-tongue, and ring-tongue. A compression terminal is simply a screw that presses onto the bare wire to make a contact. A fork-tongue or ring-tongue terminal is compression-clamped onto the wire. The screw in the terminal strip will compress onto the tongue portion. Vibrations that occur on a bridge will cause the terminals to loosen over time. Compression terminals traditionally have the least resistance to vibration and the wires may become loose. Ring-tongue terminals provide the best resistance to vibration, as the compression screw travels through the ring on the cable. If the screw becomes loose, the ring will still maintain contact.

The inspector should examine the terminations and note:

- Loose terminals.
- Any wires not tagged with a wire number.
- Any wiring not in accordance with the as-built drawings.
- Terminals not marked with the wire number of the terminated wires.
- Any movement or vibration between the panel and wires.
- Corrosion or rust on the terminals.
- That the exposed copper conductor will not come into contact with exposed metal.
- That the wire is isolated from power and sensitive equipment and perform an insulation megohm resistance to ground test on each individual wire. Record the wire number and the phase-to-ground resistance, and a phase-to-phase resistance with an adjacent disconnected wire in a table. If the resistance value is below one kilo-ohm, the wire is close to failing. If the resistance is zero, the wire has failed. Compare the results to previous results to determine if there are trends in the insulation resistance or the cable test results. This may indicate a problem in the run of wire.

Specialty cables, including flexible cables and submarine cables, are installed in areas that cannot be serviced by wire in conduit. Flexible cables are cables routed between fixed portions and movable portions of the bridge, such as cables from the rest pier to the bascule leaves. Flexibility comes at the cost of reduced jacket protection. In order for the cables to bend and move with the bridge, the jacket must be softer and more flexible. This means that they may wear more quickly from rubbing and abrasion.

Submarine cables are cables that are routed into the channel through the water from one side of the bridge to the other. The cables are usually trenched into the riverbed. They are exposed to a much harsher environment than regular cables. The portions of the cables that remain continually underwater, or continually out of the water, usually remain undamaged. The portions of the cables that are exposed to fluctuations in water level due to wet and dry periods, and the wear and tear of moving in response to the changing water level, require the closest inspection. Submarine cable is typically manufactured with a steel armor wire wrapping and polyethylene covering to protect it from the harsh conditions. Submarine cables are usually terminated in panels where the wiring is transitioned to normal wire and conduit.

The inspection of specialty cables should include the following:

- Check that the armor is terminated and grounded at the submarine cable terminal panels in special fittings.
- Verify the range of motion of flexible cables during an operation of the bridge. Cables should swing freely and move freely during the entire operation of the bridge.
- Check for sharp bends or kinks in the cables during operation.
- Note any cables that snag or rub against the structure or equipment.
- Test the insulation of the individual wires of the flexible cables using a megohm meter and record the values.
- Note the effects of wind on the cables during operation.
- Check the cable grips and supports at each end of the cables. They must have a firm grip on the cables and be solidly attached to the structure.
- Inspect submarine cables during low-water conditions if possible.
- Note any deterioration of the cables.
- Verify panel terminations and cable supports.
- Inspect the clamps of armored cable to make sure the cable is supported and grounded.
- Use a megohm resistance test to check the insulation of the individual wires of the submarine cables and record these values.

SECTION 4.8 INSPECTION OF ELECTRICAL MACHINERY

The inspection of all motors should include the following:

- Verify that the motor shaft is free from oil and grease from the bearings. Leaking oil can indicate a poor seal or misalignment of the shaft.
- Verify all keys, bolts, and pins are in their proper positions. Check all bolts along the motor housing for proper tightness.
- Check any space heaters for proper operation by touching the motor to determine if it is warm before operation.
- Check all surfaces for signs of corrosion.
- Observe the operation of each motor during opening.
- Check motor shafts for normal end play.
- Verify that all motors are smooth-running and free from vibration.
- Check motors and bearings for overheating.
- Note any unusual noises heard during operation. If the motor is fan-cooled, check for proper operation of the fan and that the motor is being properly cooled.
- Check that each motor is wired in accordance with the NEC.
- Verify there is a disconnect switch within sight of each motor.
- Check the internal equipment after disconnecting the motor from its power supply.
- Check electrical connections on the motor for proper attachment.
- Test insulation resistance values on all motors using a megohm meter. Megohm measurements should be taken from phase-to-ground and between phases for all AC, three-phase motors.
- Take megohm measurements at the collector rings to detect cracked or otherwise defective bushings. Readings should be taken using a 500-volt direct current (DC) hand crank or battery-operated megger. Record the results of the megohm meter tests and compare these to prior inspection findings. Any large changes may indicate motor deterioration.
- Recommend overhauling a motor when megohm values for phase-to-ground values are projected to reach 2.0 or less before the next scheduled inspection.
- Recommend that the motor be overhauled as soon as possible if the megohm values are 1.0 or less.

- Check the phase currents in motors under loaded conditions with a clamp-on ammeter for motors of one horsepower or larger. Record the results and compare them to the nameplate data and prior inspection results.

- With the power disconnected, open the inspector ports of the motor to check the interior of the motor. Check that collector rings (slip-rings) are free of carbon, metal dust, discoloration, and deformation. The wearing surface of the collector rings should be smooth, highly polished, and free of dirt, oil, grease, and moisture. Try to determine the source of any detrimental conditions.

- Wound rotor AC motors and synchronous AC motors use brushes to carry current to rotating parts of the motor. For all AC motors:

    - Check that all brushes have free movement within their holders. Each brush holder should be set so the face of the holder is approximately 1/8 inch from the collector ring. Each brush must be reinserted into its original holder and in its original orientation after inspection. It may be helpful to scratch a mark on one side of the brush when removing it to indicate its proper location and alignment.

    - Inspect all brushes for wear. If the remaining portion of any brush within its holder is 1/4 inch or less, the inspector should recommend that all brushes on the motor be replaced.

    - Verify that the entire surface of the brush that rides on the collector ring displays a polished finish, indicating full-surface contact. If a brush is not making full contact over its entire surface, recommend that the brush be re-seated.

    - Inspect the springs that push the brushes against the collector rings. All brushes should be held firmly on the collector ring with approximately the same pressure. Improper spring pressure may lead to collector ring wear or excessive sparking. Recommend that the springs be replaced if this is found.

    - Look for evidence of excessive heat, such as annealed brush springs.

The inspection of electrical span brakes should include the following:

- Check that span brakes are equipped with covers to prevent debris or grease from affecting brake operation.

- Check the mounting and location of limit switches on the brake. Generally, a brake will have a set switch, a release switch, and a hand-released limit switch. Follow the inspection methods listed in Section 4.9.

- Check the wiring in the limit switches.

- Manually operate the hand-release arm to verify that the linkages work properly.
- Check the clearances between the brake shoes and the drum when the brake is released.
- Observe the drum to note the wear pattern. The entire drum should be shiny if it is wearing evenly. Note any uneven wear.
- Make sure no grease, oil, water, or dirt is on the brake drum, as this will reduce braking capacity.
- Check the length of time it takes for the brake to fully release and the brake to set.
- Monitor the brake shoe and drum during operation. If the shoe and drum are not aligned, they will come into contact during operation. This contact could produce smoke and damage the brake.
- Test the insulation of the brake motor with a megohmeter and record the results.

The inspection of warning and barrier gates should include the following:

- Check the exterior of the gate housing for any damage.
- Check the access panels for proper operation.
- Open the housing and inspect for fluid or debris accumulation.
- Closely inspect conduits entering the base of the housing. Oil leaks may flow into the conduits and damage the wiring and environment.
- Inspect the internal equipment.
- Observe the gate arm or barrier during an operation.
- Verify that the flashing lights blink for the duration of the arm's movement. The lights should operate from the time the locks are engaged until the gates are raised.
- Observe the cables powering the flashing lights on the arms.
- Verify the cable is not rubbing against or catching on the gate housing during movement.
- Check the arm for any frayed wire or exposed terminal on the flashing lights. This could pose a danger to a pedestrian.

Gongs are mounted on traffic gates for oncoming traffic. They should be loud. The inspection of gongs should include the following:

- Check that gongs start operating when the warning signals are activated to stop traffic and continue to operate until the locks are released. They should operate again from the time the locks are engaged until the gates are raised.
- Inspect the cables powering the gongs for abrasion or tears.

SECTION 4.9 INSPECTION OF CONTROL SYSTEMS

The inspection of the control desk should include the following:

- Verify that the switchs or pushbuttons used to test the indicator lights on the control desk work. Note any light that operates improperly.
- Operate the bridge several times to verify that all pushbuttons, control switches, indicating lights, meters, and indicators operate properly.
- Record all voltmeter, ammeter, and kilowatt meter readings as the bridge is operated. Compare these readings to the records from previous inspections. Dramatic changes in readings may indicate problems and aid with the inspection.
- Interview several of the bridge operators to determine if they have experienced any problems with the controls or other systems.
- Examine the interior of the control desk. Verify that the interior light is working. Check for any loose wires and inspect the wiring. Look for any scorching or discoloration that could indicate a faulty piece of equipment. Inspect all interior equipment.
- Check all relays, especially plug-in types, to verify that they are firmly installed.
- Check for a strip heater and verify that it is operational.

The inspection of the interlocks should include the following:

- Verify that the interlocks in the control system are operating properly with a series of tests. Extreme care must be taken while verifying the interlocks. Vehicular traffic must be stopped by flagmen while testing roadway equipment. River traffic must be made aware of the testing and any potential delays. The testing must be performed in accordance with the AASHTO *Movable Bridge Inspection, Evaluation, and Maintenance Manual*, as follows:
    - With the bridge in the closed position, perform the following:
        - Attempt to lower the traffic gates prior to sounding the horn or activating the warning lights.
        - With the traffic gate open to vehicular traffic, insert the gate arm hand crank into the traffic gate housing and try to operate the gates from the console. The gate should not operate. Record the results and repeat for all gates.
        - With the locks in place, attempt to operate the bridge span. The span should not operate. Record the results.

- During the bridge operation, perform the following:
    - For all devices, confirm the motor will not operate if a hand crank is inserted into that device.
    - Confirm that the main motors cannot be started prior to the release of the brakes. The main drive motor starters should not engage. Record the results.
    - Test the limit switches at fully open.
    - Attempt to raise the gates and turn the traffic signals to green before the locks or jacks are fully driven and the bridge span is secure.
    - Verify that the traffic signals cannot be changed to green until all gates are raised.
- Note any problems in the interlocking and clearly notify the operators. The operators in control of the bridge must be aware of any issues found in the inspection.

The inspection of the fuses should include the following:

- Verify the fuses are the proper current rating. The fuse ampacity printed on the side of the fuse should match the ampacity on the as-built wiring diagrams.
- If the fuse ratings do not match the as-built documentation, check the load equipment. If the equipment protected by the fuses has changed, the new equipment may require a different fuse size.
- Verify that the fuse ratings are accurately documented. Inspect the fuse terminals for a tight electrical fit.
- Look for corrosion or scorch marks on the fuse blocks.
- Check for wire used to jumper a fuse, leaving the equipment unprotected, but operational. This condition is not acceptable and must be reported. Note any missing fuses.

The inspection of the circuit breakers should include the following:

- Verify that the trip settings on the circuit breakers are accurate. Compare settings to as-built documentation and equipment ratings.
- Molded-case circuit breakers are not accessible due to their plastic cover. Air circuit breakers should have their arc chutes inspected for debris, missing hardware, and damaged chutes. Check the contact surface for corrosion, pitting, and damage. Operate the circuit breaker to determine whether the contacts make and break contact.
- Check the wiring and terminations.

There are many types of motor controllers ranging from simple contactors to motor drives. The equipment may be installed in a panel or motor control center. The inspection of the circuit breakers should include the following:

- Review the manufacturer's specific written information on the drives on the bridge and follow the inspection recommendations.
- Inspect the motor control panel for any fluid or debris buildup.
- Note any damage to the panel exterior.
- Check the wiring and terminations.
- Inspect the circuit breakers and fuses.
- Inspect the individual contacts for corrosion and scorching.

The inspection of limit switches should include the following:

- Check the wiring and enclosures.
- Note any scratches or damage to the switch exterior.
- Where accessible, open the limit switch and inspect the wiring.
- Inspect the seal of the limit switch and verify that no fluid or debris have accumulated in the housing.
- Check that the limit switches are securely mounted and have little movement or play.
- Lever arm limit switches and plunger-type limit switches have arms that move to trigger the electrical contact. Lever arms rotate around a pivot point in the housing, and plunger-types are pushed into the housing.
  - Inspect the arms for debris, corrosion, and a buildup of dirt.
  - Verify that the arms move freely and do not stick in place. The making and breaking of the limit switch contacts should be audible when testing the arm.
  - Watch the limit switch during a bridge operation.
  - When safe, manually operate the switch to test whether the operation will stop or if the appropriate indicating light energizes.

- Proximity limit switches are generally magnetic sensors that make electrical contact in the presence of a metal trigger.
    - Check the limit switch magnetic sensor for a buildup of magnetic filings that may provide a false indication.
    - When safe, manually operate the switch to test whether the operation will stop or the appropriate indicating light energizes.
- Open the rotary limit switches and inspect the contacts for any corrosion or scorching. Check the bearings for proper lubrication. The rotary limit switch is coupled to the span drive gearing. Inspect these couplings for proper connection.
- Position indicators, selsyn transmitters, resolvers, and tachometers are all feedback devices that provide position or speed information to the operator or to the motor drives. Inspect the enclosures, wiring, and mountings.

The inspection of relays should include the following:

- Verify that relays, especially plug-ins, are securely mounted.
- Verify that all wires and terminals are tagged and identified.
- Check for any jumper wires that are not part of the logical control system. These wires are added to bypass logical control temporarily and should be removed when the equipment has been repaired.
- Note any wiring without tags or wiring that is not documented on the as-built drawings.
- Determine what equipment the relays with jumpers control, and pay close attention to the interlock testing on the control desk when testing that equipment. Relay identifiers should be on nameplates mounted adjacent to the relays and should match the as-built wiring diagrams.
- Inspect the individual relays for contamination, scorch marks, or discoloration and record any relays with these problems.
- Monitor the relays during a bridge operation to verify proper operation. The inspector will be able to hear a short, sharp, click sound as the relays pull in or become engaged.
- Note chattering relays.
- Use a clock to determine if timing relays are operating properly.

The inspection of PLCs should include the following:

- Review any manufacturer's manuals for specific maintenance issues with the particular type of PLC installed on the bridge.
- Small switches on the processor and I/O cards, called dip switches, are configured to allow proper operation. Never change these switches.
- Inspect the processors, I/O cards, and remote racks for any dust, dirt, debris, corrosion, or fluid on the equipment.
- Check the PLC diagnostic lights to see if there are any failures in the equipment.
- Inspect all terminals and wires.
- Inspect the cabinet for debris and fluid, and clean air filters on the fans.
- Check the PLC batteries and make sure they are fully charged.
- Check other equipment in the PLC panel, including fuses, circuit breakers, the heater unit, lights, fans, and relays. Verify proper fan, heater, and light operation. Inspect the filter on the fan for an accumulation of dirt and debris. Inspect other equipment as described in this chapter.

SECTION 4.10 INSPECTION OF LIGHTING SYSTEMS

Test the service lighting throughout the bridge. Note any damaged or inoperative light. Check that lights in machinery areas are equipped with guards and globes. Determine whether the fixture or the bulb is inoperative. Carry a typical light bulb during the inspection to test the fixture.

Use a receptacle tester to verify that the lighting receptacles work and are wired properly. Note any damaged receptacles or any exposed receptacles lacking covers.

Navigation lights will be located along the piers or fender system of the bridge and on the span. The fender navigation lights are red fixtures, while the lights on the span may vary between red only and red and green alternating fixtures.

Check each navigation light for damage, broken lenses, loose mounting, corrosion, and functionality. A night inspection may be necessary. Each light should be clearly visible when lit. Note any fixture that is inoperative or damaged. Inspect any rotating lights for proper range of motion.

Navigation signals consist of horns or public address equipment used to alert waterway traffic. Inspect the equipment for any damage, corrosion, or opened enclosures. Inspect the wiring and verify operation. Inspect all signal devices.

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CHAPTER 5 HYDRAULIC SYSTEMS

SECTION 5.1 INTRODUCTION

The Indianapolis Boulevard and Dickey Place bridges utilize closed-loop hydraulic systems. In a closed-loop circuit design, a single hydraulic pump is used to drive one or more hydraulic motors. The closed-loop circuit is not viable for hydraulic cylinder applications because of the different fluid volume displacements during extension and retraction. The fluid that passes through the actuator is returned directly to the low-pressure side of the pump. For proper operation, the pump must receive the same quantity of oil at its inlet as it is pumping from its outlet.

A charge pump is always used in a closed-loop hydraulic circuit. The charge pump is usually a small, fixed displacement pump with approximately 15 percent of the displacement of the main pump. The charge pump works on the low-pressure leg of the main loop, pumping filtered fluid into the loop. The pressure in the low-pressure leg is maintained between 100 to 300 psi by a relief valve.

During operation, the main pump control can cause the pump's displacement to "go over center." This means that the main pump can pump high-pressure oil from either of its two main ports, causing a clockwise or counterclockwise flow of fluid through the main loop plumbing. This allows the actuator to rotate in either direction.

In closed-loop systems, pressure, flow, and directional control are all achieved by the controlling elements of the pump. Cross-port relief valves are incorporated to protect the actuators from load-induced pressure peaks.

High horsepower, closed-loop systems are compact, operate with a minimum amount of excess fluid storage, and are highly efficient. The pump controls direction, acceleration, deceleration, speed, and torque of the motor actuator so pressure and flow control components are not needed. These systems also provide excellent dynamic braking control, which is highly desirable in most movable bridge applications.

SECTION 5.2 HYDRAULIC CONTROL SYSTEMS

Hydraulic control systems determine how flow and pressure are regulated from the system's pumps. Three types of hydraulic system controls are commonly used in movable bridge applications: constant horsepower control, electronic proportional control, and hydraulic cylinder control. Each is described below.

Subsection 5.2.1 Constant Horsepower Control

Constant horsepower control, also known as horsepower-limiting control, uses an electric motor connected to the pump and drives the pump at a constant speed. This keeps the pump motor working at a constant horsepower level. To maintain constant horsepower, the mathematical product of flow and pressure must be a constant value. Therefore, if the flow is high, the operating pressure must be low. Since the operating pressure level of a system is dictated by the load conditions, the flow must vary with changes in load-induced pressure to maintain the product of flow and pressure at a constant value.

Constant horsepower controls sense the load-induced pressure and regulate pump flow accordingly. The pump control holds the pump at its maximum displacement until the pressure reaches the point at which regulation or compensation begins. This type of system always uses a system pressure relief valve. Once the end of regulation is achieved, the slightest increase in system pressure will open the relief valve and bypass the minimum pump flow back to the tank.

Subsection 5.2.2 Electronic Proportional Control

Electronic proportional control utilizes a proportional solenoid to vary the pump displacement. The pump varies from minimum to maximum displacement in proportion to the current of a 24-volt direct current (DC) command signal. As DC power is applied to the proportional solenoid, the solenoid pushes the pilot spool with a specific force. When the current, and therefore the force, is high enough, the pump begins stroking and producing flow. Further increases in signal current will increase the pump's output flow proportionally.

SECTION 5.3 INTERLOCKS

Control systems on movable bridges are provided with interlocking controls that allow the bridge to be operated in a manner that provides safety to the traveling public while protecting the equipment. The requirements for interlocking controls between the hydraulic span drive and other equipment such as span locks, traffic gates, and signals, are discussed in Chapter 4, Subsection 4.9.2, Interlocks.

SECTION 5.4 INSPECTION OF HYDRAULIC COMPONENTS

The inspection of hydraulic equipment requires special precautions due to the use of fluids for the system's operation. Leaks and spills cause slippery areas and special care should be taken when working in the area of the pumps and motors. Frayed or damaged hoses pose hazards since they convey fluids under high pressure. A burst hose can spew hydraulic fluids great distances and possibly cause injury. Hydraulic System Inspections should focus on the following:

- All components should be checked for cleanliness and leakage. Dirt and debris should not be allowed to build up on the components.
- Check the fluid level in the reservoir. Compare actual levels with the recommended levels specified in the bridge's maintenance manual.
- Inspect hoses and pipes for abrasion, kinks, and flattening. Damaged, kinked, or flattened lines restrict fluid flow and may damage pumps.
- Observe and record readings on gauges and compare them to recommended operating pressures found in the bridge's maintenance manual.
- Verify that the reservoir air filter has been cleaned and is free of clogs and contamination.
- Under operation, listen for the occurrence of "water hammering," which is the sudden stoppage of fluid that causes ramming in lines and pipes.
- Under operation, listen for cavitation or a loud rattling in the pump. Cavitation is caused by a lack of fluid passing through the pump and can cause serious damage to the impellers and other parts of the pump.
- Measure the surface temperature of the pumps. Temperatures above 140 degrees Fahrenheit indicate that the fluid may require replacement.
- After checking the temperature of the hydraulic fluid, smell and touch it. If the fluid smells burnt or feels gritty, it is time to change the hydraulic oil.
- Listen and feel for excessive vibration which may cause welds to fail or bolts to become loose.

Subsection 5.4.1 Accumulators

An accumulator stores energy in the form of pressurized hydraulic fluid. Although there are several different types of accumulators, gas-charged accumulators are the most common.

A gas-charged accumulator stores hydraulic fluid under pressure by compressing an inert gas, usually nitrogen. A rubber bladder separates the gas chamber and the oil chamber. Initially, the oil chamber is vented to atmospheric pressure and the gas chamber is pre-charged with nitrogen to a known setting through a gas valve.

Generally, accumulators are maintenance-free. The nitrogen pre-charge should be checked as a part of the inspection as follows:

- Close the isolation valve between the system and the accumulator.
- Slowly vent the accumulator using the venting needle valve.
- Watch the pressure gauge for a gradual decay in pressure as the fluid empties. The moment the accumulator rids itself of all the oil, the needle on the pressure gauge will immediately drop to zero. The pre-charge pressure is the pressure preceding this drop.

If the nitrogen pre-charge is below that value required by the system design, the inspector should recommend that the accumulator be recharged. Recharging an accumulator is dangerous and should only be performed by a qualified technician who is fully trained to properly and safely perform this procedure.

Subsection 5.4.2 Valves

Modern hydraulic system valves are very reliable. However, dirty system fluid or unintentional maladjustment could lead to problems with hydraulic valves. The inspector should perform the following for the system valves:

- Verify that pressure settings on all relief valves are correct.
- Check for leaks at the manifold interface.
- Verify that any directional control valve spools move freely.
- Verify that manual override pushbuttons are functional.
- If spools are sticking, disassemble the valve and inspect the internal components for wear, scoring, and fluid debris.
- Check the condition of pilot lines, if applicable.
- Inspect all shut-off valves and their connections to the system pipes for leaks.
- Verify that shut-off valves are fully open or fully closed as required by the system.

Subsection 5.4.3 Hydraulic Cylinders

Hydraulic cylinders are used for span motion or actuation of locking devices. Cylinders should be periodically inspected to ensure proper, safe, and long-term operation. The inspector should:

- Observe the extension and retraction of hydraulic cylinder rods. Span or locking device movement should be smooth.
- Inspect the condition of cylinder rod coating. Look for scoring, nicks, or other surface imperfections that could damage the rod seals.
- Inspect the area around rod seals for fluid leakage. A small amount of fluid is not cause for alarm. If leakage is excessive, recommend the replacement of the rod seals.
- Inspect the cylinder valve manifold blocks and pipe attachments for leaks. Verify that flexible hoses do not scrape anything due to cylinder movement.
- Inspect all connections of the cylinders to the structure or locking device. Verify that all bolted connections are tight. Verify that cylinder end-pin connections have freedom of movement. Verify that cylinder attachments have freedom of movement throughout the entire operating range.

Subsection 5.4.4 Pumps

Inspect system pumps and observe/listen during operation. Operation should be smooth. Verify that pumps equipped with a flow meter provide the required flow. The inspector should:

- Check the pump suction, high-pressure lines, and case drain lines for leaks. Verify that suction shut off valves are fully open, if equipped.
- Check the connections between the bell housing and the pump, and the bell housing and the motor for tightness.
- Check the tightness of the shaft-coupling assemblies.
- Check the tightness of other pump/motor mountings.
- Verify the temperature of the motor under operation. If the temperature is in excess of 140 degrees Fahrenheit, this indicates that the hydraulic fluid should probably be replaced.
- Listen to the pump when in operation. A loud rattling sound is the indication of cavitation, a serious condition which causes permanent damage to the pump.

Subsection 5.4.5 Rotary Motors

Observe and listen to the system's hydraulic motors during operation. Operation should be smooth. The inspector should:

- Inspect the pressure line and case drain line connections for leaks. If loose, note the condition and recommend they be tightened. Check all housing joints for leaks. Verify that any suction shut-off valves are fully open.
- Check the tightness of the hydraulic motor to its support and mating equipment. Check the tightness of shaft-coupling assemblies, if applicable.

Subsection 5.4.6 Filters

Adequate and proper system filtration is the most important aspect of maintaining a movable bridge hydraulic system. Degradation or catastrophic failure could result from inadequate system filtration.

The abrasiveness of tiny particles wearing the close tolerance surfaces of internal components causes degradation failure. This type of failure spreads throughout the system and is usually not detected until the damage is irreversible. A sluggish system response, the loss of speed adjustment accuracy, the inability of the system to produce full load, and/or overheating, are all indications that degradation failure has occurred.

Catastrophic failure is the immediate failure of a system component and is usually related to large particles causing moving parts to jam or stick. In pumps, dirt can block lubrication passages and cause pump failure. Large debris can collect in orifices which supply oil to components such as the pilot circuit of the pilot-operated relief valve and pressure-compensated flow controls.

In a suction filtration system, the filtering element is located between the reservoir and the pump. The strainer is usually well below the minimum oil level within the reservoir, making servicing inconvenient. It is not unusual for these filters to go unserviced until they starve the pumps and cause cavitation damage.

If the system is equipped with suction filtration access holes, these filters can be serviced without draining the reservoirs.

Pressure filters are commonly used to protect high-pressure components such as directional spool valves and piston-type hydraulic motors. They are contained in a housing that is subjected to the full system pressure and flow. If a clogged pressure filter ruptures in service, a large concentration of contamination could dump directly into the components.

Return-line filtration is based on the assumption that a clean hydraulic system will remain clean if the contamination is filtered out of the fluid soon after it is ingested or created by the system.

Subsection 5.4.7 Pipes, Tubing, and Hoses

Plumbing systems for hydraulic movable bridge machinery often consist of complex arrangements of high-pressure pipes, stainless steel tubing, and hoses. Pipe runs usually contain many bends, elbows, fittings, and mountings due to the complex nature of the bridge structure. Vibration from operation of the equipment, vibrations from vehicular traffic, as well as movement of the equipment itself has the tendency to loosen pipe fittings and pipe supports. Inadequate support can also cause leaks or damage to the plumbing. The inspector should:

- Check for damaged, nicked, or worn hoses, which should be replaced immediately.
- Check all plumbing fittings for signs of leakage.
- Inspect pipe support systems. Check the tightness of hangers and mounting hardware.
- Visually inspect all pump and control valve pilot lines for leakage.
- Visually inspect inlet and outlet plumbing to main pumps.

Subsection 5.4.8 Hydraulic Fluids

Modern movable bridge hydraulic systems utilize either standard mineral oil or synthetic oil as their working fluid. The useful life of these fluids is not infinite. Several factors influence the expected life of hydraulic fluid including usage, operating temperature, system cleanliness, and water intrusion. Synthetic oils tend to oxidize after several years and require replacement. The inspector should touch and smell the hydraulic fluid. If the fluid smells burnt or feels gritty, the fluid should be replaced.

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CHAPTER 6 MECHANICAL SYSTEMS

SECTION 6.1 INTRODUCTION

This chapter discusses the basic inspection of mechanical components. All machinery components are related to, and function as, a system with the electrical and structural components. A deficiency found at one item would most likely affect other elements. Special care must be taken when inspecting mechanical components. Inspectors must make certain that the power is disconnected to motors and other drive mechanisms to prevent accidentally engaging the motor. Serious injury can result from clothing getting caught in the gears. The gears usually have a liberal application of grease to minimize wear. The grease is difficult to remove from hands and clothing and can cause skin irritation. Gloves should be worn when working around the gears and disposed of after use. Rags or paper towels are invaluable when cleaning gear teeth to obtain tooth wear.

SECTION 6.2 OPEN GEARING

Open gearing refers to gears that are not contained in a sealed housing. The gears are supported by shafting and bearings that are mounted onto fabricated or cast metal structural supports or framing. Distortion of the supports, deterioration of the fasteners, or deterioration of the shims may result in an abnormal alignment and/or wear of open gears. Wear of open gearing is compounded by the constant exposure to weather and the presence of abrasive, foreign materials that lodge in the gear mesh. The most common type of open gearing found on movable bridges is spur gearing. Spur gears transmit power and regulate the speeds of parallel shafts.

Subsection 6.2.1 Gear Alignment

Gears may be misaligned due to incorrect installation or deterioration of the supports. Misalignment may result in accelerated wear and undue stress on the gear teeth.

Inspection for gear alignment should include the following:

- View the grease patterns left behind during operation for even contact across the full tooth width at the pitch line. If the pattern is heavier on one edge of the tooth, or the pattern is not along the pitch line, the shafts are not parallel.
- Determine the amount of misalignment, indicated by grease patterns, by measuring the backlash between the mating gears. Backlash is the space between adjacent noncontacting teeth. Measure backlash to ± 0.003 inch using feeler gauges.
- Check the alignment of the bevel gears. Misalignment can show as heavier contact at the heel portion or the toe portion of the tooth.

Subsection 6.2.2 Gear Wear

Detailed examples of types of wear are described and pictured in the American Association of State Highway Transportation Officials (AASHTO) *Movable Bridge Inspection, Evaluation, and Maintenance Manual*.

Inspection for gear wear should include the following:

- Verify the tooth surface is smooth at the contact area. Scoring or deep gouges are evidence of deterioration of the tooth surface.
- Inspect the tooth roots for cracks. This is the area of highest bending stress.
- Inspect each tooth for fins that may form due to plastic flow of the steel.
- Verify that the teeth of one gear properly mesh with the teeth of the other gear and are properly aligned.

SECTION 6.3 BEARINGS

Two types of bearings are used on the movable bridges in Indiana: sleeve bearings and anti-friction bearings. These are discussed below.

Subsection 6.3.1 Sleeve Bearings

A sleeve bearing is a fixed cylinder in which a shaft journal rotates. The sleeve is usually made of bronze and is held to a fixed point within a steel housing. Housings are usually split in order to remove the shaft for repairs. The top half is bolted down to the base, and the base is bolted to the steel structure. Often, the sleeve bearing is provided with a flange that acts as a thrust surface to hold the shaft in the horizontal position.

A sleeve bearing requires lubrication between the sliding surfaces of the journal and bushing. Normally, one or more grease fittings are located at the top of the housing. A path is drilled through the housing and bushing and meets with grooves machined into the surface of the bushing. The groove is usually in a spiral pattern, which helps to lubricate the entire surface of the journal.

Inspection of sleeve bearings should include the following items:

- Inspect bearing supports, mounting bolts, and grout pads for cracks, damage, and deterioration.
- Inspect mounting bolts and cap bolts for tightness.
- Inspect bearing housing for cracks and damage.
- Inspect bushing and flange for cracks and damage.
- Confirm that old grease exits from the space between the journal and bushing during lubrication.
- During operation, note any movement of the bearing or support. This will indicate damage to the system that may need repair.
- During operation, note any movement of the shaft within the bushing. Any excessive radial movement indicates wear to the bushing. If excessive movement is found, other parts of the system may be adversely affected.
- Measure and record the clearance between the shaft and the bushing, using feeler gauges.
- Feel the exterior housing of the bearing after operation. The bearing should remain cool to the touch. Any heat generation may indicate improper lubrication or damage to the bearing.

Subsection 6.3.2 Anti-Friction Bearings

Anti-friction bearings include roller bearings and ball bearings. Typically, heavy-duty, spherical roller bearings are used to transmit power. Lighter-duty ball bearings are commonly used for instrumentation that drives electrical control feedback devices. In general, the clearances of the bearing are set during installation, and the unit is sealed for operation. Little wear occurs at these bearings, so wear measurements are not required. Overheating, unusual noises, and shaft or bearing vibration are indications of potential problems or the failure of an anti-friction bearing. Too much or inadequate lubrication, dirt, rust, or foreign materials in the bearing; a faulty ball or roller; seal failure; and loss of clearance or preloading can contribute to a failure.

Inspection of the anti-friction bearings should include the following:

- Examine bearing supports, mounting bolts, and grout pads for cracks, damage, and deterioration.
- Check the mounting bolts and cap bolts for tightness.
- Inspect bearing housing for cracks and damage.
- Note any movement of the bearing or support during operation.
- Listen to each bearing for any unusual noises during operation. Anti-friction bearings should operate smoothly and quietly.
- Inspect the seals for damage and proper sealing. Excessive lubricant may indicate a problem.
- Feel the exterior housing of the bearing after operation. The bearing should remain cool to the touch. Any heat generation may indicate improper lubrication or damage to the bearing.
- If possible, open the housing and visually inspect accessible portions of rollers and races. Check for internal contamination.

SECTION 6.4 SHAFTS AND COUPLINGS

Shafts transmit torque from one rotating part to another. Shafts ends are usually connected by couplings, which are secured to the shaft by an interference fit and key.

Inspection of shafts should include the following items:

- Inspect the keyways and shoulders for cracks.
- Check suspect cracks using nondestructive testing (NDT) methods.
- Inspect shafts for excessive radial movements and vibration during operation.

Couplings can be rigid, flexible, or adjustable. Rigid couplings are commonly found on older bridges, and are used to clamp shaft ends together. Flexible-type couplings are designed with internal elements that allow for misalignment during operation due to distortion of the bridge structure. The intent is to avoid bending the shafts. They also simplify shaft installation by allowing slight misalignment at the joints. Adjustable couplings are used when an angular adjustment, over time, is needed, or to monitor electrical control devices.

Inspection of couplings should include the following:

- Inspect the keyways for cracks.
- Look for corrosive deterioration and cracks.
- Check the flange bolts for tightness.
- Check for adequate lubrication of flexible couplings.
- Inspect all seals and gaskets of flexible couplings for leakage of lubricant.
- Make sure couplings rotate smoothly and are free of noise during operation. Noise indicates inadequate lubrication or misalignment of the shafts greater than the tolerances of the coupling.
- Disassemble the housings or covers. Inspect the internal flex grids and coupling hub teeth.

SECTION 6.5 LIVE LOAD BEARINGS

Live load bearings transfer vehicular live load from the span to the pier or approach span when the span is in the closed position. The bearings also prevent the span from rolling into the water in the closed position. The assembly consists of a shoe with a rounded surface (mounted to the span) and a flat strike plate mounted to the pier or other fixed structure. Both are secured with mounting bolts and are provided with shims for adjustment of the span position.

Inspection of the live load bearings should include the following:

- Determine if the mounting bolts are tight.
- Inspect the bolts and shims for deterioration.
- Check the contact surfaces of the shoe and the strike plate for deformations and wear.
- Confirm that firm contact exists between the shoe and the strike plate. If a gap exists, measure with feeler gauges and recommend re-shimming.

SECTION 6.6 SPAN LOCKS

A centering device called a span lock is located at the toe of each span to ensure roadway alignment of a rolling lift bridge. The two-part device consists of a tapered male upper and lower jaw and female diaphragm that gradually align the span horizontally during seating. The span locks also serve to transmit the live load shear between the two movable spans. The male jaws are faced with hardened steel shims that can be adjusted to nearly eliminate all movement between the spans under load.

Inspection of the span locks should include the following items:

- Inspect for adequate lubrication.
- Inspect for uneven wear that may indicate span misalignment.
- Inspect fasteners for tightness and deterioration.
- Inspect housing for cracks and damage.
- Observe the device during operation. Under normal conditions, the device should not encounter much sideward force.

SECTION 6.7 TREADS AND TRACKS

On rolling lift bridges, the weight of the leaf during operation is transferred from the curved segmental girders to the flat tracks through the treads. The treads are constructed with sockets that engage mating pintles or lugs on the tracks as the leaf rolls. These serve to position the span during operation and provide resistance against wind forces.

Inspection of the tread plates should include the following items:

- Inspect the mounting bolts that attach the treads to the girder.
- Inspect the contact surfaces for even wear across the width of the tread and track.
- Inspect the treads and tracks for cracks or surface deformation.
- Inspect the lugs, pintles, and sockets for wear and interference.
- Check the girders for cracks. Pay particular attention to the angles between web and flange.

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CHAPTER 1 OVERVIEW

SECTION 1.1 INTRODUCTION

Nondestructive testing (NDT) and partially-destructive testing (NDT) are used to investigate the material integrity of a bridge component and not the function of the component beyond material failure. NDT methods permit the inspection of an element without inflicting damage, while PDT typically causes minor, localized, repairable damage. NDT and PDT can be used when there is no observed defect, or when a defect is observed, but the extent of the problem is not known.

Part 6 presents an overview of NDT and PDT techniques as they apply to bridges. Although this testing is often performed by specialists, all structure inspectors should be familiar with available techniques so they can recommend appropriate testing procedures and recognize the limitations of the data.

Many NDT and PDT techniques have been developed and are commonly employed in the inspection of bridges. While the most common techniques are described in Part 6, the inspector should be aware that other methods are also currently available, and new techniques are constantly being developed. Refer to Figure 6.1-1 for a brief comparison of the techniques covered in Part 6.

Chapter in Part 5	Testing Techniques	Nondestructive	Partially Destructive	Material Tested			Desired Information, Measured Defect or Material Property
				Concrete	Steel	Timber	
2	Visual Inspection	X		X	X	X	Overall external material deterioration.
3	Audible Inspection	X		X	X	X	Concrete delamination; steel bolt and rivet looseness; timber integrity.
4	Infrared Thermography	X		X			Concrete deck delamination.
5	Ground Penetrating Radar	X		X			Concrete deck voids, overlay thickness, and reinforcing steel location; soil/foundation engineering; and underwater profiling/scour location.
6	Acoustic Emission	X		X	X	X	Crack, corrosion, weld defects and material embrittlement.
7	R-Meter Testing	X		X			Reinforcing steel concrete cover, location and size.
8	Schmidt Hammer	X		X			In-situ, relative surface hardness of concrete.
9	Impact Echo Testing	X		X			Internal concrete flaw detection.
10	Windsor Probe		X	X			In-Situ, relative penetration resistance.
11	Half-Cell Testing	X		X			Corrosion of reinforcing steel in concrete.
12	Chloride Ion Testing		X	X			Chloride infiltration of concrete and potential for corrossion of steel.
13	Material Sampling		X	X	X	X	Various material properties and defects.
14	Ultrasonic Testing	X		X	X	X	Non-homogenous investigation, delamination, surface crack and weld discontinuity detection.
15	Liquid Penetrant	X			X		Crack or surface flaw detection in non-porous metals.
16	Magnetic Particle	X			X		Crack or flaw detection in ferrous metals.
17	Monitoring Systems	X		X	X	X	Measurement of loads and strains to calculate stresses in members.
18	Unknown Foundation Investigation	X	X	X	X	X	Determination of foundation type or length of piles.
19	Hydrographic Surveys	X					Hydrographic surveys map a channel bottom. Locating areas of scour that can undermine substructure units allows the inspector to assess the integrity of the structure.

Figure 6:1-1: Summary of NDT and PDT Methods

SECTION 1.2 NDT AND PDT TESTING INSPECTOR QUALIFICATIONS

NDT and PDT methods range from simple chain drags and timber coring, to complex testing such as ultrasonic or Windsor probe testing. It is important that the people conducting the test and interpreting the test data are properly trained in the applied method. These individuals must work together. The person interpreting the data must understand of the theory behind the test and have practical experience with the testing method.

All inspections should be conducted in accordance with applicable American Society for Nondestructive Testing (ASNT) procedures, American Society for Testing and Materials (ASTM) standards, and American Association of State Highway and Transportation Officials (AASHTO) specifications.

The testing technician must be trained and experienced to properly interpret the output data. Refer to Part 1 of this manual for the minimum qualifications for specialists performing NDT and PDT. Many tests particular to bridges, such as thermography and ground-penetrating radar testing of bridge decks, are not covered by ASNT certifications; however, these tests are covered by the ASTM standards and experience can be documented.

NDT personnel shall be qualified in accordance with ANST Level II or Level III. For all NDT work, other than dye penetrant, the NDT personnel must work hand-in-hand with a professional engineer, licensed in Indiana, who is qualified as an Inspection Team Leader.

Consultants, contractors, and their subcontractors performing magnetic particle testing, liquid penetrant testing, or ultrasonic testing on bridges must be prequalified by the State Program Manager prior to being allowed to solicit or perform these activities.

SECTION 1.3 DATA COLLECTION AND INTERPRETATION

For all NDT or PDT programs, a plan should be developed which details the type(s) of testing to be performed, amount of data needed, test locations, criteria for data interpretation, and follow-up procedures for handling unanticipated test results. All data should be entered into the Central Database or adequately documented in the bridge file.

Testing data should be interpreted by persons knowledgeable in both the test theory and the analysis or evaluation of the bridge being tested. For some tests, such as ultrasonic weld inspection, recognized criteria exists for evaluating any detected anomalies. However, for many test methods, the data must be evaluated based on the behavior of the bridge component.

Most NDT programs detect and assist in the evaluation of flaws and discontinuities, as well as determine the strength or serviceability by indirect methods. The tests typically indicate the existence, extent, and location of discontinuities. However, the influence of the discontinuity on the strength or serviceability of the structural component is often difficult to determine. The validity of any testing depends on good engineering judgment based on experience. The information collected by NDT/PDT is typically raw data and the specialist must interpret the information for it to be of use. Also, certain techniques may provide false data under certain conditions. The specialist must be familiar with a technique and be able to recognize the false readings. No inspector should recommend testing, or accept testing results, without being familiar with the technique.

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CHAPTER 2 VISUAL EXAMINATION

SECTION 2.1 INTRODUCTION

Visual examination is the most basic of the nondestructive testing (NDT) inspection techniques. It allows for detecting and inspecting a wide variety of surface flaws such as cracks, discontinuities, corrosion, and contamination. Detection of surface cracks is particularly important due to their relationship to failure mechanisms. NDT methods utilizing a visual examination, such as liquid penetrant testing, often supplement other nondestructive tests. Close visual examination requires proper access to the element being inspected and appropriate tools. Figure 6:2-1 shows an inspector conducting a visual inspection.

Figure 6:2-1: Inspector Conducting Visual Examination

SECTION 2.2 APPLICATIONS AND LIMITATIONS

Visual examination is applicable to all structures either as a Routine Inspection, or as the first step in any other type of inspection. It can identify where a failure is most likely to occur, and identify when a failure has commenced. Visual examination is often enhanced by other surface methods of inspection, which can identify defects that are not easily seen by the unaided eye. Furthermore, visual examination may be aided with magnifying equipment or tools.

Inspections should always proceed in a logical manner from element to element. Proper access is necessary so that the inspector can examine elements from a reasonable distance during Routine Inspections and from a maximum arm's-length distance, approximately two feet, during Fracture Critical and In-Depth Inspections. Surfaces must be properly cleaned to expose the base material. The element being inspected should also be well-lit, either naturally, or by the use of a portable light source. The inspector should have good vision and color acuity. The inspector should also possess knowledge of the types of failures to look for. A variety of tools should be employed, when necessary, to aid the inspector. These tools may include binoculars, low-power magnifying glasses, crack gauges, and boroscopes to view inaccessible areas.

Because visual examination can only detect defects visible to the eye, the internal condition of an element remains unexamined. In addition, some small surface flaws may be difficult to locate or, once found, it may be difficult to accurately determine their extent. Badly deteriorated elements may be difficult to examine effectively due to heavy corrosion buildup. Furthermore, access to visually examine an item may be difficult even with the use of specialized equipment.

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CHAPTER 3 AUDIBLE INSPECTIONS

SECTION 3.1 INTRODUCTION

The most common types of Audible Inspections are chain dragging, hammer sounding, and listening under load. Chain dragging is normally used on large concrete surface areas, such as bridge decks, while hammer sounding can be used on a number of materials in random locations. Listening under load is used for all types of bridges. These methods rely on the experience of the inspector to differentiate the relative sounds of similar materials.

Chain dragging requires an inspector to drag several lengths of heavy chain over a concrete surface. The chains contact the concrete surface and produce an audible indication of delaminated areas, much like tapping with a hammer. These areas are marked and mapped for further evaluation.

Hammer sounding can aid in detecting impending spalls and existing delaminations which, when struck with a hammer, give off a dull sound or loud pop as opposed to the sharp ring of hard concrete without any internal discontinuities. This sound is easily noted when progressing from solid areas to delaminated areas. Similarly, hammer sounding of bolts and rivets can serve as an aid in detecting loose fasteners. Bolts and rivets should be struck sideways, as well as on their ends. In the inspection of timber elements, hammer sounding is used to detect the presence of significant decay. When a seriously decayed member is struck with the hammer, a dull or hollow sound is produced. However, when suspected timber decay is encountered, it must be verified by other means such as boring or coring. Hammer sounding can be satisfactorily accomplished using a light hammer. Figure 6:3-1 shows an inspector hammer sounding a concrete abutment.

Listening under load can be used to detect many problems, including loose bars in steel grid decks, settled areas, and bad expansion joints. Inspectors listen for thuds, pops, vibrations, or other unusual sounds when traffic is passing to help identify and locate problems.

The Audible Inspection procedure for bridge decks is covered in the American Society for Testing and Materials (ASTM) publication D4580-86 (1997) “Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding.”

Figure 6:3-1: Inspector Hammer Sounding a Bridge Abutment

SECTION 3.2 APPLICATIONS AND LIMITATIONS

Chain dragging is most commonly used as an aid in inspecting concrete bridge decks, but it can be used on other horizontal surfaces. Large areas can be quickly examined utilizing several chains in each drag. This method is most efficiently conducted using a two-person team.

Hammer sounding is most commonly used as an aid in inspecting concrete, but can also be used on metal fasteners and timber members. This technique works well on both horizontal and vertical surfaces. Large areas can be inspected in a reasonable amount of time only if spacing is random. However, the inspector should take care to thoroughly cover the entire surface of the element since the hammer only provides information on the local area under the point of impact. A single inspector can conduct this method of investigation, but access equipment may be needed.

Listening under load can be used on any type of bridge, but is most commonly used to detect loose bars in steel grid decks, settled areas, and bad joints. This technique is supplemental to all bridge inspections.

Chain dragging is limited to locating areas of delamination in exposed horizontal surfaces. It is not effective on asphalt-overlaid decks, since there is no difference in sounds between delaminated concrete and debonded overlays. Hammer sounding is limited to areas visually identified for possible deterioration. Deterioration may include delamination and impending spalls in exposed concrete; rotting timber; and loosened fasteners. Although chain dragging and hammer sounding are inexpensive, they can be physically demanding and time-consuming, and the inspector must be familiar with the tonal differences between sound and delaminated concrete. Traffic control is often needed for utilizing these methods on bridge decks. Listening under load is inexpensive, but requires the attention of an experienced inspector. It is best suited for low-volume bridges.

The extent of any noted defects is subject to the inspector’s interpretation of the tonal differences in the produced sound. Areas with high levels of background noise, such as those with large traffic volume or adjacent airports, industry, or construction sites will make the tonal differences difficult to distinguish. Data recording must be done manually using field sketches and photographs. Refer to Part 6, Chapter 6 for an Audible Inspection method using acoustic emissions.

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CHAPTER 5 GROUND-PENETRATING RADAR

SECTION 5.1 INTRODUCTION

Ground-penetrating radar can be used on bridges to evaluate the condition of the bridge deck, measure the thickness of an overlay, detect voiding under bridge approach slabs, locate reinforcing steel, investigate foundations, and for underwater profiling. This chapter will discuss the use of ground-penetrating radar on bridge decks and approaches, while Chapters 18 and 19 will discuss additional uses of ground-penetrating radar.

A radar system typically consists of a control unit, radar antenna, and display unit. The control unit generates a radar pulse and sends it through a cable to the antenna. The antenna transmits the pulse into the surface. When this energy encounters an interface between two materials of differing dielectric properties, such as reinforcing steel, air, moisture, or the base-course material, a portion of the energy is reflected back to the radar antenna. The received pulse is sent back to the control unit for processing/storage. The display unit (video or chart recorder) presents the data.

The reflected energy is received by the transducer, amplified, and recorded. The electromagnetic pulse is repeated at a rapid rate and the resultant stream of radar data produces a continuous record of the subsurface. The radar system creates a linear profile of the materials beneath the antenna pass. Figure 6:5-1 shows an example of radar output on a typical pavement section.

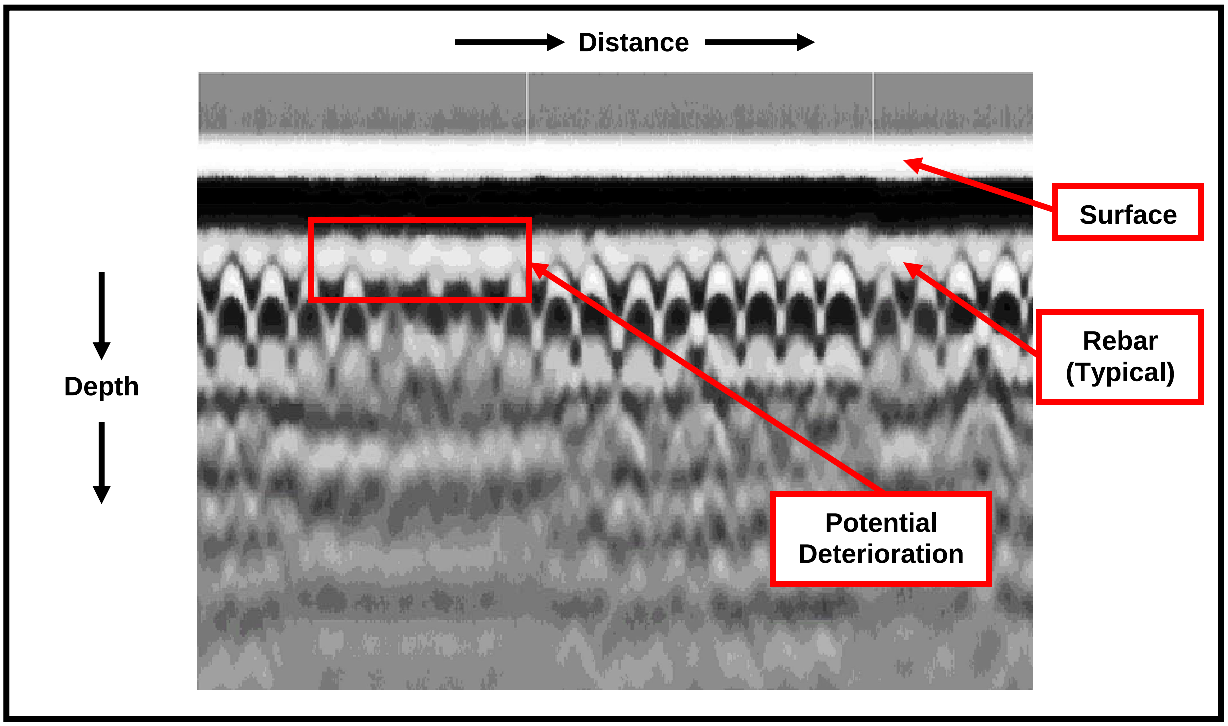

Figure 6:5-1: Typical Radar Output Image With Notations

Two different types of transducers, contact or horn types, can be mounted on a data collection vehicle, or hand-towed. Refer to Figure 6:5-2 for views of two types of vehicle-mounted transducers.

Figure 6:5-2: Horn Type (Left) and Contact Type (Right) Vehicle-Mounted Transducers

The location of the transducers can be varied across the width of the pavement and, if additional information is required, a number of passes with the antenna in different locations can be made.

For the majority of surveys, the antennae are mounted over the wheel tracks. The data is normally collected at a vehicle speed of five mph or less. Faster speeds are attainable, but the longitudinal and vertical resolution of the system is reduced. Horizontal data positioning is accomplished by using a distance transducer connected to the drive train of the data collection vehicle.

An event mark is automatically placed on the data at user-defined intervals, allowing defects to be located accurately. Once the survey is completed, a computer processes the data and the results of the survey can then be presented in a variety of formats.

Ground-penetrating radar is covered in the American Society for Testing and Materials (ASTM) publication D6087-97 (2001), “Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar.”

SECTION 5.2 APPLICATIONS AND LIMITATIONS

Ground-penetrating radar is most commonly used on concrete bridge decks with an overlay surface. This allows for an inspection of the concrete deck surface, which is hidden by the overlay surface. Ground-penetrating radar is not often used on bare concrete decks since it is not as accurate or rapid as thermography.

The ground-penetrating radar system can be used to determine the following:

- Pavement and/or overlay thickness
- Locating and/or determining the depth of reinforcing steel or mesh
- The thickness of pavement cover above reinforcing steel
- Pavement or joint types
- The size of voids beneath pavements

Ground-penetrating radar identifies areas of a concrete deck with different dielectric properties or conductivities. Some concrete, such as dry, low-permeability concrete, affect the accuracy of ground-penetrating radar to detect areas of delamination. Ground-penetrating radar is also sensitive to the presence of water and chlorides on the deck and between overlays and the base concrete, as well as the presence of debris on the deck surface. These conditions can significantly influence the accuracy of the data.

Ground-penetrating radar must be scanned perpendicular to the top layer of reinforcing steel. Therefore, inspection of some structures will require the survey to be conducted perpendicular to the flow of traffic. This will require traffic to be restricted or stopped altogether while the survey is being conducted. Frequently, several passes must be made on the deck area and the cost may be prohibitive.

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CHAPTER 4 INFRARED THERMOGRAPHY

SECTION 4.1 INTRODUCTION

Infrared thermography is used to locate and map delaminations in bridge decks. Using an infrared scanner and a video camera, infrared thermography senses temperature differences between delaminated and nondelaminated areas. A delamination in a concrete deck creates a thermal discontinuity that acts as an insulator. Thermography operates on the principal that when the sun warms the deck, the delaminated area heats up at a faster rate and reaches a higher temperature than the solid areas.

A temperature difference between delaminated and solid areas is normally established only on sunny or partially sunny days. The deck must be dry and winds must be less than 25 mph. Temperature difference is primarily related to the amount of sun, not the ambient air temperature, so inspections can be undertaken under various temperatures. Generally, these inspections are made between March and November with the use of a moving vehicle. Figure 6:4-1 shows a schematic diagram of an infrared thermography scan.

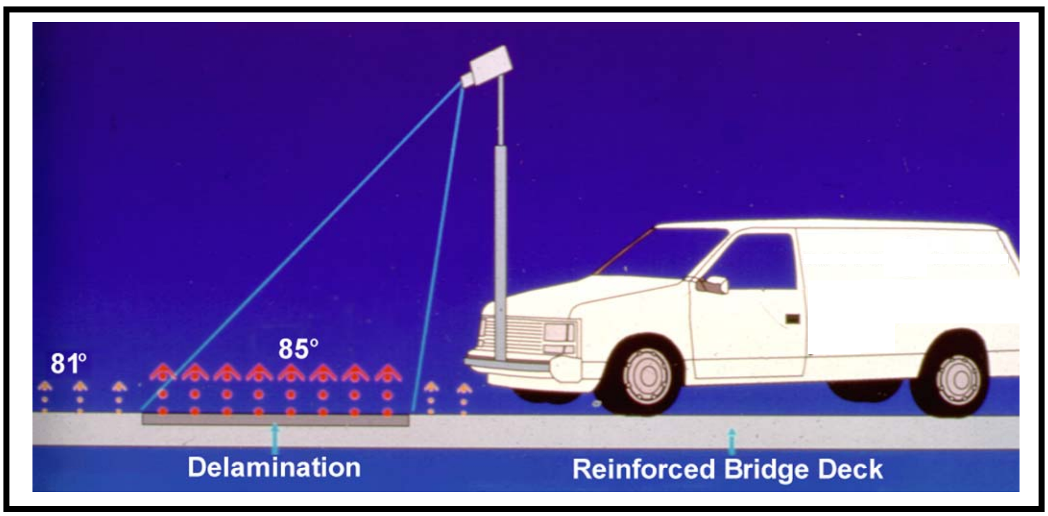

Figure 6:4-1: Illustration of Infrared Thermography of a Bridge Deck

The bridge deck is scanned from a vehicle mounted with an infrared camera. The video signal is recorded on videotape for detailed analysis in the office. A single pass, with a vehicle speed of approximately five mph, is typically made for each lane and shoulder. A video control image of the bridge deck surface is recorded simultaneously. Distance footage is superimposed onto both videotape signals to locate defects. Figure 6:4-2 shows a view of the display images from an inspection.

Field confirmation of the infrared data consists of sounding several suspect deteriorated areas and measuring surface temperatures of both suspect and solid areas. Select deck cores are taken for confirmation. The proposed core locations are typically marked at the time of the inspection.

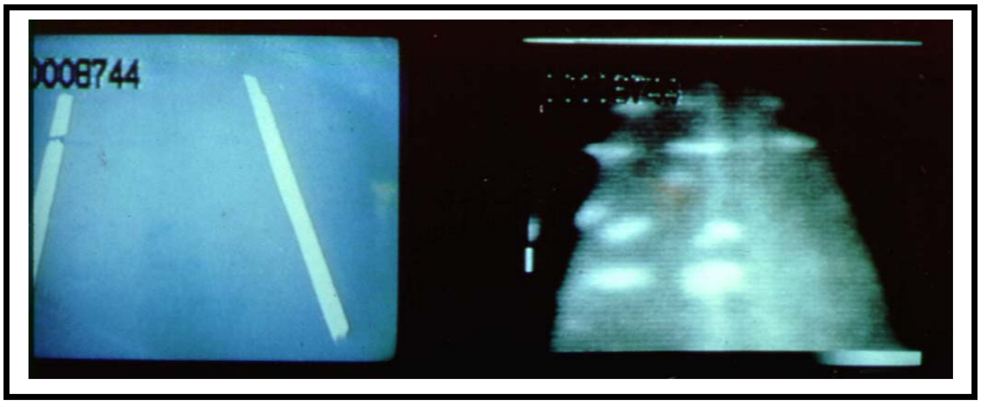

Figure 6:4-2: Video Control Image (Left) and Infrared Image (Right)

Analysis of the infrared data is completed with the aid of a computer digitization program. During the analysis, the recorded temperature variations are interpreted to identify specific, delaminated areas. Each delamination is identified and plotted onto plan view drawings of the bridge deck. Square footage and percentage of delaminated deck are calculated. The video control data is examined to make sure that temperature variations were not caused by concrete spalls, discoloration, patches, tar, or debris. In addition, the video control data is used to plot patches or spalls.

The use of infrared thermography for bridge decks is covered in the American Society for Testing and Materials (ASTM) publication D4788-88; "Standard Test Method for Detecting Delaminations in Bridge Decks Using Infrared Thermography."

SECTION 4.2 APPLICATIONS AND LIMITATIONS

Infrared thermography is most commonly used on concrete bridge decks with or without overlays; however, it can also be used on other concrete components. The method has proven to be accurate and easily repeatable.

Infrared thermography also provides for quick data collection, since the equipment can be vehicle-mounted and driven over the bridge deck. By mounting the equipment to a vehicle, the process typically results in minimal traffic disruption. Infrared thermography can be used in areas with high-traffic volumes or noise levels.

Data collection for infrared thermography is completed with the aid of computer logging software, and the image can be digitally processed for an overall assessment of the bridge deck.

Infrared thermography requires a temperature differential of approximately 0.9 degrees Fahrenheit (0.5° C) to identify the delaminated or debonded areas of a concrete deck. This typically requires that inspections be done on days when less than 50 percent of the sky is covered by clouds. Inspected areas must be dry, exposed to the sunshine, and without debris.

Thermography locates the delaminated areas in the horizontal plane and does not provide any information on the depth layer where the defect occurs. If confirmation on depth is desired, cores can be taken from the deck.

Cost may be a prohibitive factor for using this on a small number of structures since the scanning equipment and data processing software are expensive. Also, the vehicle must typically be operated by at least two inspectors. When compared to manually sounding a large deck or several smaller decks, thermography may be cost-effective and it may require less traffic control.

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CHAPTER 6 ACOUSTIC EMISSION

SECTION 6.1 INTRODUCTION

Fatigue cracks, weld discontinuities, and many other failure-causing mechanisms produce sound energy. Although a portion of the sound produced by materials under stress may exist as audible sound, most is low-energy and inaudible. An example of an audible stress release occurred at the Mianus River Bridge in Greenwich, Connecticut, where newspapers reported loud noises were heard by nearby residents days before the actual collapse occurred. At the Hoan Bridge in Milwaukee, witnesses reported a loud noise at the time of the brittle fracture of the steel girders.

An acoustic emission is defined as inaudible sound energy released within a material undergoing deformation or flaw growth. An acoustic emission test is described as a method used to detect this sound energy. To detect acoustic emissions, one or more “listening” transducers are attached to the test object. Positioning of acoustic emission transducers in the path of anticipated sound propagation enables detection. The detected signals are then electronically processed to derive information on the location and severity of growing flaws. It should be noted that “guard” transducers are also used in conjunction with the “listening” transducers to differentiate the flaws from normal bridge noises. Figure 6:6-1 shows a schematic of a basic acoustic emission test.

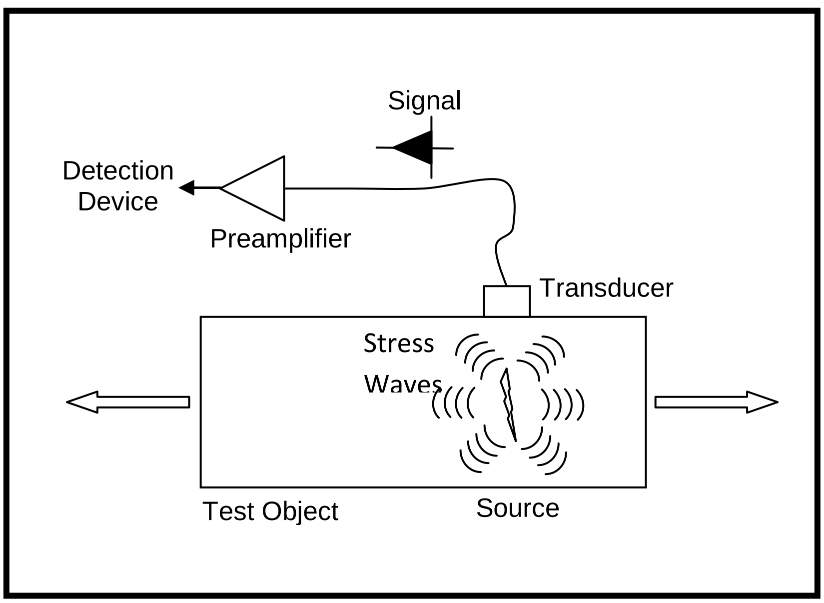

Figure 6:6-1: Acoustic Emission Test Configuration

Note: The guard transducers are not shown for clarity in Figure 6:6-1.

The detected signal is produced by the test material, not by an external source. An acoustic emission transducer acts as receiver. Acoustic emission tests detect movement, where most other methods detect existing geometrical discontinuities. An applied stress is required to cause flaw growth and, hence, the acoustic emission. The applied stress can be the result of the bridge live and dead loads, or an induced load used specifically for the acoustic emission test. In many tests, a combination of the two is necessary.

Various American Society for Testing and Materials (ASTM) standards cover acoustic emission testing and are dependent on the material and type of structural component being tested.

SECTION 6.2 APPLICATIONS AND LIMITATIONS

Acoustic emission testing is used to detect cracks, corrosion, weld defects, and material embrittlement. This method can be used on a wide variety of materials, such as metal, timber, concrete, fiberglass, composites, and ceramic.

An entire structure can be monitored with acoustic emission testing from a few locations, reducing the amount of access required. Acoustic emission testing can be conducted while the structure is in service.

Acoustic emission testing is a real-time testing method. It monitors the actual condition of the component during the test. An acoustic emission test method can also be used to record an accumulation of damage within a structure. The data obtained can be used as history for a structure, and possibly to anticipate failure.

It is difficult to differentiate the sound energy released by a growing flaw from background noise. Many background noise generators such as bolts, joint friction, and traffic can mimic or mask the sound energy released from growing cracks. Some acoustic emission test methods avoid this problem by isolating areas known to contain background noise generators.

When a global acoustic emission test is conducted to determine areas where structural problems exist, additional nondestructive or partially-destructive testing methods may be required to identify the exact nature of the defect.

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CHAPTER 7 COVERMETER TESTING

SECTION 7.1 INTRODUCTION

Covermeters, often referred to as pachometers or R-Meters, are electromagnetic devices that detect the reinforcing steel in concrete and measure its size and the depth of cover. The device produces a magnetic field and locates the reinforcing steel by measuring the distortion of the magnetic field created by the presence of the steel. The signal received increases with increasing bar size and decreases with increasing cover thickness. The covermeter can be calibrated to convert the signal into a distance, which indicates the depth of cover.

The depth of cover is important because of the relationship between cover depth and deterioration mechanisms. Inadequate cover can undermine the protection that the concrete provides to the steel reinforcement from corrosion. If the cover is too deep, there is the possibility of increased crack widths and decreased effective depth, which both affect design parameters on a concrete member. Figure 6:7-1 shows a basic covermeter.

Figure 6:7-1: View of a Basic Covermeter Unit

SECTION 7.2 APPLICATIONS AND LIMITATIONS

Covermeters can accurately measure the cover depth within 0.25 inches in the range of zero to three inches in lightly reinforced structural members. Covermeters can also locate reinforcing steel for the purpose of tying in a new structural member to an existing structure and is often used during rehabilitation.

The effectiveness of a covermeter is limited by several factors. A covermeter only locates the reinforcing steel and does not provide any actual information about defects or the material's state of deterioration. The intensity of the signal may be misinterpreted and the cover depth can be incorrectly noted as less than the true depth if more than one bar is present at a location. This problem is common in heavily reinforced structures or when large steel objects, such as scaffolding, are near the test area. Some reports indicate that the epoxy coatings on reinforcing steel can distort the readings of a covermeter. Also, the relative material properties of the concrete must be assumed to utilize conversion charts for the reading.

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CHAPTER 8 REBOUND HAMMER

SECTION 8.1 INTRODUCTION

A rebound hammer, commonly referred to as a Schmidt hammer, is a mechanical device used to measure the compressive strength of in-place concrete. The device consists of a plunger and a spring-loaded hammer. When triggered, the hammer strikes the free end of the plunger that is in contact with the concrete, which in turn causes the plunger to rebound. The extent of the rebound is measured on a linear scale attached to the device. Figure 6:8-1 shows a standard rebound hammer.

This test is covered in the American Society for Testing and Materials (ASTM) publication C805-97, "Standard Test Method for Rebound Number of Hardened Concrete."

Figure 6:8-1: Standard Rebound Hammer

SECTION 8.2 APPLICATIONS AND LIMITATIONS

A rebound hammer is used to assess the uniformity of in-situ concrete and to delineate zones of poor quality or deteriorated concrete. It is also useful to detect changes in concrete characteristics over time, such as hydration of cement, for the purpose of removing forms or shoring.

The rebound hammer is portable, easy-to-use, low-cost, and can quickly cover large areas.

The rebound hammer is valuable only as a qualitative tool since it measures the relative surface hardness of the concrete. Other tests, such as a compression test, must be used to determine the actual strength of the concrete. The rebound measurement is governed by several factors including the size, age, and finish of the concrete, as well as the aggregate type and the moisture content. A rebound hammer will give a false reading if used over exposed aggregate.

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CHAPTER 9 IMPACT ECHO TESTING

SECTION 9.1 INTRODUCTION

The impact echo method is a nondestructive testing (NDT) technique used for detecting internal flaws in concrete. It has been used on a variety of members, particularly slab, beam, and wall type members. The impact echo test method produces a transient stress pulse into a member by means of a point impact. This pulse produces a surface wave, as well as waves that travel into the element. These waves are reflected by internal defects and the boundaries of the element.

The testing apparatus consists of a handheld unit that generates an impact which produces a wave, and a receiving transducer which receives the reflected waves. A computer-based system is then used to process the data and display the echo wave form data. The operator interprets the data to determine the presence and extent of defects found. Figures 6:9-1 and 6:9-2 show an impact echo test unit and an inspector using a unit.

Figure 6:9-1: Impact Echo Test Unit

Figure 6:9-2: Inspector Using an Impact Echo Test Unit

Impact echo testing is covered in the American Society for Testing and Materials (ASTM) publication C1383-98a; “Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method.”

SECTION 9.2 APPLICATIONS AND LIMITATIONS

The impact echo technique utilizes easily transportable equipment and can be performed by one individual. Testing is fairly rapid and only minimal surface preparation is needed to assure proper transfer of the impact energy to the structure. Tests are often made on a grid pattern, with the size of the grid determined by the suspected damage. The technique can be used to locate defects such as delaminations, honeycombing, cracks, and voids. It may also locate voids around reinforcing steel and within grouted prestressing strands and post-tensioned tendons.

The impact echo method requires interpretation of the wave form output for each test by the field technician. The technician must be trained and experienced to properly interpret the output data. Prior to testing, design plans should be carefully reviewed for embedded items or other details that may affect wave behavior and test results. The presence of reinforcing steel must be properly accounted for. The maximum element thickness for this test is approximately 6.5 feet.

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CHAPTER 10 PENETRATION METHOD

SECTION 10.1 INTRODUCTION

The penetration method utilizes a device that fires a probe into the concrete using a constant amount of energy. The probe is made of a hardened steel alloy specifically designed to crack the aggregate particles and to compress the concrete being tested. Once fired, the length of the probe projecting from the concrete is measured. A test typically consists of firing three probes and averaging the projecting lengths. Figure 6:10-1 shows a Windsor Probe test kit, one of the most commonly used tests for penetration testing.

This test is covered in the American Society for Testing and Materials (ASTM) publication C803/C803M-97C1, "Standard Test Method for Penetration Resistance of Hardened Concrete."

Figure 6:10-1: Windsor Probe Test Kit

SECTION 10.2 APPLICATIONS AND LIMITATIONS

Penetration tests are used to assess the uniformity of in-situ concrete and to delineate zones of poor quality or deteriorated concrete. It is also well-suited for estimating compressive strength of concrete and the relative strength of concrete across the same structure. Penetration tests are commonly used to estimate early age strength of concrete for the purpose of stripping forms.

The penetration test method is a qualitative tool and, like the rebound hammer, it requires that other tests be conducted to determine the actual strength of the concrete being tested. The penetration method also damages the concrete at the test location. The probes must be removed and the holes patched.

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CHAPTER 11 HALF-CELL TESTING

SECTION 11.1 INTRODUCTION

Steel reinforcement is typically protected from corrosion by the alkaline nature of concrete. If the alkalinity of the concrete is compromised, corrosion on the steel will commence if moisture and oxygen are present. The corrosion reaction will promote anodic and cathodic activity along the reinforcing steel. The corrosion of the reinforcement produces a corrosion cell caused by these differences in electrical potential.

The half-cell testing method is used to determine if the reinforcing steel is under active corrosion. This method utilizes a multimeter to measure the potential difference between the steel and a half-cell apparatus. The analysis of the potential difference can indicate if active corrosion is taking place on the reinforcing steel. Refer to Figure 6:11-1 for a schematic of a basic half-cell test.

This test is described in the American Society for Testing and Materials (ASTM) publication C876-91, “Standard Test Method for ‘Half-Cell’ Potentials of Reinforcing Steel in Concrete.”

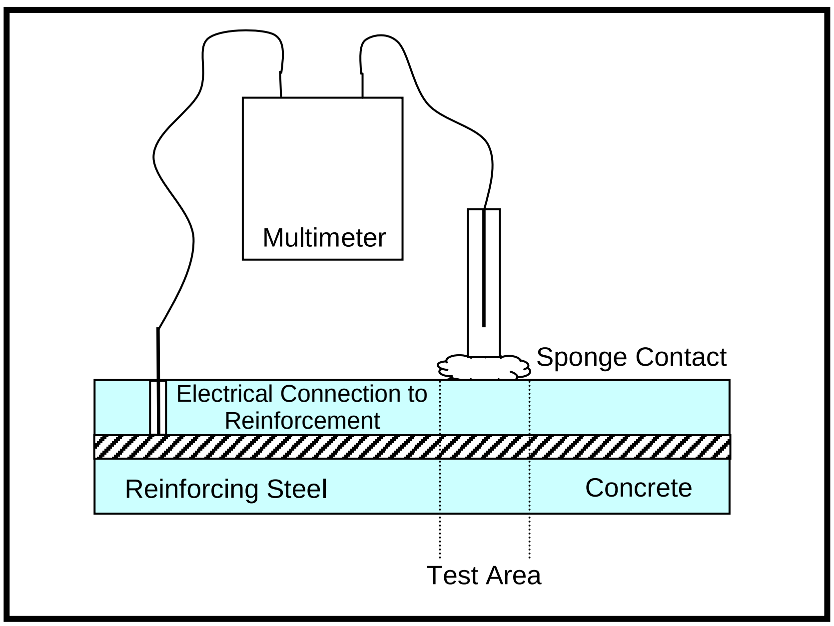

Figure 6:11-1: Basic Half-Cell Test Configuration

SECTION 11.2 APPLICATIONS AND LIMITATIONS

Although commonly used on bridge decks, the half-cell test can be performed on any reinforced concrete component, provided a direct electrical connection can be made to the reinforcing steel. Since the test can only detect corrosion directly under the device, a systematic grid of test points should be created to map the potential readings throughout the concrete component. This map can then be analyzed to determine the probable areas of active corrosion.

It is generally agreed that the potential measurements can be interpreted as follows:

- 0.00 to –0.20 volts indicates greater than 90 percent probability of no corrosion
- -0.20 to –0.35 volts indicates that corrosion is uncertain
- < -0.35 volts indicates greater than 90 percent probability that corrosion is occurring
- Positive number indicates that the moisture content of the concrete is insufficient and, therefore, test is not valid

Half-cell testing requires specialized equipment, typically including a copper/copper-sulfate half-cell apparatus and a multimeter. A connection with the reinforcing steel is required, so holes may need to be drilled in the concrete to connect to the steel. This test method only indicates the probability of corrosion present at the time of testing and does not indicate the extent or the rate of corrosion. Traffic control, access to electricity, and tools such as drills are required to perform this testing.

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CHAPTER 12 CHLORIDE ION TESTING

SECTION 12.1 INTRODUCTION

Chloride ions are the major cause of reinforcing steel corrosion in concrete. Chloride ions are most often provided from road salt, although they may also be available as contaminants in the original concrete mix. Chloride ions are not likely to cause problems unless they exist in unusually high concentrations. Since corrosion of steel reinforcing is generally considered to begin at a chloride ion content of between 0.025 percent and 0.033 percent by weight of concrete, knowledge of chloride content can aid in determining the likelihood of the onset or presence of corrosion.

A chloride profile must be developed to evaluate the concrete. The profile should show the percent of chloride concentration versus the depth below the concrete surface. This profile is important for assessing the future corrosion susceptibility of steel reinforcing and in determining the primary source of chlorides.

The chloride content in concrete is typically determined through laboratory analysis of powdered concrete samples. Field-collected, powdered samples are typically taken by drilling at different depths down to and beyond the level of the reinforcing steel. Extreme care should be exercised to avoid inadvertent contamination of the samples. Alternatively, core samples can be extracted and powdered samples can be obtained at different depths in the laboratory. The extraction of these samples destroys a portion of the component. However, since this test can be performed in the field and results obtained quickly, it has been separated from the Material Sampling section described in Chapter 13 of this part of the manual.

The chloride ion content of concrete is usually measured in the laboratory using wet chemical analysis. Although laboratory testing is the most accurate, it is time-consuming and often takes several weeks before results are available. As a result, field test kits have been developed. The use of field test kits allows rapid determination of chloride levels to be made on-site. Although the field kits are not as accurate as the laboratory method, they do provide good correlation with laboratory tests when a correction factor is used.

The detailed procedure for chloride sampling and testing is covered in the American Association of State Highway and Transportation Officials (AASHTO) publication T 260-84; “Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials,” and in the American Society for Testing and Materials (ASTM) publication C114-00; “Standard Test methods for Chemical Analysis of Hydraulic Cement.” However, both of these publications apply to testing in the laboratory, not in the field.

SECTION 12.2 APPLICATIONS AND LIMITATIONS

Chloride ion testing can be performed on any concrete component. Field kits allow inspectors to perform the test on-site and determine chloride levels immediately.

When samples are collected at different depths and plotted on a chloride profile chart, this method is a very useful tool in determining the depth of deck to be milled off prior to an overlay.

Collecting samples to perform this test requires the removal of a portion of the concrete member. Therefore, several samples cannot be taken from a single location to validate results. This method is also time-consuming and requires access to the member. In the case of a bridge deck, the bridge may need to be closed to traffic during the sampling process.

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CHAPTER 13 MATERIAL SAMPLING

SECTION 13.1 INTRODUCTION

To fully determine the condition of a structure, it may sometimes be necessary to extract material samples from the bridge so that laboratory tests can be used to determine the condition of the material, or the state of deterioration or damage. Typical laboratory tests include compressive tests and petrographic examination of concrete, tension tests, charpy tests, steel crack investigations, and integrity examination of timber.

The extent and purpose of the sampling must be determined prior to taking samples. The sample size is often stipulated by the specific test method used. In most cases, particularly where deterioration is present, it is advisable to take samples from both good and bad areas so that a comparison can be made. Once the number and location of samples is determined, they should be plotted on a drawing of the structure to aid in fieldwork and to serve as a record for the evaluation of the test results.

SECTION 13.2 APPLICATIONS AND LIMITATIONS

All materials can be sampled and tested either in the field or in a laboratory to provide useful information about the extent of deterioration and the material characteristics. Specimens should come from representative areas of the structure and typically three samples are required.

All material samples should be collected, and tests conducted, in accordance with applicable American Society for Testing and Materials (ASTM) and American Association of State Highway and Transportation Officials (AASHTO) methods for the respective materials.

The removal of material should only be used when a specific piece of information is required for the evaluation of the structure.

Repairs are required for the sample extraction holes or voids in the tested component. Concrete and timber repairs are relatively easy, but steel repairs may be more complex. Care must be taken to minimize any residual stresses or the creation of any fatigue-prone details when making a repair.

SECTION 13.3 CONCRETE TESTING

Concrete material sampling most often consists of drilled cores, though sections may also be obtained by sawing or breaking off a portion of the component. The core size should be determined by the tests to be run; however, in most cases, a four-inch diameter core is extracted. Core holes are normally filled with grout; other sample areas should also be repaired with a suitable mortar material.

Samples should be marked for location and orientation and packed to prevent damage during transport. As part of the sampling operation, reinforcing steel is typically located and marked to avoid cutting it during the sample extraction. In some instances, it may be desirable to include reinforcing steel as part of the sample. In these cases, it is necessary to confirm that the cut reinforcing steel will not jeopardize the structure's integrity. Figure 6:13-1 shows a view of a concrete coring machine and core sample.

Concrete tests that require samples include:

- Carbonation.
- Permeability.
- Cement content.
- Percent air content.
- Moisture content.
- Steel reinforcing yield strength.
- Concrete compressive strength.
- Modulus of elasticity (static & dynamic).
- Concrete splitting tensile strength.

Figure 6:13-1: Concrete Coring Machine (Left) and Core Sample (Right)

SECTION 13.4 STEEL TESTING

Material coupons for steel members are usually obtained by sawing, coring, or by collecting drill shavings. Flame cutting should be avoided because the heat induced by the cutting operation alters the material's properties in the vicinity of the cut, both in the sample and remaining base material. These heat-affected areas must then be removed by grinding prior to testing and repair to the base material is also often required. Coupon locations should be carefully selected because the properties of steel members vary over the cross-section as a result of varying rates of heat loss due to fabrication techniques and rolling/production practices. The orientation of the steel samples must be recorded prior to removal.

Steel tests that require samples include the following:

- Brinell hardness test
- Charpy impact test
- Chemical analysis
- Tensile strength test

Figure 6:13-2 shows a Charpy impact testing machine.

Figure 6:13-2: Charpy Impact Testing Machine

SECTION 13.5 TIMBER TESTING

Drilling, boring, and probing are most often used to assess the presence of voids, the extent of rot, and the depth of preservative penetration. An incremental borer is usually used to extract cores for timber sampling, although sections may also be obtained by sawing off a portion of the component. Core holes should be plugged with a treated hardwood dowel. Figure 6:13-3 shows several incremental borer core samples.

Timber cores are assessed to determine if bacterial or fungal decay is present, the extent of interior rot, and to determine the species of timber, if required. These methods typically do not produce a global sample specimen. Several local specimens from random locations can be used to get an overall picture of a member. Any holes should be plugged with a treated hardwood dowel.

Moisture content and rot can also be assessed on specimens using electrical devices, such as the Shigometer. These devices require electrodes to be driven into the timber or that small holes be drilled to insert probes into the timber. These detect the presence of timber rot; however, drilling or coring should be conducted to determine the extent of the rot.

Figure 6:13-3: Typical Incremental Borer Core Samples

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CHAPTER 14 ULTRASONIC TESTING

SECTION 14.1 INTRODUCTION

Ultrasonic testing is used to evaluate the internal (volumetric) condition of materials. Specifically, it is used to confirm suspected discontinuities or cracks, as well as check questionable material thicknesses or lengths. Typical discontinuities, which are detectable by use of ultrasonic testing, include laminations, surface cracks, and many surface and subsurface weld-related discontinuities, such as lack of fusion or porosity.

The use of sound to determine the internal properties of a member is not new; audible sound has been used as a nondestructive testing (NDT) method for centuries. For instance, striking a porcelain bowl to listen for either a ring or dull tone is an old way to detect a crack. Today, shear stud connectors used for composite bridge beams are still tested by striking them with a hammer and listening to the change in ringing note.

With ultrasonic testing, the transducer can be thought of as replacing both the hammer and ear. The transducer directs a wave of high frequency vibrations, inaudible to the human ear, into the test specimen, and then receives the returning echoes. The ultrasonic instrument provides the necessary electronics to produce these waves and display the returning echoes for interpretation.

A transducer is a device that is capable of converting energy from one form to another. In the case of ultrasonic testing, electrical energy is changed to mechanical energy and vice versa. Ultrasonic testing transducers convert electrical energy into mechanical vibrations, which in turn produce high-frequency sound waves. They also convert high-frequency sound back into electrical energy upon receiving the return echoes.

The most common ultrasonic technique currently in use in the United States is called pulse echo. The pulse echo method employs short bursts, or pulses, of waves which are transmitted into the specimen by the transducer, which must be in integral contact with the specimen. Any returning, unexpected echo from these pulses is evaluated to determine the location and size of the reflector.

The signal height or amplitude is related to the amount of reflected sound energy. Large reflectors, causing total reflection of sound, produce signal responses of higher amplitude than smaller reflectors, which only reflect a portion of sound energy. Larger return echo amplitudes suggest larger-sized flaws. Echo indications are normally retested from another position to confirm flaw size and position. Refer to Figure 6:14-1 for an illustration of pulse echo ultrasonic testing.

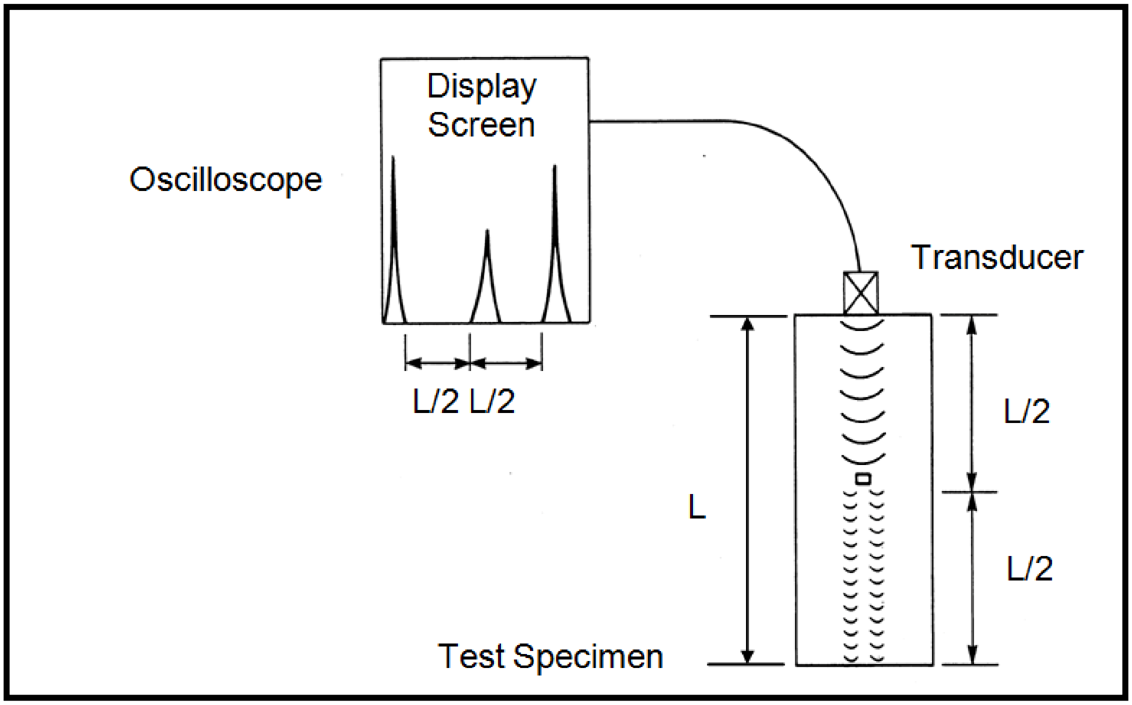

Figure 6:14-1: Illustration of Pulse Echo Ultrasonic Testing

Basic ultrasonic pulse echo systems include the following:

- Power supply
- Pulser
- Receiver/amplifier
- Oscilloscope
- Timer (clock)
- Transducer

Power for the testing equipment is supplied by portable battery packs or by an external alternating current (AC) source. The pulser, also called the pulse generator, produces the short duration burst of voltage, which is applied to the transducer. The rate of these voltage bursts is controlled by a clock or timer. Sound echoes returning to the transducer are relayed to the receiver, amplified, filtered, and sent to the display screen. Pulse echo methods include compression, shear, and surface wave modes.

Compression wave testing, also called straight beam testing, is used for flaw detection, particularly laminations, and for thickness measuring. It directs waves into the material perpendicular to the specimen's surface. Refer to Figure 6:14-2 for a schematic of the compression wave mode.

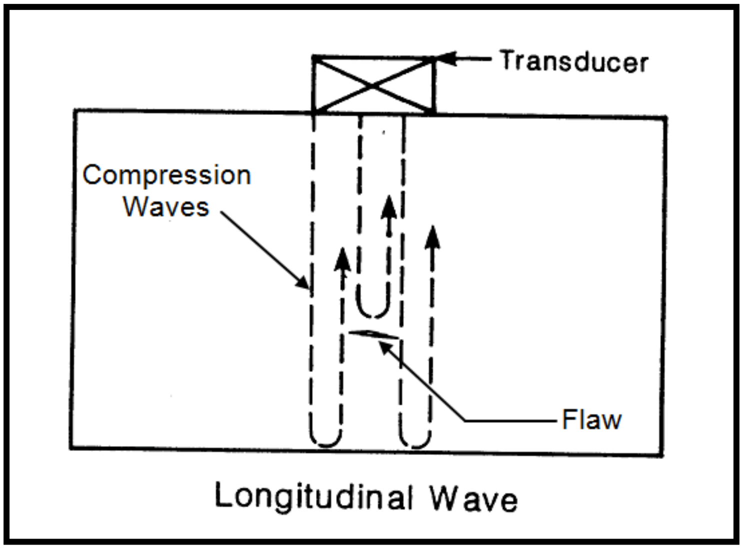

Figure 6:14-2: Pulse Echo Ultrasonic Testing Compression Wave Schematic

Shear wave testing, also called angle beam testing, is ideally suited for weld testing. Waves are directed into the material at an angle other than 90 degrees to the specimen surface. The shorter wavelength (lower velocity) increases sensitivity, and angular capability allows for weld examination at predetermined angles. Refer to Figure 6:14-3 for a schematic of the shear wave mode.

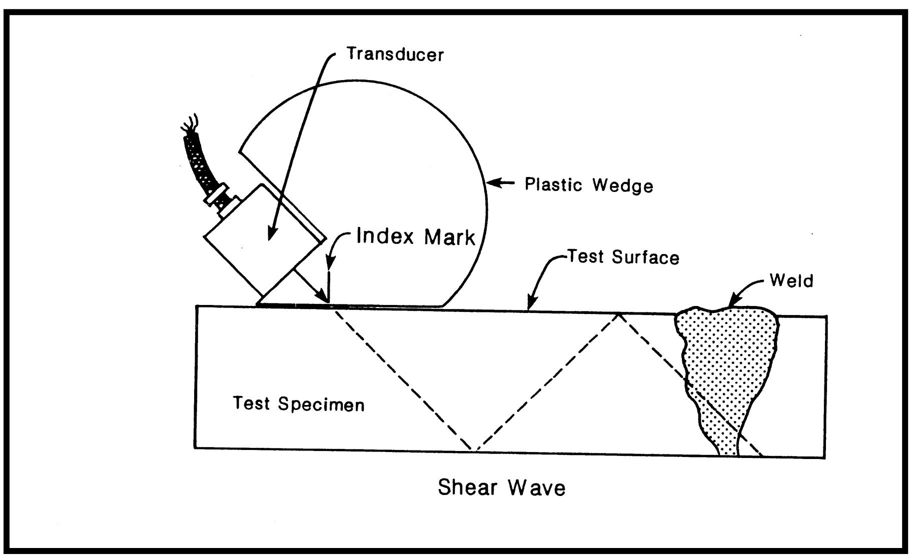

Figure 6:14-3: Pulse Echo Ultrasonic Testing Shear Wave Schematic

American Society for Testing and Materials (ASTM) standards cover ultrasonic testing dependent on the material and type of structural component. American Welding Society (AWS) standards cover ultrasonic testing of welds.

SECTION 14.2 APPLICATIONS AND LIMITATIONS

Ultrasonic testing allows an examination of the internal structure of a material when accessibility is limited to one side. It is an ideal method for the detection of flaws, which are not readily detectable by visual means. It is used to inspect a variety of both metallic and nonmetallic members, such as welds, forgings, castings, plastics, ceramics, concrete, steel sheeting, aluminum tubing, fiberglass, and timber. Since ultrasonic testing is capable of economically revealing subsurface discontinuities (variation in material composition) in a variety of dissimilar materials, it is an extremely effective and useful tool. Relatively thick specimens can be examined. Ultrasonic testing results are definitive for both bare and covered concrete slabs. Penetration of asphalt thicknesses of up to six inches has been successful. The length and integrity of piles and caissons can be determined using ultrasonic testing.

Ultrasonic testing is most successful for detecting discontinuities, which are oriented perpendicular to the direction of propagating sound. It is also often used as a complimentary method to other NDT procedures such as radiography.

The method is readily adaptable to field testing, as portable lightweight units contain a rechargeable battery having a typical eight-hour battery life. Figure 6:14-4 shows an inspector conducting ultrasonic testing in the field.

Figure 6:14-4: Inspector Conducting Ultrasonic Testing on a Sign Structure Anchor Bolt

Ultrasonic testing should not be performed on rough surfaces, on parts with complicated geometries, or where the size of the discontinuity is expected to be smaller than one-half of the wavelength. Rough surfaces may require grinding. Ultrasonic testing requires properly trained personnel who understand the limits of the accuracy of the method. Clearly written test procedures are needed. A certified Level III NDT specialist should evaluate and develop written testing procedures for any uncommon applications. It is important that the ultrasonic testing equipment be calibrated prior to each use.

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CHAPTER 15 LIQUID PENETRANT

SECTION 15.1 INTRODUCTION

Liquid penetrant testing, also known as dye penetrant testing, is used to confirm the presence of a crack or flaw. It relies on the ability of a liquid to enter into a discontinuity. Therefore, it can only find discontinuities open to the surface of the material. It can be applied to any nonporous material that is not adversely affected by the penetrant material.

The material is cleaned to remove all surface contaminants before the penetrating liquid is applied. The penetrant will seek out and enter small surface openings. Excess penetrant is removed from the test surface by wiping or rinsing with water. A drying developer is then applied and the penetrant remaining in the discontinuity bleeds out, forming a highly visible, contrasting indication on the test surface.

The characteristics of a good penetrant relate to the ability of the fluid to be drawn into small openings, even against gravity. This penetrating ability is affected by many variables, including surface tension of the liquid, wetting ability, surface condition, surface contamination, and temperature.

Two major types of penetrants used: visible dye penetrants and fluorescent penetrants. Visible dye penetrants are normally red, providing contrast with the applied white developer under visible light. Fluorescent penetrants contain dyes which fluoresce brilliantly when viewed under black light in a darkened area. Fluorescent penetrants provide better contrast than visible dye penetrants and are, therefore, more accurate. Figure 6:15-1 shows a casting with a visible dye and developer applied to the surface. Figure 6:15-2 shows a gusset plate with applied fluorescent penetrant.

The indications must be interpreted by trained personnel. Interpretation includes determining what caused the indication, evaluating the seriousness of the problem, and reporting the inspection results accurately and clearly.

Proper interpretation and evaluation of liquid penetrant indications require knowledge of the types, causes, and appearance of indications, knowledge of the test method and material fabrication process, adequate illumination, good eyesight, and experience.

This testing method is covered in the American Society for Testing and Materials (ASTM) publication E165-95 “Standard Test Method for Liquid Penetrant Examination” and the ASTM publication E1417-99 “Standard Practice for Liquid Penetrant Examination.”

Figure 6:15-1: Visible Dye Penetrant and Developer Applied to a Casting

Figure 6:15-2: Gusset Plate With Fluorescent Penetrant

SECTION 15.2 APPLICATIONS AND LIMITATIONS

Liquid penetrant tests can be conducted on a wide variety of nonporous materials, including those that are metallic and nonmetallic, magnetic and nonmagnetic, and conductive and nonconductive. This method is highly sensitive to small surface discontinuities and produces indications directly on the surface of the component, providing a visual representation of the flaw.

The penetrant materials typically come in aerosol form, making them portable and well-adapted to field use. This also allows large areas of a component to be tested rapidly, even if the component has a complex geometric shape. Powder penetrant materials are also available, but are typically cumbersome to use in the field.

Penetrant materials and the associated equipment are relatively inexpensive, especially when compared to most other nondestructive testing methods.

This method only works on nonporous materials. Also, surface finish and roughness can affect the sensitivity of the test.

It can only detect discontinuities which are open to the surface. Discontinuities filled with contaminants, paint, rust, oxidation, or corrosion products may not be detected. Therefore, pre-cleaning is critical. The process also requires multiple steps: cleaning, applying the dye/fluorescent, cleaning off the dye/fluorescent, applying the developer, and cleaning off the developer after the test is completed. This effort requires the safe handling of chemicals and the proper disposal of saturated cleaning rags and empty aerosol cans.

The test sensitivity is lowered at reduced temperatures since crack widths are typically reduced and the test medium is less fluid.

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CHAPTER 16 MAGNETIC PARTICLE

SECTION 16.1 INTRODUCTION

Magnetic particle testing is used for testing ferromagnetic materials such as steel, wrought iron, and cast iron. Magnetic particle testing is used to confirm suspected cracks or test suspect details. Magnetic particle testing is highly sensitive in detecting tight surface cracks and other small discontinuities. Cracks, lack of fusion, weld-related surface discontinuities, and base metal discontinuities are easily detected.

The magnetic particle method utilizes the principle that magnetic lines of force, when present in a ferromagnetic material, will be distorted by a change in material continuity, such as a sharp dimensional change or a discontinuity. If the discontinuity is open to, or close to, the surface of a magnetized material, flux lines will be distorted at the surface causing a condition termed flux leakage. When fine magnetic particles are distributed over the area of the discontinuity when the material is magnetized, they will be held in place and the accumulation of particles will be visible.

In magnetic particle testing, one must apply a magnetic field of sufficient strength and predetermined direction to cause flux leakage if discontinuities are present. The inspector detects these leaks by sprinkling the test area with iron filings, blowing away the excess, and observing areas where the filings have accumulated. Accumulations indicate a surface, or possibly, a subsurface discontinuity.

Magnetic particle test methods and implementation procedures are described as follows:

- In the dry method, the iron filing powder used as an indicating medium is dry. Commercial powders are available in various colors including red, black, grey, or yellow. The color should be selected to maximize the contrast with the material to be tested. Figure 6:16-1 shows a sample of test powder colors. Dry, fluorescent particles are also available for use with a black light. Dry particles are finely divided, ferromagnetic material with high permeability and low retentivity. The powder consists of a mixture of particle sizes, smaller ones being attracted by weak leakage fields, and larger ones for detecting larger discontinuities.

Figure 6:16-1: Sample Powder Colors

- If the test powders or particles are suspended in oil or water, the method is considered wet. Wet suspensions are also available in various colors and fluorescent. They can be sprayed onto the part, or the part can be bathed in a suspension. Wet fluorescent particles provide maximum sensitivity if used with the proper current, lighting, and surface preparation. Wet particles are mixed with the suspension in predetermined concentrations and particle sizes. The concentration will affect the test sensitivity. Light concentrations will produce faint indications, and heavy concentrations may provide too much coverage. They are generally smaller in size and lower in permeability than dry particles.
- The term continuous procedure is used if a magnetizing force is applied prior to the application of the particles, and terminated only after excess powder has been blown away.
- The term residual procedure is used when the particles are applied after the part has been magnetized, and the magnetizing current terminated.

A portable unit is used for the field testing of bridges. These units include a small, portable prod or yoke units with alternating current (AC) or half-wave direct current (HWDC) capability. Portable prod equipment is commonly available in amperages up to 1,500 amps. However, it can also be powered from a 115-volt, single-phase, alternating current. Direct current (DC) prods may cause arc strikes and, therefore, and should never be used on fracture critical members.

Yokes are lightweight portable units easily carried to the job site. On some yokes the legs are fixed at a set distance. On others, the legs are adjustable for various pole spacings. Yokes operate with 115-volt AC. Refer to Figure 6:16-2 for a view of a portable field kit.

Magnetic particle testing is covered in the American Society for Testing and Materials (ASTM) publication E709, “Standard Guide for Magnetic Particle Examination.”

Figure 6:16-2: Magnetic Particle Inspection Kit

SECTION 16.2 APPLICATIONS AND LIMITATIONS

Magnetic particle testing is a sensitive means of locating small and shallow surface cracks and has the ability to locate near-surface discontinuities with DC. Cracks filled with foreign material can be detected and no elaborate cleaning is necessary. This test is effective on painted surfaces.

This magnetic particle method is reasonably fast and inexpensive, and the equipment is very portable. There is also little or no limitation due to size or shape of the part being inspected. Refer to Figure 6:16-3 for a view of a magnetic particle test being performed in the field. Refer to Figure 6:16-4 for a view of a crack that was identified using magnetic particle testing.

Figure 6:16-3: Magnetic Particle Testing on a Built-Up Plate Bridge Girder Butt Weld

Figure 6:16-4: Crack Identified by Magnetic Particle Testing

This test will work only on ferromagnetic material and the magnetic field must be in a direction perpendicular to the principal plane of the discontinuity for best detection. Magnetic particle testing will not disclose fine porosity. The deeper the discontinuity lies below the test surface, the larger the discontinuity must be to provide a readable indication.

Electricity is required on-site, and must be alternating current for Fracture Critical members. DC prods should not be used on Fracture Critical members. Test surfaces should be clean and paint removed for highest sensitivity. Also, the residual magnetism may need to be removed. Experienced and knowledgeable operators are required.

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CHAPTER 17 MONITORING SYSTEMS

SECTION 17.1 INTRODUCTION

Monitoring systems provide continuous data over an indefinite time interval since the monitoring devices are typically mounted to the structure, connected to a data collection device, and left by the inspector to monitor the structure. These systems can monitor a specific component or section of the structure, or they can be designed to monitor the entire structure. The scope is dependent on the desired data, the potential problem areas of the structural components, and/or the potential areas of movement.

A monitoring system is generally comprised of a variety of sensors, a computer to collect data, and in the case of a remote system, a communication device, which transmits the data to the monitoring station for analysis. Figure 6:17-1 shows a view of a remote system computer and communication device.

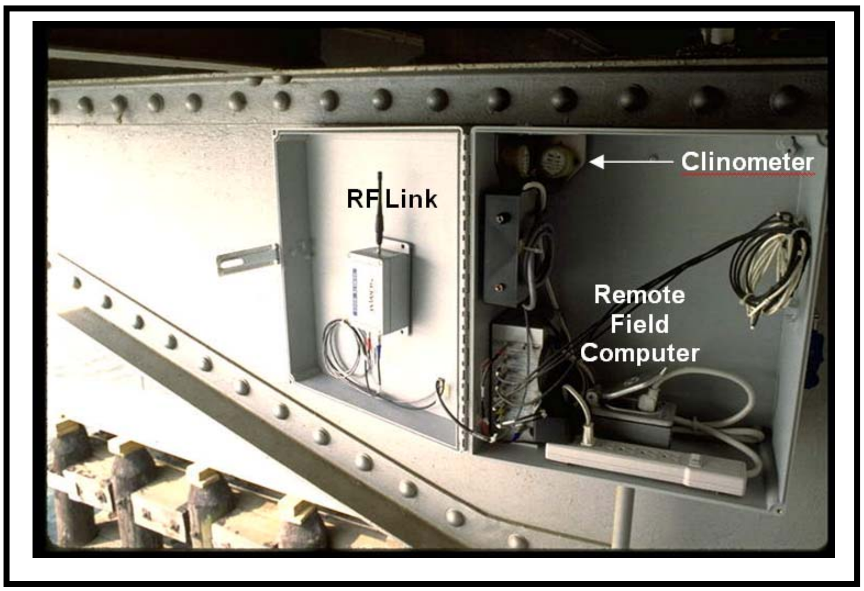

Figure 6:17-1: Remote Field Computer, Clinometers, and RF Link Mounted in an Enclosure

Sensor types include strain gauges, clinometers or tilt meters, accelerometers, and thermocouples. The term strain gauge typically covers a wide range of devices that are used, as their name implies, to measure the strains of structural members under load. Clinometers measure the inclination or tilt of a bridge component. Accelerometers measure bridge dynamics under conditions such as high winds, seismic activity, and vehicular traffic. Thermocouples measure the temperature of a bridge or its environment.

Strain gauges are the most common sensor in use today. A variety of strain gauges are available, and their selection should be made based on the location of their use, as well as the type of data and the amount of data to be collected. A strain gauge will have an established initial set length, the gauge length, which is used as a datum. The gauge will electronically measure any elongation. The elongation divided by the gauge length yields the strain at that point. This calculation is typically performed automatically by the data acquisition system. Strain gauges can also be used to measure rotational strain. Groups of gauges are usually installed in patterns determined by the type of data desired. Strain gauges are typically small and flat and do not interfere with the use of the bridge. The strain gauges are connected to a data acquisition system which records the strain data. Under real-time loading situations, the acquisition system can automatically collect data at a given time interval (e.g., every 10 minutes) to record a strain-time history.

Strain gauges are often installed at carefully selected locations on a bridge to measure strains under live load conditions. These strains may be due to traffic, wind, temperature, or applied test loads. This strain data can be evaluated directly, or converted to stresses that can be compared to calculated design stresses. Strain data allows the real performance of a structure to be compared to the theoretical design, and can provide data for an analytical model to more accurately predict actual performance. Strain gauges are also often employed to study the performance of a local area or detail for which theoretical analysis may be difficult.

In field situations, strain gauges may also be used as monitoring systems at locations of great concern, where movement or changes in stresses may be present. Figures 6:17-2 and 6:17-3 show strain gauges attached to steel bridge components. This work may be required to verify the safety in areas of uncertain stability or strength. In a system of enough sophistication, movement beyond a certain range may cause alarms to sound at the structure or at an off-site monitoring station. Therefore, strain gauges may be used at locations where it is difficult or prohibitively expensive to replace an existing structure of uncertain strength, while still allowing safe use of the structure.

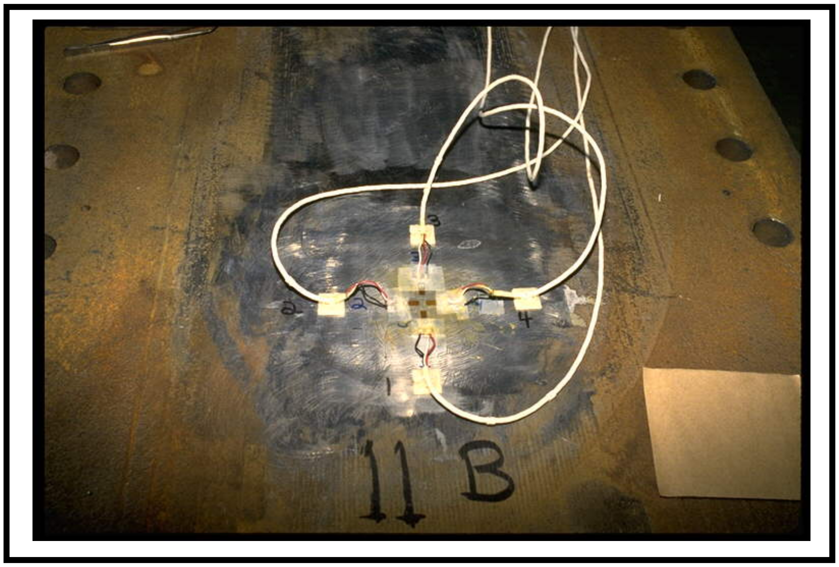

Figure 6:17-2: Strain Gauges Attached to the Steel Track Casting of a Movable Bridge

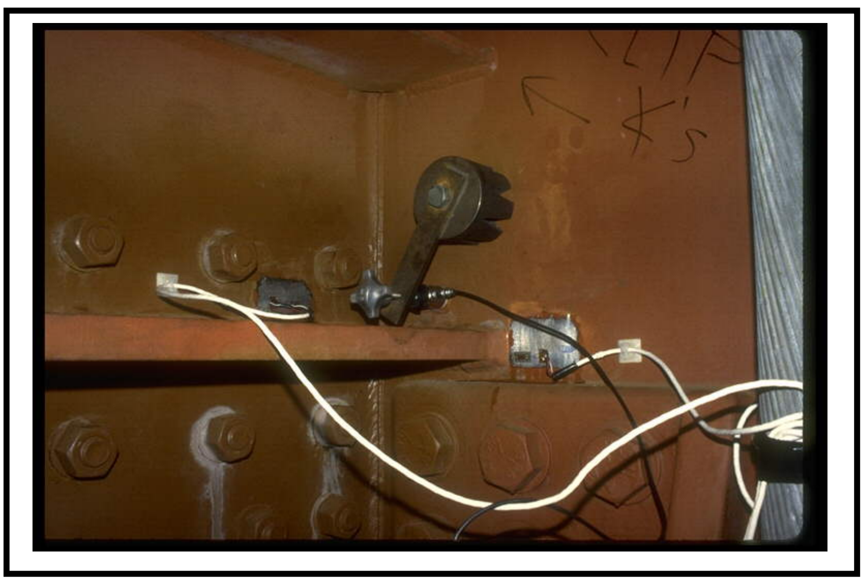

Figure 6:17-3: Strain Gauges Attached to the Tie Girders of a Tied Arch Bridge

SECTION 17.2 APPLICATIONS AND LIMITATIONS

Monitoring systems have many applications in the inspection of bridge components. The sensors are very versatile and can be applied to many materials. They typically are small and can be attached in tight fitting areas. Many have a high level of accuracy and can be applied in both static and dynamic situations. Once installed, the sensors can provide data for an indefinite period of time. The ability to continuously monitor structures or specific components allows the owner to record and clearly observe the performance and detect deterioration.

Monitoring systems do have limitations. The sensors, although typically inexpensive, are often one-time use devices. Once mounted to a particular structure, they cannot be removed and reused in another application. The sensors typically require a high level of expertise to install. The data collection and transmission devices can be expensive and require specialized individuals to gather and process the data. The data must also be analyzed and manipulated to provide useable information.

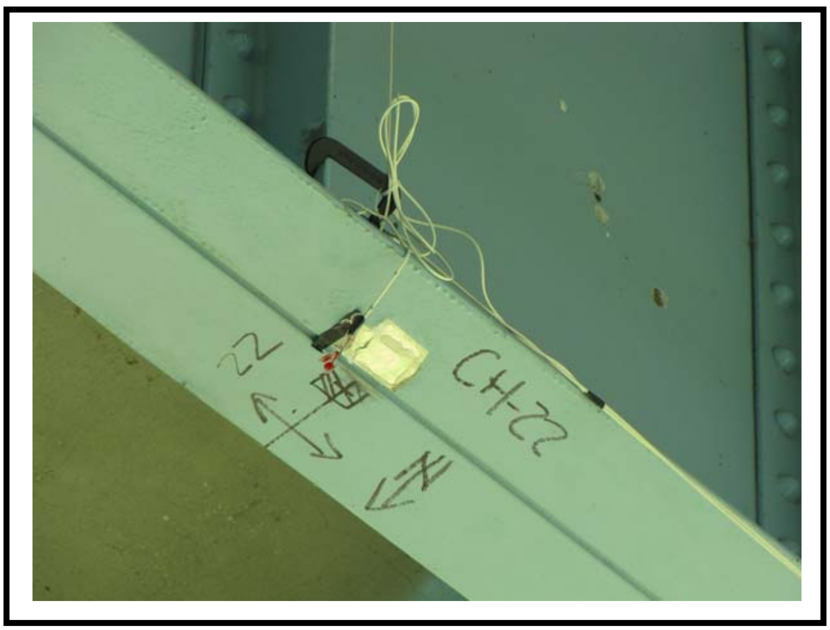

Figure 6:17-4: Strain Gauge on a Girder Flange

Figure 6:17-5: Strain Gauge Close-Up

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CHAPTER 18 UNKNOWN FOUNDATIONS

SECTION 18.1 INTRODUCTION

A large number of older bridges do not have any design or as-built plans on file to document the type, depth, geometry, or materials incorporated into their foundations. Bridges with unknown foundations potentially pose a scour safety problem. Since the undermining of bridge foundations poses a risk to the public safety, it is crucial to evaluate all bridges over or near water and determine their susceptibility to scour. Unknown foundations are also a concern when a bridge is considered for improvements.

The evaluation of unknown foundations can be conducted either by conventional methods, such as physically disruptive excavation, coring, or boring methods, or less invasive nondestructive testing (NDT) methods. Conventional methods are typically considered to be expensive, destructive, and limited in their application. Research emphasis has recently been placed on NDT methods that can inexpensively and reliably determine the foundation properties.

It is important to find the following:

- **Foundation Depth** – What is the bottom elevation of the footing, piles, or combined system?
- **Foundation Type** – Are there shallow footings, deep foundations such as piles or shafts, or a combined system?
- **Foundation Geometry** – What are the dimensions and locations of buried substructure units?
- **Foundation Materials** – Is the foundation steel, timber, concrete, masonry, or a combination?
- **Foundation Integrity** – What is the condition of the foundation?

The foundation depth and type are considered to be the most critical pieces of information in a scour evaluation. The foundation geometry, materials, and integrity are frequently desired when improvements are being considered.

In determining which NDT methods might be useful, the ability of the method to detect and to delineate the foundation components from the surrounding environment is often the deciding factor. The subsurface environment typically consists of a mixture of air, water, riprap materials, soil, and/or rock. Thus, the method needs to consider the wide range of substructure, geological, and hydrological conditions at a particular structure site.

The NDT methods used for unknown foundation investigation can be categorized into either surface methods or borehole methods. Surface methods are generally less invasive since they do not require soil disruption. Although the following list provides a brief sample of applicable methods, the inspector should be aware that other methods are also currently being researched and implemented.

Surface methods include the following:

- **Sonic Echo/Impulse Response Test:** The source and receiver are placed on the top and/or sides of the exposed pile or column. This test determines the depth of the pile or column using the identified echo time(s) for sonic echo tests, or resonant peaks for impulse response tests.
- **Bending Wave Test:** Two horizontal receivers are mounted a few feet apart on one side of an exposed pile, and then the pile is impacted horizontally on the opposite side a few feet above the topmost receiver. This method is based on the dispersion characteristics and echoes of bending waves traveling along very slender members such as piles. This method locates the bottom of the piles.
- **Ultraseismic Test:** An exposed substructure is impacted with an impulse hammer to generate and record the travel of compression or flexural waves down and up the substructure at multiple receiver locations. This test is used to evaluate the integrity and determine the length of shallow and deep foundations.
- **Spectral Analysis of Surface Waves Test:** This test involves determining the variation of surface wave velocity verses depth in layered systems. The bottom depths of exposed substructures or footings are indicated by slower velocities of surface wave travel in underlying soils.
- **Ground-Penetrating Radar:** This method uses a radio frequency signal that is transmitted into the subsurface and records the reflection echoes from the concrete/soil interface to locate the thickness and depth of a foundation.

Borehole methods include the following:

- **Parallel Seismic Test:** An exposed foundation substructure is impacted either vertically or horizontally with an impulse hammer to generate compression or flexural waves that travel down the foundation and are reflected by the surrounding soil. The reflected compression wave arrival is tracked at regular intervals by either a hydrophone receiver or geophone receiver to determine the depth of the foundation.
- **Borehole Radar Test:** A transmitter/receiver radar antenna is used to measure the reflection of radar echoes from the side of the substructure foundation. This locates the foundation bottom.
- **Induction Field:** A magnetic field is induced around the steel of the pile or reinforced concrete foundation to measure the depth of the foundation. The field strength will decrease significantly below the bottoms of the foundation.

Figure 6:18-1: Bridge With Unknown Foundations

SECTION 18.2 APPLICATIONS AND LIMITATIONS

Applications vary depending on the chosen NDT method. Refer to Figure 6:18-2 for a comparison of the NDT applications.

Method		Applications	Advantages
Surface	Sonic Echo/Impulse Response	Most useful for columnar structures. Best penetration attained in loose soils. Good for determining thickness and geometry of foundations.	Low-cost equipment and inexpensive testing. Data interpretation may be able to be automated. Theoretical modeling should be used to plan field tests.
	Bending Wave	Most useful for determining the bottom of a purely columnar substructure. Best penetration attained in loose soils.	Low-cost equipment and inexpensive testing. Theoretical modeling should be used to plan field tests. Horizontal impacts are easy to apply.
	Ultraseismic	Good for determining thickness and geometry of the foundation. Best penetration attained in loose soils.	Low-cost equipment and inexpensive testing. Can identify the bottom depth of foundation inexpensively for a large class of bridges. Combines compressional and flexural wave reflection tests for complex substructures.
	Spectral Analysis of Surface Wave	Good for determining thickness and geometry of the foundation.	Low-cost equipment and inexpensive testing. Shows variation of bridge material and subsurface velocities verses depth and thickness of accessible elements. Must have access to the top of the footing.
	Ground-Penetrating Radar	Can indicate geometry of inaccessible elements and bedrock depths.	Low testing costs. Fast testing times.
Borehole	Parallel Seismic	Accurate for determining foundation bottom depths for a large range of structures. Under certain conditions, can indicate foundation orientation.	Low-cost equipment and inexpensive testing. Can detect foundation depths for largest class of bridges and subsurface conditions. Can be used to find the depth of complex foundations.
	Borehole Radar	Good for determining foundation parameters. Sensitive to detecting steel or steel reinforced members.	Relatively easy to identify reflections from the foundation; however, imaging requires careful processing.
	Induction Field	Highly sensitive to detecting steel or steel reinforced members that are electrically connected to the surface.	Low-cost equipment. Easy to test. Compliments Parallel Seismic in determination of pile type.

Figure 6:18-2: Comparison of NDT Methods

Refer to Figure 6:18-3 for a comparison of the limitations of the methods discussed.

Method		Applications
Surface	Sonic Echo/Impulse Response	Response complicated by bridge superstructure elements. Can only detect large defects. Stiff soils and rock limit penetration.
	Bending Wave	Response complicated by various bridge superstructure elements. Response complicated by stiff soils that may show only depth to the stiff soil layer.
	Ultraseismic	Cannot image piles below the cap. Difficult to obtain foundation bottom reflections in stiff soils.
	Spectral Analysis of Surface Wave	Cannot image piles below the cap. Use restricted to bridges with long, flat access for testing.
	Ground Penetrating Radar	High-cost equipment. Signal quality is highly controlled by environmental factors. Adjacent substructure reflections complicate data analysis.
Borehole	Parallel Seismic	Difficult to transmit large amount of seismic energy from pile caps to smaller (area) piles.
	Borehole Radar	Radar response is highly site-dependent (very limited response in conductive, clayey, salt water-saturated soils).
	Induction Field	The reinforcement in the columns is required to be electrically connected to the piles underneath the footing. Only applicable to steel or reinforced structure. Requires a cased boring.

Figure 6:18-3: Comparison of Limitations

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CHAPTER 19 HYDROGRAPHIC SURVEY

SECTION 19.1 INTRODUCTION

Hydrographic survey is known as underwater profiling, bottom profiling, or water-depth sounding. This process is used to obtain underwater surface elevation data for evaluating the channel bottom surrounding a structure and the waterway in general. Similar to a topographic land survey, a hydrographic survey consists of a series of elevation measurements over a particular area in a waterway. Refer to Chapter 7 in Part 4 for discussions on scour inspections with hydrographic surveys. The level of accuracy in hydrographic surveying varies greatly based on the equipment and methods used. The United States (U.S.) Army Corps of Engineers has specifications and general requirements for hydrographic surveying. There is a process to become a certified hydrographic surveyor. However, scour inspections typically require the use of simplified methods performed by an individual familiar with the applications and limitations of water depth measurements near a bridge.

The inspector determines channel bottom elevations, and then compares the values to previous data. It is necessary to measure the water level at the time of the inspection against a benchmark or known elevation on the substructure. This location of the known elevation should be documented in the Central Database and should be permanently marked on the structure.

SECTION 19.2 APPLICATIONS AND LIMITATIONS

Hydrographic surveys evaluate channel bottom movement. The methods include: lead line, sounding pole, fathometer, multi-beam sonar, and other complex systems.

A lead line is a standard surveyor's tape with a weight attached to the end. The inspector lowers the lead line until the weight comes to rest on the channel bottom. The inspector then pulls the line taut and records the reading from the channel bottom to the waterline or top of the deck. An inspector working from the top of the deck most often obtains lead line readings.

Lead lines are limited by the softness of the channel bottom. The swiftness of the current can introduce horizontal drift into the line or cause a lightly weighted tape to drift downstream. It takes a significant amount of time to lower and raise the tape for each new measurement position. This method is also prone to inaccuracies based on the experience of the inspector.

Figure 6:19-1: Inspector Using a Sounding/Range Pole

A sounding pole is an extendable, graduated rod. An inspector in the water or in a boat places the pole vertically on the channel bottom and records the measurement at the waterline. The inspector then records the distance from the waterline elevation to a known elevation on the structure. Refer to Figure 6:19-1 for a view of an inspector using a sounding pole.

Sounding poles are limited by the softness of the channel bottom. It can be dangerous and difficult to use this method in swift currents or where the bottom is uneven.

The most commonly used electronic sounding device is a 200 kHz black-and-white fathometer, most often referenced as fish finders. This device uses a transducer just below the waterline and repeatedly transmits sound energy through the water column. The time interval between the transmission of the sound pulse and the returning echo from the channel bottom is used to automatically calculate a depth measurement that is recorded onto the device. Figure 6:19-2 shows an example of a black-and-white fathometer reading.

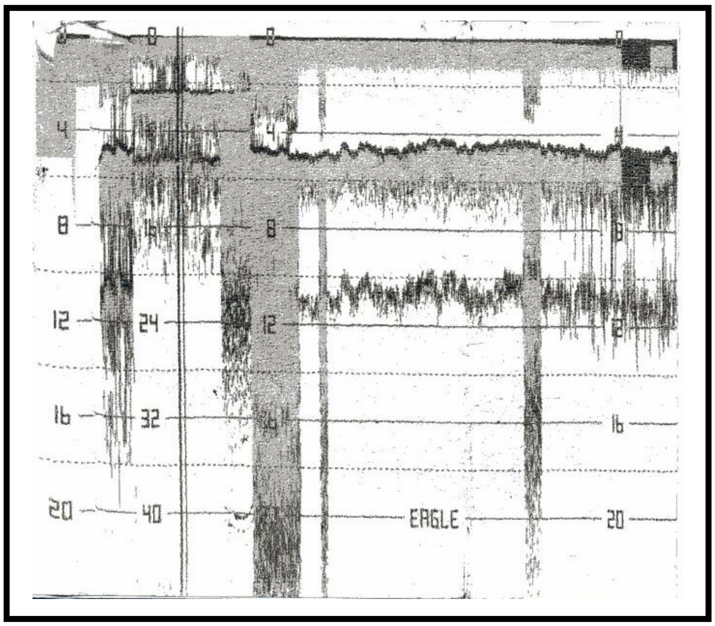

Figure 6:19-2: Example of a Black-and-White Fathometer Reading

A color fathometer works in the same fashion as a black-and-white fathometer, but it transmits at a lower frequency, usually 25 kHz, and will penetrate up to 10 feet into the channel bottom. The display will indicate materials of different densities as different colors. This can be useful in determining if any silt or timber debris infilling of previous scour holes has occurred.

Fathometers are limited by their ability to detect refilled scour holes. They are subject to false readings from heavy drift or heavy turbulence. Care must be taken to avoid a distorted scale on the readout due to varying boat speed. They provide only limited information about the sub-bottom.

Continuous seismic-reflection profiling (CSP) is a more complex system utilizing low-frequency sonar to transmit seismic energy from a transducer through the water column and into the channel bottom. It can be either fixed-frequency or swept-frequency. Fixed–frequency systems typically use a 3.5-, 7-, or 14-kHz signal, whereas the swept-frequency systems typically use a signal that sweeps from 2- to 16-kHz. The swept-frequency CSP system can be used in water as shallow as one-foot deep, can penetrate up to 200 feet in some silts and clays, and may be able to detect layers as thin as three inches. Exposed pier footings, scour depression geometry, and scour depression infill thickness can often be detected with this device.

The data collected by a CSP system can be affected by side echoes and by multiple reflections. Side echoes from the shoreline or piers will interfere with the true echo from the channel bottom. Water-bottom multiple reflections occur when the echo is bounced back and forth between the channel bottom and the surface, creating multiple readings. These are most evident when the water-bottom reflection coefficient is large, such as in a river with a hard bottom.

Ground-penetrating radar systems radiate short pulses of electromagnetic energy from a broad-bandwidth antenna. These systems typically use a signal of 80-, 100-, or 300-MHz. Scour depression geometry, scour depression infill thickness, and riverbed deposition can often be detected using this technique. Penetration up to 40 feet into resistive granular material can be attained and layers as thin as two feet can be detected. However, ground-penetrating radar systems will not work in soils or waters that are highly conductive due to chlorides or pollution.

Ground-penetrating radar is typically only useful in fresh water less than 20-feet deep with granular bottom and sub-bottom sediments.

Multi-beam sonar utilizes high-frequency sound waves to generate pictures of underwater elements. An ultrasonic transducer placed below water emits sound waves that travel through the water towards an object. These are reflected back to the transducer for processing by the computer software. Multi-beam sonar utilizes numerous sound beams side by side. The beams are stitched together by the software to create a continuous image, producing near-photo-quality images. The units operate at very high frequency, which provides good detail and resolution.

Multi-beam sonar provides highly detailed images of bridge substructures and the adjacent channel bottom. The resulting data can be used to evaluate channel scour and locate major substructure damage. The multi-beam equipment is expensive and requires specially trained personnel. It is difficult to use in high-velocity flow conditions.