Bridge Inspection and Rating Manual

Montana Department of Transportation

May 2022 - Interim

ACKNOWLEDGMENTS

The May, 2022 Interim edition of Montana's Bridge Inspection and Rating Manual (BIRM) was developed by the Montana Department of Transportation Inspection Unit, with oversight and technical assistance provided by the following:

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The Montana Department of Transportation acknowledges the following organization and publication for information utilized in the development of Chapter 3 of this Bridge Inspection and Rating Manual:

Connecticut Department of Transportation: *Bridge Inspection Manual*

Table of Contents

Preface

i. Purpose

This May, 2022 MDT Interim Bridge Inspection and Rating Manual (BIRM) is an update to the 2018 BIRM. It incorporates many of the changes in procedures and policies that have been established through 2021 The development of Montana's Bridge Inspection and Rating Manual is on-going, and therefore this is an interim manual intended for use by bridge inspectors for the inspection of highway bridges within the state of Montana, until it is superseded by a planned December, 2022 BIRM. The December, 2022 BIRM is planned to incorporate additional procedures and policies that are currently being revised by both FHWA and Montana's Department of Transportation. Below are tables which illustrate and summarize the current and proposed future changes to the content of the various chapters within this manual.

This interim manual is intended to provide an update, supplement and consolidation of information regarding the evolving inspection and evaluation procedures for Montana's bridges. Thus, the new/revised content came from multiple memorandums, new policies, inspection resources and the need for clarification based on QC/QA reviews of inspection reports and activities. Templates, checklists, tables and flowcharts have been added, typically in appendices, to guide and improve inspection, data collection, coding and reporting. Also, significant content has been removed, where it made more sense to reference source manuals for that content. Examples of removed content include Chapters 3 through 6 – NBE/MBE coding tables; fatigue prone details and ultrasonic calibration procedures in Chapter 7; Chapter 8 Load Rating – being developed as a separate manual and Chapter 10 – Federal Coding Guide. Lastly, Chapter 9 procedures for Underwater Inspection, have not been changed from the 2018 BIRM, as MDT is in the process of revising those policies and procedures.

The procedures and descriptions in this manual conform to American Association of State Highway and Transportation Officials (AASHTO) standards, Federal Highway Administration (FHWA) administrative rules and Montana Department of Transportation (MDT) policy. Discussion and the examples in this manual represent the most common bridge types in Montana.

If there is conflicting information or requirements between this manual and the National Bridge Inspection Standards (NBIS), the NBIS will govern. Inspectors are not relieved from the responsibility of complying with the NBIS even when a conflict exists. If a conflict is discovered, notify the Bridge Management Section as soon as possible.

MDT uses a database management system software referred to as the Structure Management System (SMS) to manage bridge data, track and report system-wide conditions, and perform analysis that supports bridge funding decisions. The platform for this database has recently changed over to AASHTOWare BrM and so the transition and changes to data entry are also on-going and will be consolidated and clarified in the December, 2022 BIRM.

Depending on Montana's timeline for incorporating the New NBIS Regulations (effective starting June 6, 2022) the December, 2022 BIRM will begin to incorporate those requirements as well.

BIRM Changes from 2018 to 2022 Interim Manual:

Chpt #	2018 Manual	Chpt #	May, 2022 Interim Update
1	Program Organization	1	Program Organization - Update
2	Bridge Inspection	2	Bridge Inspection – Update / Supplement
3	Deck, Slab and Top Flange Elements	3	Inspection and Documentation Procedures - New
4	Superstructure Elements	4	Agency Defined Elements (Coding Tables)
5	Substructure Elements	NA	NA – Reference latest MBEI
6	Culvert Elements	NA	NA – Reference latest MBEI
7	Steel, P&H and FC Inspections	7	Steel, P&H and FC Inspections – content reduction and minor update plus Climbing Bridges as Appendix
8	Load Rating and Posting	NA	Removed
9	Underwater Inspection	9	Underwater Inspection – no change
10	Federal Coding Guide	NA	NA – Reference instead
11	Commentary (no content)	NA	NA – Not necessary

Proposed BIRM Changes from May, 2022 Interim to December, 2022 Manual:

Chpt #	May, 2022 Interim Update	Chpt #	December, 2022 Update
1	Program Organization	1	Program Organization - Update
2	Bridge Inspection –	2	Bridge Inspection - Update
3	Inspection and Documentation Procedures	3	Inspection and Documentation Procedures - adjustments
4	Agency Defined Elements (Coding Tables)	4	Additional ADE add-ons
NA	NA	5	NBE and BME Clarifications
NA	NA	6	Inventory Coding Clarification (may include SNBI Coding)
7	Steel, P&H and FC Inspections	7	Steel, P&H, FC Inspections
NA	NA	NA	
9	Underwater Inspection	8	Underwater Inspection – Major Update

ii. Interim Manual Format

This manual is formatted into chapters that cover major areas of inspection evaluation. Each chapter is divided into sections that cover specific issues and needs.

Chapter 1 – Program Organization

This chapter provides a brief background and overview of the bridge inspection program and the five primary responsibilities of the program. On-System, Off System, Major bridges and Minor bridges are defined. The functions and responsibilities of the Bridge Management Section and District Offices are listed. Chapter 1 concludes with MDT staff positions, qualifications and roles.

Chapter 2 - Bridge Inspection

Chapter 2 provides significant information regarding multiple aspects of bridge inspection. It covers minimum qualifications for inspection staff, by title, to meet both the NBIS and MDT's requirements for compliance. Bridge inspector training and documentation of such is covered. Various inspection types are listed and described. Lower and Higher risk bridges are described as well. Inspection manuals, equipment, tools, general procedures and methodologies are reviewed. A general review of Element Level inspection, condition coding, reporting, Significant Change reporting and Guidance for Repair Suggestions is provided. Critical Findings procedures are covered for both State-Owned and Non-State-Owned bridges. Procedures and record-keeping requirements are provided for Quality Control by Districts and Quality Assurance by Bridge Management. Consultant Inspection requirements are covered. Illustrations and descriptions of common bridge elements are provided, including Agency Defined Elements for clarity. Element matrix tables grouped by categories as well as material defect hierarchy tables are provided for inspector's use and reference. A numerical listing and description of MDT's inventory items, as they currently stand, is provided.

Chapter 3 – Condition Evaluation Procedures

Chapter 3 is comprised of 7 sections. Section 3.1 is an introduction that describes the purpose and MDT guidance on bridge numbering, bridge labeling convention, and the method for measuring, documenting and coding clearance measurements, as well as clearance posting requirements. It also includes guidance for bridge traffic safety features, bridge and span length coding, scour coding for canals, Measurement Forms, note taking / narrative fields (i.e. for object marker documentation), condition coding for rehabilitated elements and pedestrian bridge inspection. Sections 3.2 through 3.6 cover specific requirements for inspection and documentation for each of the various types of inspections (Initial / Inventory, Routine, Underwater, Fracture Critical, Damage, and Follow-up). These requirements include the proximity and extent of visual and physical inspection and when forms and photos are required. They also include report review requirements, and maintenance considerations. The last section, 3.7, contains alternative supplemental inspection methods which focuses on the benefits, methods and procedures for both Climbing/Rope Access and Unmanned Aerial Systems (UAS) techniques for difficult access locations.

Chapter 4 – Agency Defined Elements

All current Agency Defined Elements (ADEs) are provided in standard MBEI coding table format for use in identifying and condition state coding of all relevant Agency Defined Elements for each bridge.

Chapters 5 & 6 – No longer used / needed

Chapter 7 - Steel, Pin and Hanger, and Fracture Critical Inspections

Chapter 7 begins with a brief history of steel fracture critical bridge failures in the United States, providing emphasis for the reason for proper steel bridge inspections. This chapter includes discussion on fatigue, stress and redundancy and the proper inspection and reporting of Fracture Critical bridge members and Other (Pin and Hanger) Inspections. This chapter concludes with magnetic particle inspection techniques It also now includes "Climbing Bridges" in Appendix 7A.

Chapter 8 - No longer used / needed

Chapter 9 - Underwater Inspection

This chapter focuses on the underwater inspection of the channel and its effect on substructure. Discussion includes stream stability and scour and recording of this data. In this manual, this chapter remains unchanged from the 2018 BIRM Chapter 9; however, much of it has been superseded by various MDT Interim Memos. This Chapter will be updated to reflect all new procedures in the December, 2022 BIRM. Note that some of the outdated language in other chapters has begun to be replaced (i.e. Type 1 Underwater Inspection replaced with Probe and Wade).

Chapter 10 – No longer used (reference FHWA Federal Coding Guide)

iii. Revisions

Since this is an Interim Manual, any identified need for revisions should be documented for incorporation into the proposed 2022 BIRM manual being developed by the end of 2022. After that time, the manual will be updated to incorporate periodic revisions based on the practices outlined by FHWA, AASHTO and the MDT. The Bridge Management Section will review Montana bridge inspection practices and procedures for compliance with the Code of Federal Regulations (Title 23 CFR 650.3), AASHTO Manual for Bridge Element Inspection (MBEI), and FHWA Recording and Coding Guide for Structure Inventory and Appraisal of the Nation's Bridges. In addition, the Bridge Management Section will review comments from the MDT inspection community. We encourage users to submit any errors, recommendations or revisions to the Bridge Management Section.

iiii. Abbreviations and Acronyms

Manuals / Standards and Terminology	
Abbreviation / Acronym	**Measurement**
ADE	Agency Defined Element
ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
ANSI	American National Standards Institute
ArcGIS	A software which provides Geographic Information System services
ASNT	American Society for Nondestructive Testing
AWS	American Welding Society
BF	Both Faces or Bottom Flange (depending on context)
BIRM (MDT)	Bridge Inspection and Rating Manual
BIRM (FHWA)	Bridge Inspector's Reference Manual
BLM	Bureau of Land Management
BME	Bridge Management Element
CoRE	Commonly Recognized Structural Elements (AASHTO)
CTDOT	Connecticut Department of Transportation
DBIC	District Bridge Inspection Coordinator
DMS	Degrees Minutes Seconds
DT	Destructive Testing
EV	Emergency Vehicle
FAA	Federal Aviation Administration
FC	Fracture Critical

Manuals / Standards and Terminology	
Abbreviation / Acronym	**Measurement**
FCM	Fracture Critical Member
FF	Far Face
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standards
FRP	Fiberglass Reinforced Polymer
FSD	Fatigue Sensitive Detail
GRS-IBS	Geosynthetic Reinforced Soil-Integrated Bridge Systems
GVW	Gross Vehicle Weight
IIW	International Institute of Welding
IRATA	Industrial Rope Access Trade Association
LRFR	Load and Resistance Factor Rating
LRS	Linear Referencing System
MBE	Manual for Bridge Evaluation
MBEI	Manual for Bridge Element Inspection (AASHTO)
MBS	Minimum Breaking Strength
MDT	Montana Department of Transportation
MDT ID	MDT Bridge ID Number
MHP	Montana Highway Patrol
MPO	Metropolitan Planning Organization
MT	Magnetic Particle Testing or Montana (depending on context)
MDTSID	Montana Structure Identification
MUTCD	Manual for Uniform Traffic Control Devices
NBE	National Bridge Element
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NDT	Non-Destructive Testing
NF	Near Face
NHI	National Highway Institute
NHS	National Highway System
OSHA	Occupational Safety and Health Administration
P&H	Pin and Hanger
P/S	Prestressed
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
RC	Reinforced Concrete
SHV	Specialized Hauling Vehicle
SIP	Stay-In-Place
SMS	Structure Management System

Manuals / Standards and Terminology	
Abbreviation / Acronym	**Measurement**
SNBI	Specification for National Bridge Inspection
SPRAT	Society of Professional Rope Access Technicians
SR	Sufficiency Rating
STRAHNET	Strategic Highway Network
TE	Transporter Erector
TL	Team Leader
UAS	Unmanned Aerial System(s)
UBIV	Under-bridge Inspection Vehicle
UPN	Uniform Project Number
USDA	U.S. Department of Agriculture

Units of Measure	
Abbreviation / Acronym	**Measurement**
AVE	Average
CL	Centerline
DEG	Degree
DP	Deep/Depth
FD	Full Depth
FH	Full Height
FL	Full Length
FT	Foot or Feet
FW	Full Width
H	High
HZ	Horizontal
IN	Inch
L	Long/Length
LAT	Lateral
LF	Linear Feet
LONG'L	Longitudinal
MAX	Maximum
MEAS'D	Measured
MIN	Minimum
MSMT	Measurement
SQIN	Square Inch
TV	Transverse
VT	Vertical
W	Wide/Width

Field Note Defects	
Abbreviation / Acronym	**Defect**
AGG	Aggradation or Aggregate (depends on context)
AL	Active Leakage (typically joint related)
AR	Abrasion Rust (typically at connections)
BOT	Bottom
CHK	Check
COND	Condition
CR	Crack
CS	Condition State (generic, without a numerical association)
CS-1,CS-2,CS-3,CS-4	Condition State 1,2,3,4
DAM	Damage
DELAM	Delamination
DET	Deteriorated/Deterioration
EFFLO	Efflorescence
ENV	Environment
EXP	Exposed or Expansion (depends on context)
HA	Hollow Area (hollow sounding but no perimeter cracks)
HLCR	Hairline Crack
HVY	Heavy
IMP DAM	Impact Damage
INSP	Inspection, Inspect, Inspected
LAM	Laminated
LR	Laminated Rust
LT	Light or Left (depends on context)
MATL	Material
MOD	Moderate
MPCR	Map Crack
PERF	Perforation
PH	Pothole
PP	Peeling Paint
PROT	Protective/ Protection (as in protective coating or scour protections)
PTT	Pitting
REP/REP'D	Repair/ Repaired
RT	Right
RTH	Rusted through hole
SC	SCALE
SEV	Severe

Field Note Defects	
Abbreviation / Acronym	**Defect**
SL	Section Loss
SP	Spall
SR	Surface Rust
SURF	Surface
TYP	Typical
W/	With….

Materials	
Abbreviation / Acronym	**Material**
AL	Aluminum
BIT	Bituminous
CONC	Concrete
GALV	Galvanized
MAS	Masonry
P/S	Prestressed
P/T	Post Tensioned
RC	Reinforced Concrete
STL	Steel

Bridge / Roadway / Channel Notes	
Abbreviation / Acronym	**Name**
AB	Anchor Bolt
ABUT	Abutment
AOL	Ahead on Line (Upstation)
APPR	Approach
BF	BF Flange
BOL	Back on Line (Downstation)
BR	Bridge
BRG	Bearing
CMP	Corrugated Metal Pipe
COL	Column
CONN	Connection
D/S	Downstream
DIAPH	Diaphragm
DWL	Dashed White Line or Double White Line (rare)

Bridge / Roadway / Channel Notes	
Abbreviation / Acronym	**Name**
DWNSTA	Downstation
DYL	Double or Dashed Yellow Line
EB	Eastbound
ED	End Diaphragm
ELAST	Elastomeric
EMBK	Embankment
ET	End Treatment (guide rail end)
FB	Floorbeam
FLG	Flange
FTG	Footing
GIRD or G	Girder
GP	Gusset Plate
GR	Guardrail
HWY	Highway
LL	Live Load
LN	Lane
MT##	Montana State Highway (i.e. MT40 = Montana State Highway 40)
NB	Northbound
O/LAY	Overlay
P&H	Pin & Hanger
PED	Pedestal
PL	Plate
PPT	Parapet
RCP	Reinforced Concrete Pipe
RDWY	Roadway
RET	Retaining (Wall)
RR	Railroad
SB	Southbound
SIP	Stay-in-Place (formwork)
STIFF	Stiffener
STR	Stringer
SUB	Substructure
SUPER	Superstructure
SWL	Solid White Line
SYL	Single Yellow Line
TF	Top Flange
U/S	Upstream
UPSTA	Upstation

Bridge / Roadway / Channel Notes	
Abbreviation / Acronym	**Name**
WB	Westbound
WL	Water Line
WS	Wearing Surface
WW	Wingwall

Chapter 1- Program Organization

1.1 Background

During the highway expansion of the 1950s and 1960s, inspection and maintenance of bridges was not considered a high priority. After the collapse of the Silver Bridge in Point Pleasant, West Virginia in 1967, a National Bridge Inspection program was developed. This program emphasized inspection frequency, inspector qualifications, reporting format, and inspection and rating procedures. Several other bridge failures established the expansion of the national program to include culverts and underwater and fracture critical components. In the mid-1990s, there was a movement to evaluate individual components of a bridge utilizing the AASHTO Guide for Commonly Recognized Structural Elements (CoRE), published in 1998. AASHTO revised the CoRE Manual in 2013 to the MBEI Manual and updated the publication in 2015 and 2019 to revise Condition States and eliminate Smart Flag language. This MDT BIRM is based on the latest Manual for Bridge Element Inspection and FHWA’s Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges.

1.2 Overview

The MDT Bridge Inspection Program is administered by the Bridge Management Section of the Bridge Bureau and operates under the auspices of the Federal Highway Administration (FHWA) in accordance with National Bridge Inspection Standards (NBIS). The five primary responsibilities of the Bridge inspection program are:

- Maintain Public Safety and Confidence (Structural Concerns)
- Protect Public Investment (Maintenance Concerns)
- Maintain a Desired Level of Service (Functionality Concerns)
- Provide Accurate Bridge Records
- Fulfill Legal Responsibilities (Comply with the Code of Federal Regulations)

MDT is responsible for the inspection of both on and off system bridges within the state. Approximately five thousand four hundred bridges are inspected by MDT with a little more than half of the bridges on the national and state highway systems. Each of the five districts is responsible for the inspection of both On- and Off- System bridges within their boundaries.

Bridges on the network are categorized by On or Off System and Major or Minor structures. These categories and their requirements are defined as follows:

1.2.1 On-System Bridges

On-System bridges are bridges on any route of the National Highway System. This includes Interstate, Primary, Secondary, and Urban routes.

1.2.2 Off-System Bridges

Off-System bridges are bridges on any route that is not an on-system route. Some off-system bridges are on State Highways. State Highways are not located on the National Highway System, but are on the state maintenance system.

1.2.3 Major Structures

Only major structures qualify for federal funding for inspection, replacement and rehabilitation work. A major structure is defined as a structure, including supports, erected over a depression or an obstruction, such as a water, highway or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between under coping 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 are less than half of the smaller contiguous opening.

1.2.4 Minor Structures

Some structures not meeting major qualification still require inspection either due to FHWA exceptions or because of MDT requirements. On National and State Highway systems, the inspection of bridges down to 8 feet in length is desirable. Box or buried structures are to be treated as culverts and need not be inspected unless considered a critical facility (TE Routes) or qualifying under major structure guidelines.

This means that we inspect bridges down to 8 feet in span length on Primaries, NHS routes, Urban Routes, State-Maintained Locals (Frontage Roads, or X Routes), and Interstates. Montana does not inspect bridges down to 8 feet in span length on county maintained local routes, local urban routes, municipal bridges, or bridges on Secondary Routes, regardless of whether they are state or county maintained.

Buried structures are those buried under a depth of fill equal to or greater than ¼ of the span length. Minor box or buried structures do not need to be inspected unless they carry a critical facility. Interstates and TE Routes are critical facilities. All box or buried structures with a single span of at least 8 feet on critical routes are to be inspected. Any box or buried structures with a span of less than 8 feet are not to be inspected, regardless of how many smaller spans there are. For example, two independent 6-foot culverts that are side-by-side add up to a span of more than 8 feet, but no single span is over 8 feet, so they do not need to be inspected. See Appendix 1A flowchart for proper classification of structures.

In order to meet the requirements of MAP-21, the Department of Transportation is now developing bridge projects as part of an overall asset management system. MDT has adopted a number of Bridge Program Objectives and determined various Bridge Performance Measures required in order to meet those Objectives.

NBIS require each bridge inspection organization to prepare and maintain an inventory of all bridges for which they are responsible. The bridge inventory provides certain standard information about each bridge and is updated throughout the bridge's life until it is no longer in-service.

The MDT Structure Management System (SMS) contains the required FHWA fields as well as additional MDT defined fields to manage the bridge inventory. The NBIS information is transmitted to FHWA yearly to update the National Bridge Inventory (NBI) Database.

1.3 Inspection Program Functions

Bridge inspection strictly refers to condition inspection of bridges. The NBIS requires all states to collect inspection data and maintain an inventory of all public bridges. Each state must have a bridge inspection organization capable of performing the required inspections, completing required reports, and maintaining inventory records. In Montana this responsibility is divided between the Bridge

Management Section located in Helena and each of the five district offices.

1.3.1 Bridge Management Section

The Bridge Management Section is responsible for the overall Bridge inspection program and is a part of the Bridge Bureau in Helena. The section consists of a number of engineers and technicians that provide direction and support to the program. The primary functions and responsibilities are provided below.

Bridge Management Section Functions and Responsibilities	
Program Management	Technical Support for the Districts
Bridge Database Management	Backup Support and Coordination
Consultant Inspection Contract Management	Bridge Load Rating
Specialty Inspection Consultant Contract Administration	Overweight Load Permitting
Set Inspection Standards	Shop Drawing Review and Approval
Inspector Coordination, Training, and Certification	Research and Implementation of New Methods and Techniques
Inspection QA/QC	Bridge Maintenance
Program Quality Assurance	

Figure 1.3.1-1 Bridge Management Section - Functions and Responsibilities

The Bridge Management Section also assists in updating the performance measures of structure condition and deck condition to determine whether proposed projects will assist in meeting program objectives. They also work with FHWA to verify that the 23 bridge metrics are satisfied.

1.3.2 Program Manager Qualifications

MDT's Bridge Inspection Program Manager must be a registered professional engineer in Montana, have five-years of bridge inspection and/or load rating experience and have successfully completed FHWA approved comprehensive bridge inspection training. They must also successfully complete FHWA approved bridge inspection refresher training every 5 years.

1.3.3 District Offices

Each District office is responsible for inspecting the bridges within the District. The primary District functions and responsibilities are given below.

District Offices' Functions and Responsibilities	
District Program Management	Safety Management for Inspections
Coordination with Bridge Management Section, Counties, Cities, and Other Local Entities	Performing Bridge Inspections
Inspection Planning, Scheduling and Coordination	Data Entry and Validation
Inspection Equipment and Resources	Problem Identification and Follow-up
Training	Inspection Quality Control

Figure 1.3.3-1 District Offices - Functions and Responsibilities

1.3.3.1 Key Inspection Personnel and Qualifications

There are a minimum of two positions in each district that are dedicated to bridge inspection.

District Bridge Inspection Manager

The District Bridge Inspection Coordinator position is a full-time bridge inspection position responsible for inspection compliance at the District level. Duties of the position include scheduling inspection activities, performing Quality Control Checks on district inspections, and inspecting bridges. MDT requires this person to be a qualified Team Leader.

Assistant District Bridge Inspection Manager

The Assistant District Bridge Inspection Coordinator position is a full-time bridge inspection position. MDT requires this person to be a qualified Team Leader.

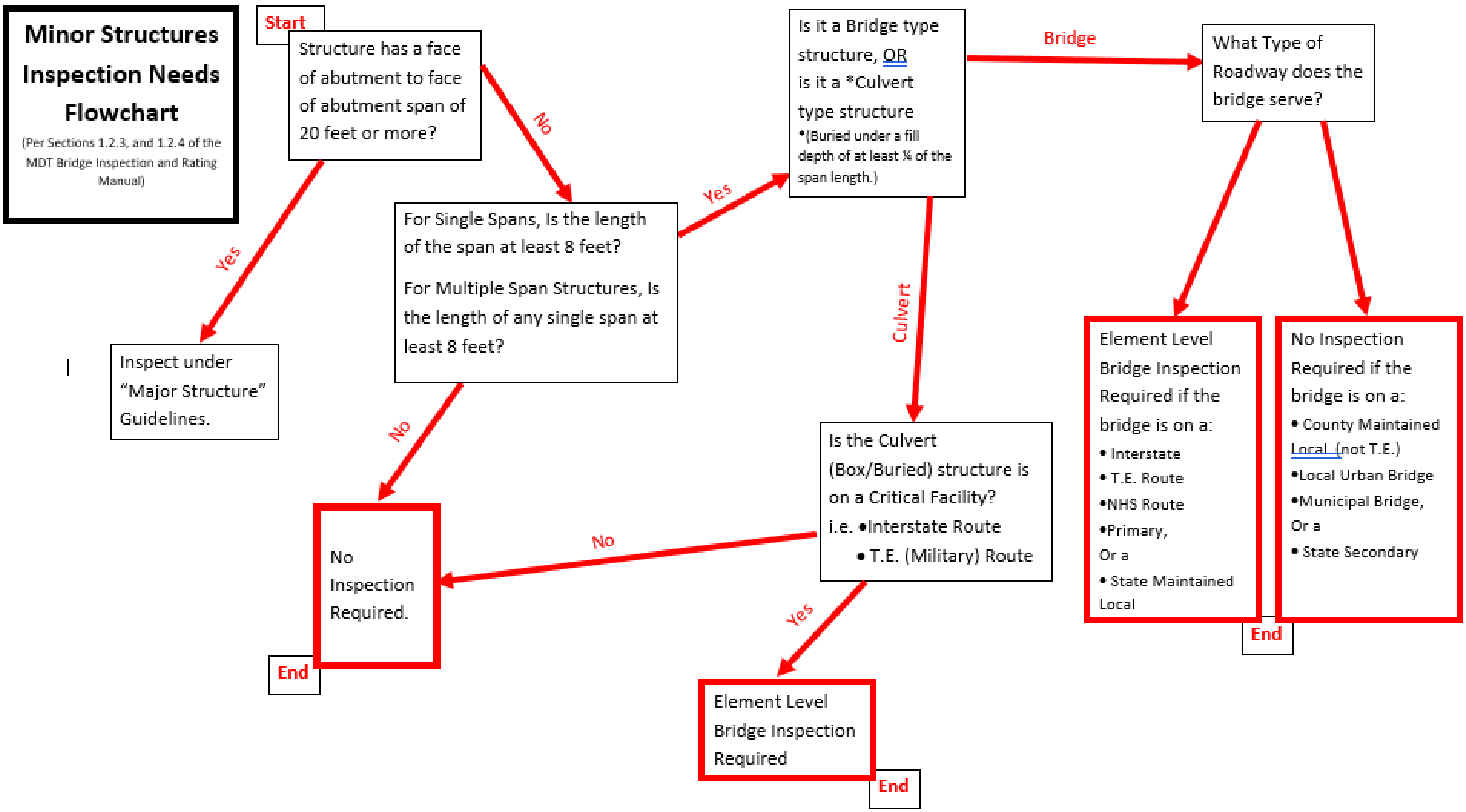
1.3.3.2 Inspection Crew

An inspection crew will have a minimum of two members. One of the members must be a qualified Team Leader. The crew is required to physically inspect the bridge and gather the required information. If the design of a bridge is such that it requires specialized knowledge, then the members of the crew will include persons with that special knowledge.

See Section 2.1.2 for Team Leader qualification requirements.

Chapter 1 Appendices

Appendix 1A Minor Structure Flowchart



Chapter 2 - Bridge Inspection

Chapter 2 provides significant information regarding multiple aspects of bridge inspection. It covers minimum qualifications for inspection staff, by title, to meet both the NBIS and MDT's requirements for compliance. Bridge inspector training and documentation of such is covered. Various inspection types are listed and described. Lower and Higher risk bridges are described as well. Inspection manuals, equipment, tools, general procedures and methodologies are reviewed. A general review of Element Level inspection, condition coding, reporting, Significant Change reporting and Guidance for Repair Suggestions is provided. Critical Findings procedures are covered for both State-Owned and Non-State-Owned bridges. Procedures and record-keeping requirements are provided for Quality Control by Districts and Quality Assurance by Bridge Management. Consultant Inspection requirements are covered. Illustrations and descriptions of common bridge elements are provided, including Agency Defined Elements for clarity. Element matrix tables grouped by categories as well as material defect hierarchy tables are provided for inspector's use and reference. A numerical listing and description of MDT's inventory items, as they currently stand, is provided. The appendices include checklists for Field Inspection and Report Review and a listing of all NBI and MDT Items, along with where they are found in SMS and which are the inspector's responsibility to code.

2.1 State and Consultant Inspection Personnel Qualifications

2.1.1 Project Manager Qualifications (Consultants)

Must be a registered professional engineer in Montana, have five-years of bridge inspection and/or load rating experience and have successfully completed FHWA approved comprehensive bridge inspection training (FHWA-NHI-120053). They must also successfully complete FHWA approved bridge inspection refresher training (FHWA-NHI-130055) every 5 years.

2.1.2 Team Leader Qualifications

Qualification as a Team Leader requires any one of the following:

- Five years' experience in bridge inspection and successful completion of the Safety Inspection of In-Service Bridges course (FHWA-NHI 130055). A portion – up to but not more than 2.5 years - of the experience required to satisfy this requirement can be obtained through participation in construction inspection activities during a bridge construction project.
- Certification as a Level III or IV Bridge Safety Inspector (National Institute for Certification in Engineering Technologies), one year of experience in bridge inspection, and successful completion of the Safety Inspection of In-Service Bridges course (FHWA-NHI 130055).
- A Professional Engineering license for the State of Montana, one year of experience in bridge inspection, and successful completion of the Safety Inspection of In-Service Bridges course (FHWA-NHI 130055).
- A bachelor's degree in engineering from a college or university accredited by or determined as substantially equivalent by the Accreditation Board for Engineering and Technology, a current Engineer Intern license from the Montana Board of Professional Engineers and Professional Land Surveyors, two years of inspection experience, and successful completion of the Safety Inspection of In-Service Bridges course (FHWA-NHI 130055).

Team Leaders must also successfully complete FHWA approved bridge inspection refresher training every 5 years (FHWA-NHI 130053).

2.1.3 NDT Consultant Qualifications

NDT inspector's certifications will be current and meet the minimum industry and manufacturer requirements for the materials and tests being performed. Ultrasonic testing must be performed by an American Society for Nondestructive Testing (ASNT) NDT Level II inspector.

2.1.4 Inspection Assistant / Trainee Qualifications

This person is not required to have a minimum education, certification, or technical knowledge, but must be able to physically assist a Team Leader in the inspection of bridges. Note that these inspectors can become Team Leaders with a combination of bridge inspection experience, technical training, education and / or certification as noted above under Section 2.1.2.

2.1.5 Underwater Bridge Inspection Diver Qualifications

All underwater bridge inspection divers are qualified by having successfully completed at least one of the following training courses:

- FHWA approved comprehensive bridge inspection training course (FHWA-NHI 130055)
- FHWA approved underwater bridge inspection diver training course (FHWA-NHI 130091)

The above includes Team Leaders who are also acting as divers. Divers who are not acting as Team Leaders are not required to complete refresher training. Additional divers providing support roles only, such as 'tender' divers, are not required to have completed bridge inspection training.

2.2 Continuing Education Requirements

2.2.1 MDT Inspectors

To remain qualified to inspect bridges as a team leader, MDT requires inspectors to meet at least one of the following requirements every 2 years:

- Attend at least 8 hours of a field Quality Assurance Review
- Attend the entire Bridge Inspectors' Workshop

If one of these requirements is not met, MDT may accept other bridge inspection training on a case-by-case basis.

2.2.2 Consultant Inspection Requirements and Inspector Training

MDT uses the following process to complete a regular inspection performed by consultants.

- Consultants are hired using MDT's Consultant Design Selection processes and access is granted to the SMS.
- The consultant performs bridge inspection that meets MDT specifications for use with the SMS.
- Consultant uploads the bridge inspection data into SMS, ensuring the data entered meets quality control guidelines established by MDT Bridge Management Section. Consultant electronically signs the bridge inspection report.
- The consultant performs Quality Control of a regular inspection in alignment with the processes outlined in Section 2.15.
- The District Bridge Inspection Coordinator (DBIC) accepts the final signed and reviewed electronic inspection.
- The SMS application stores historical bridge inspection data and can generate a signed legal hard or electronic copy of an inspection report.
- DBIC distributes either electronic or hardcopy signed bridge inspection reports to bridge owners and entities responsible for bridge maintenance.

Consultants inspecting bridges for MDT are required to attend at least 8 hours of continuing education training related to bridge inspection every 2 years. This continuing education requirement can be met under the requirements for MDT inspectors, or can be met through attendance at any NHI class related to Bridge Inspection. Attendance at bridge inspection conferences is also acceptable training. Other training may be evaluated and accepted by MDT on a case-by-case basis. Proof of training, including hours is the responsibility of each inspector.

Inspectors who do not meet continuing education requirements will be disqualified and no longer allowed to inspect bridges for MDT until they complete additional training as required by the Bridge Management Engineer. The type and amount of training will be decided on a case-by-case basis.

2.3 Bridge Inspector Training

2.3.1 NHI Courses

National Highway Institute (NHI) courses will be brought to MDT for inspector training on a rotating basis, or as-needed. These courses are listed below:

- FHWA-NHI-130053 Bridge Inspection Refresher Training
- FHWA-NHI-130054 Engineering Concepts for Bridge Inspectors*
- FHWA-NHI-130055 Safety Inspection of In-Service Bridges
- FHWA-NHI-130056 Safety Inspection of In-Service Bridges for Professional Engineers
- FHWA-NHI-130078 Fracture Critical Inspection Techniques for Steel Bridges FHWA-NHI-130055 Safety Inspection of In-Service Bridges
- FHWA-NHI-135047 Stream Stability and Scour at Highway Bridges for Bridge Inspectors

*One form of Prerequisite for FHWA-NHI-130055

2.3.2 Bridge Inspectors' Meeting

MDT's Bridge Management Section provides quarterly training meetings with the inspectors for approximately 2 hours. In addition, MDT provides annual training meetings that are 8 hours in length. Topics discussed during these meetings may include any updates/changes in bridge inspection/reporting procedures/BIRM, results of QA reviews, lessons learned from QA reviews, industry updates, and open discussion about the bridge inspection program.

2.3.3 Additional Training as Needed

Additional bridge inspector training is provided on an as-needed basis for topics that must be addressed prior to the regular meetings discussed in Section 2.3.2. Also, annual Underbridge Inspection Vehicle (UBIV) training is also required to operate UBIVs. Railroad Safety Training is required for any inspector who works on railroad right-of-ways.

2.4 Inspector Training and Experience Records

2.4.1 Bridge Management Section

The Bridge Management Section keeps records on classes taken by all inspectors and inspection trainees, and the amount of time inspectors have spent on a QA review or attending the Bridge Inspectors Meeting as required.

2.4.2 District Offices

The District Inspection Manager is responsible for tracking inspection time that an inspection assistant/trainee has acquired, and keeping records for each trainee.

2.5 Load Rating Engineer Qualifications

See MDT's stand-alone Load Rating Manual, currently under development in 2022.

2.6 Inspection Types and Intervals

Each bridge must be inspected in accordance with the nationally recognized procedures in the latest version of the AASHTO Manual for Bridge Element Inspection (MBEI) contributing to quality assessments, ratings, and documentation, as measured by the following criteria:

- Condition codes within generally accepted tolerances.
- All notable bridge deficiencies identified.
- Condition codes supported by narrative that appropriately justifies and documents the rating or condition state assignment.

Generally acceptable tolerances for condition assessments occur when the inspector determined NBI condition codes are within one value of the review team's coding. Additionally, the inspector determined element level data are in proper condition states, with elements and quantities properly determined.

A qualified team leader must be at the bridge at all times during each initial, routine, fracture critical member and underwater inspection.

All bridges are to receive thorough inspections and all elements should be inspected when they are fully visible. If the inspector is unable to fully inspect any element during any inspection because it is obscured by snow, water, ice or any other environmental issue that is likely to improve at a different time of year, the bridge requires a follow-up inspection. Follow-up inspections must be performed to collect necessary information to allow proper assignment of NBI Condition Ratings and Element Condition States. Refer to section 2.6.7 for examples of common situations where follow-up inspections may be required.

Where it is reasonable, the inspector should shovel snow away from the bridge to make it visible for the inspection in order to avoid a follow-up inspection.

For efficiency, move as many inspection dates as possible to avoid months with inclement weather and to avoid follow-up inspections. Higher risk bridges should have the highest priority for being moved to summer months.

It is critical to inspect each bridge thoroughly to establish its condition and ensure the continued safe operation of the structure. Listed below are the inspection types:

- Initial / Inventory Inspection
- Routine Inspection
- Underwater Inspection
- Fracture Critical Inspection
- Damage Inspection
- Other Inspection

The inspection types used for each bridge depend on several factors, including the type of bridge design, condition of the structure, and condition of the stream channel below the bridge.

To establish a regular inspection schedule, each district is to review its inventory records to determine inspection frequency. Factors influencing the inspection schedule may be special inspection equipment needed, low or high-water levels, snow and ice conditions, and proximity of bridges to one another. By considering all of these factors, a manageable schedule of inspection for the district's jurisdiction can be established and carried out.

Lower Risk Bridges

Lower risk bridges are defined as those with superstructure and substructure, or culvert, condition ratings of fair or better, and do not require load restriction.

For lower risk bridges, routine inspections must be performed at regular intervals not to exceed 24 months, or not to exceed 48 months when adhering to FHWA approved criteria (FHWA Technical Advisory T 5140.21), which allows state DOTs to extend the inspection frequency for routine bridge inspections. All bridges must be inspected within the required 24 or 48-month interval, as applicable, unless documented unusual circumstances have caused a 1-month delay for any inspections.

For any bridge to be considered for a four-year inspection cycle, it must meet all of multiple qualifying conditions which are illustrated in Appendix 2C. If a bridge meets all of the criterion, then it would be eligible for a four-year inspection cycle.

Any structure on the 4-year inspection cycle list that is subjected to unusual flooding, earthquakes or other natural disasters will be inspected immediately and the interval adjusted as deemed appropriate by the inspector.

Higher Risk Bridges

Higher risk bridges are defined as those with a superstructure / substructure, or culvert condition rating of poor or worse, or require load restriction.

For higher risk bridges, routine inspections must be performed at regular intervals not to exceed 24 months. All bridges must be inspected within the required 24-month interval, unless documented unusual circumstances have caused a 1-month delay for any inspections.

Higher risk bridges criteria: (NBI Item 59 or 60, or 62) < 5 OR (NBI Item 63 = 5 and Item 70 = 5) OR (Item 113 = 0, 1, 2, 3 or U)

All actions within reasonable measure must be taken in order to inspect each structure on time. In the event that a bridge is inspected after its due date due to unusual circumstances, it is considered late. All late inspections must have documentation explaining why the bridge was inspected late.

Documentation for late inspections must be entered into the "comments" box under the info tab of the inspection in SMS, or an equivalent narrative field in future programs. Documentation must include:

- Relevant dates (including the date access was attempted, if applicable).
- Reason why the inspection was not completed on time.

The inspection team leader is responsible for documenting late inspection reasons.

2.6.1 Initial / Inventory Inspections

An Initial / Inventory Inspection is the first inspection of bridges that are not already in the Structure Management System (SMS) and the first inspection of new bridges or rehabilitated bridges that were fully closed to traffic during rehabilitation work.

When a bridge is replaced by a new structure, or a bridge is fully closed to traffic during rehabilitation work, the Inventory Inspection will be completed and entered into SMS within 90 days of the bridge opening to traffic if the bridge is State-Maintained, and within 180 days for all other bridges.

For an existing bridge that is open to public traffic during rehabilitation work, regularly scheduled Routine NBI/Element inspections will be performed. If an inspection cannot be conducted on or before its due date because of reasonable circumstances such as a hazardous project site or conditions unfavorable to complete an inspection, then those circumstances will be documented and sent to the Bridge Management Section and the inspection will be rescheduled at the earliest date possible – this date will be no later than 30 days past the original due date for the inspection.

An Initial / Inventory Inspection consists of up to 3 steps, depending on the bridge being inspected as noted in the following subsections:

2.6.1.1 Determination of the Structure Location

For bridges that are new to the inventory (not previously in the SMS), the structure location is determined using a GPS device and the aerial photos in the SMS. The bridge ID will be assigned as a five-digit number and entered into the SMS.

2.6.1.2 Collection of Inventory Data

For bridges new to the inventory, the New Bridge Form will be completed and sent to the Bridge Management Section in Helena. If the new structure is a culvert, the New Culvert Form will be completed and submitted with the New Bridge Form. Once the New Bridge Form (or New Culvert Form as needed) has been submitted, Bridge Management Section personnel will enter a bridge “stub” into BIMS. The New Bridge Form and New Culvert Form are in SMS on the Inspection Aids page.

When available, the inspector will use the bridge construction plans to determine the measurements, design type, material, and other pertinent inventory information. The inspector is responsible for obtaining bridge construction plans and shop drawings from local agencies and forwarding these plans on to the Bridge Management Section in Helena. When plans are not available for the bridge, the inspector will determine the inventory information for the bridge during a site visit. This includes filling out Bridge Measurement Forms as needed. Copies of Bridge Measurement Forms can be found in SMS on the Inspection Aids page.

2.6.1.3 Initial Inspection

The inspector will visit the bridge site to complete the initial inspection for the bridge. Then, the inspector will fully enter all inspection information into SMS within the Initial Inspection time frame stated previously.

2.6.2 Routine Inspections

A Routine inspection is performed on all bridges at least every 24 months on the entire bridge throughout its life. Montana is allowed to extend the inspection interval to 48 months for bridges that meet certain conditions. If a bridge has received major structural repairs by Maintenance authorities or under Maintenance contracts, the inspection cycle will be reduced to 24 months until the Bridge Management Engineer is satisfied that the repairs are performing satisfactorily. When a bridge becomes eligible for a 48-month inspection cycle, contact the Bridge Management Section and recommend the bridge for an extended inspection cycle. Bridge Management Section personnel will set the inspection cycle to 48 months if they agree with the recommendation. When a bridge no longer meets the criteria listed for a 48-month inspection cycle, the Bridge Information Management System automatically changes the inspection cycle to 24 months. If major structural repairs are made to a bridge by Maintenance forces, the inspector will contact the Bridge Management Section to reduce the inspection cycle to 24 months.

2.6.3 Underwater Bridge Component Inspections

An inspection focusing on channel and underwater bridge components will be performed on bridges with substructure elements located underwater and not visible for inspection during Routine Inspections. For structures whose underwater components can be accessed/inspected safely via wading, Probe and Wade Inspections (previously referred to as Probe and Wade) will be performed at the same time as the regular structure inspections. If seasonal channel conditions or water levels prohibit inspections, consider shifting the scheduled Routine and Probe and Wade inspection dates to when conditions allow. For structures whose underwater bridge components cannot be accessed/inspected via wading, Underwater Inspections will be performed. Structures requiring underwater inspection will be identified as needing further review by either inspection with special equipment such as a boat or by an experienced consultant utilizing divers. Consultants are retained through the Bridge Management Section for Underwater inspections. Structures requiring a Probe and Wade inspection are required every 48 months. Underwater inspections are required every 60 months.

2.6.4 Fracture Critical Inspections

A fracture critical inspection is a focused, arm's length inspection of fracture critical bridge members. A Fracture Critical Member (FCM) is defined as a steel member in tension or with a tension element, whose failure probably causes a portion of or the entire bridge to collapse. Fracture critical inspections are required every 24 months. See chapter 7 for more information on fracture critical inspections.

2.6.5 Damage Inspections

A damage inspection is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions, such as earthquakes or vehicular collisions. The scope of the inspection depends on the extent of the damage. Damage inspections are typically used in the decision-making process for implementing emergency load restrictions and closure. They are also be used in the decision-making process to lift emergency restrictions that were put in place by Maintenance personnel until a Damage Inspection could be completed and the structure assessed for strength and structural stability.

2.6.6 Steel Bridge Inspection

2.6.6.1 Non-FC Hands-on Inspection Frequency:

Steel members that are not fracture critical are required to receive a hands-on inspection for their first and second inspections after construction. After the first two inspections, hands-on access may be reduced according to the following table, or as determined by the Bridge Management Engineer:

NBI Item 59 Rating	Hands-on Inspection Frequency (months)
7 and above	96
6	72
5	48
4	24
3 and below	*

*Determined by Bridge Management Engineer.

Hands-on inspection frequency is determined by the Bridge Management Engineer when the bridge meets any of the following criteria:

- Any fatigue cracks are present in the steel members
- There are fatigue cracks in the bridge's twin interstate structure. If the second structure is not identical to the cracked one, this does not apply.
- Steel members contain multiple fatigue prone details such as closely spaced welded transverse stiffeners, welded cover plates, or welded longitudinal stiffeners.
- Impact damage or other defects in steel members that warrant frequent monitoring
- High Average Daily Truck Traffic (general rule: ADTT > 1,000)
- Bridge nominated by an Engineer, Inspector or Local Agency Owner and approved by Bridge Management Engineer

District Bridge Inspection Coordinators are responsible to ensure hands-on inspections are performed within the appropriate frequency. Any observations or information that warrants a change in inspection frequency is required to be brought to the Bridge Management Engineer's attention within one month of the field inspection.

Hands-on inspection frequency is tracked through the *Hands-on Steel Inspection* (Inspection Master type) in SMS. All inspection data is recorded in the *Map21 Inspection*, and the *Hands-on Steel Inspection* is used only as a reminder of the snooper requirement. The frequency of UBIV inspections is also recorded in SMS attribute *MDT134 UBIV Frequency*.

When the NBI Item 59 condition rating is reduced due to an inspection that is not hands-on, the Team leader and District Bridge Inspection Coordinator will work together to determine if an immediate follow-up hands-on inspection is necessary. The follow-up inspection may or may not require a UBIV, depending on access to the structure. The Team leader will include an explanation of why the bridge will or will not receive an immediate follow-up hands-on inspection in the General Inspection Notes (*Inspection – Info Tab – Comments*).

2.6.7 Follow-up Inspections

Shown below in Figures 2.6.7-1 to 2.6.7-4 are common situations where a follow-up inspection would be required.

Figure 2.6.7-1 A follow-up inspection is required to check the condition of the bridge deck and associated elements (joints, rail, etc.).

Figure 2.6.7-2 A follow-up inspection is required to check the condition of the wingwalls, abutments, and part of the exterior girder.

Figure 2.6.7-3 A follow-up inspection is required to check the condition of the bottom of the abutments and to check for scour.

Figure 2.6.7-4 A follow-up inspection is required to check the condition of the pipe culverts.

2.6.8 Other Inspections

2.6.8.1 Pin and Hanger NDT Inspections

Pin and Hanger assemblies are inspected using non-destructive testing methods. The Bridge Management Section hires consultants to do these inspections. Pin and Hanger inspections are required every 48 months.

2.6.8.2 Special Inspections

Special inspections are performed on bridges with defects that require inspection more frequently than the regular inspection cycle. A special inspection can be set at any interval less than 24 months, depending on the type of defect needing inspection and its condition.

2.7 Inspection Manuals, Equipment and Tools

It is important that bridge inspectors have the tools necessary to conduct a thorough inspection. A successful bridge inspection program is dependent upon proper use of reference materials, equipment and tools.

2.7.1 Required Manuals

Inspectors should have access to the following manuals or books while in the field provide assistance in the inspection of structures:

1. MDT Bridge Inspection and Rating Manual
2. Fracture Critical Inspection Techniques for Steel Bridges (FHWA-NHI 11-015)
3. Bridge Inspector's Reference Manual (FHWA NHI 16-013)
4. Manual for Bridge Element Level Inspection (MBEI)
5. Federal Coding Guide

2.7.2 Equipment and Tools

Inspectors need the following equipment to inspect the wide variety of bridges encountered in Montana:

Inspection Equipment and Tools		
Steel-toe Boots	Toolbox	Digital Camera with Flash
Hard Hat	Tool Belt	Clipboard
Safety Vest	Geologist Hammer	Flashlight
Eye Protection	100' and 25' Tapes	D-Meter
Fall Protection Harness	6’ folding rule	Calipers
Lanyard	Ladder	Temperature Gauge
Waders	Screwdriver	Depth Gauge
Sound Pole	Shovel	Increment Borers and Plugs
Plumb Bob	Pocket Knife	Binoculars
Lead Line	Wire Brushes	Industrial Crayons
Boat	Ice Pick	Inspection Tablet (optional)

2.8 Inspection Procedure and Data Collection

Inspectors need to organize inspections to make the most efficient use of time, travel, and equipment. Ideally, the inspection workload from year to year will be divided equally, and structures in the same geographical area will be inspected together to avoid repetitious trips.

Traffic flow and density need to also be considered when planning the time of day to be at the site. The inspection itself will be conducted in a safe and systematic manner that will minimize the possibility of bridge elements being overlooked.

2.9 Photo Requirements

A minimum of three photos (approach, profile, and underside/inside of barrel for culverts) is required for each inspection, and additional photos are required when deterioration or a defect is found per Chapter 3 requirements. Any signed weight or clearance posting signs at the bridge site will be clearly shown in the photographs. If a photograph of the posting sign does not provide a close enough view of the bridge approach, an additional photo is to be provided.

2.10 Field Inspection - QC/QA

Before leaving the bridge site, the inspector will review the Field Inspection Checklist (see Chapter 2 Appendix 2A) to ensure a thorough inspection was completed.

2.11 Pre-Inspection Review

Previous inspection reports and bridge related documents (ie. plans, load rating, correspondence, scour, etc...) in the SMS Multimedia tab will be reviewed before visiting the site. Additional reviews outside of the previous inspection report include previous testing and monitoring results; maintenance and repair records; and accident and damage history. During this review, the inspector will become familiar with the design(s) and material(s) of the structure. This will alert the inspector to any special inspection equipment needs or the need for an expanded inspection, that may have not been scheduled, such as Fracture Critical, Underwater, or Pin and Hanger.

The inspector will need to develop a general inspection plan during this review, which may include the use or modification of previously developed fracture critical and underwater inspection plans as necessary. These plans are to include assigning inspection responsibilities to appropriate team members and how the effective, efficient, and safe inspection of all bridge elements will be carried out. The inspection plan will need to consider the extent of the traffic control required at the bridge site, coordination of traffic control with MDT Maintenance personnel, coordination with railroad personnel and any special equipment required to carry out the inspection.

2.12 Inspection Methodologies

Inspections are performed using two distinct inspection methodologies. The Element inspection concentrates on the bridge elements and the deterioration of the discrete components. The NBI inspection concentrates on the overall condition of the structure and how the structure functions in its environment.

2.13 NBI Inspection

The NBIS requirements include the condition rating for the aggregate bridge components into four possible categories: deck, superstructure, substructure, and culvert components. Additional condition rating items include load rating, roadway evaluation, and waterway/channel evaluation. For full descriptions of each NBI item, refer to the latest edition of the FHWA Recoding and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges.

2.14 Element Inspection

For Element Level Inspections, bridges are considered to be composed of individual elements, each represents a particular part of the bridge and the material it is made of (e.g., steel girder, timber abutments, pourable joint seals). Over 100 National Bridge Elements (NBEs) and Bridge Management Elements (BMEs) are used to standardize reporting of bridge components and their defects throughout the country. There are also 30 Agency Defined Elements (ADEs) for additional bridge components that MDT desires to condition code. These are covered in Chapter 4.

For NBIS inspections, bridge components are given a whole number rating from 1 – 9 for the component being rated (deck, superstructure, substructure, channel, culvert and overall rating). In contrast, an Element Level inspection is done by rating bridge elements (girders, bearings, etc.) as quantitative units expressed as percentages of the total or actual quantity of the element in each of the four condition states (1 – 4). For example, a stringer may have twenty percent in condition state 1 (good), twenty-five percent in condition state 2 (fair), fifty-five percent in condition state 3 (poor) and 0 percent in condition state 4 (severe).

Both the NBIS and Element Level inspections will be completed for MDT bridges. The element level inspections will supplement the ratings supplied by the traditional NBIS inspections.

2.14.1 Elements

Of the 100 different elements, up to 40 elements per bridge could be used, but generally about four to twelve elements are needed to describe a bridge. The elements are grouped into a logical numbering sequence:

1-99	Deck Elements
100-199	Superstructure Elements
200-299	Substructure and Culvert Elements
300-599	Miscellaneous Elements
800-999	Agency Defined Elements

After the initial inspection is complete, SMS will include the element numbers and description for each structure. During each inspection, the inspector will verify that the elements describing the structure are correct and complete. The elements may change from year to year because of environmental conditions, maintenance, and/or construction activities. If an inspector discovers that an element is missing, or has been exposed due to environmental conditions, the inspector will add the new element to SMS. Conversely, if a previously inspectable element is no longer exposed for inspection, then it should be removed from SMS and a general note should be added to the report to explain this change.

2.14.2 Defects and Condition State Rating

There are 45 possible defects for each bridge. These defects include material defects such as corrosion in steel, spalling in concrete, as well as other defects such as settlement.

Each individual element (NBE, MBE and ADE) has a specific list of possible defects and associated defect codes. When a defect is noted along an element, the code for the proper defect is selected (i.e., code 1080 for spalling), and the severity of the defect is noted along the entirety of the element from condition state 1 (good) to condition state 4 (severe). All defects should be recorded regardless of if they overlap with other defects. The total of condition states 1 to 4 for any given defect should not exceed 100%. The defect condition states are rolled up to the parent element. The total of condition states must total 100% for any parent element. The default coding method is percentages. When multiple defects are present at the same location, Defect Hierarchy Rules must be followed to ensure that the total of all parent element condition states total 100%. See Section 2.17.7 for Defect Hierarchy Rules and tables.

2.14.3 Environment

To model the deterioration of elements, knowing the environment of each element is necessary. Elements exposed to different environmental factors and service environments deteriorate differently. These factors may include:

- Operational activities from traffic volumes and truck movements,
- Exposure to water, road salt and other corrosive materials,
- Condition of protective and water proofing systems, or
- Temperature extremes, either from nature or human activity

For Montana, bridges have different environmental factors due to topography, humidity, freezing temperatures and greater chloride use as well as higher truck and general traffic volumes. Environmental factors in SMS are determined through research and coded by the Bridge Management Section.

2.14.4 Post-Inspection and Reporting

A complete and accurate inspection report is required for each bridge inspection performed. This report is essential as it provides specific details about the inspection and about the bridge itself. Standard report forms have been developed for NBI and element-level inspections. These forms provide a means of recording standard information pertinent to all bridges and special information unique to each particular bridge.

Inspection data gathered from the site will need to be compiled and entered / uploaded to SMS. The inspectors must verify that the appropriate bridge elements are used, their total quantity is correct, and that field notes make it into the proper areas of the reports. Also, all NBI/MDT items coding must be completed and Work Items (Repair Suggestions) generated; see Section 2.14.6 for guidance. The Team Leader is required to perform quality assurance of the report using Appendix 2B – Inspection Report Review Checklist prior to approving and e-signing the inspection in SMS. The first inspection of new or rehabilitated structures requires a full inventory of all element level data and revision as needed of all NBI and MDT fields. After the first inspection, SMS will show the element designation, total quantity, and percentage in each condition state for all elements from the previous inspection, along with the previous work items, previous inspection ratings for the field inspected NBI items, and values entered for all MDT fields.

Notes will be placed in the proper section of the inspection report (i.e., element notes with the corresponding element and NBI notes in the General Inn Notes section). These notes need to be clear and detailed enough to accurately communicate the characteristic and condition data of the bridge to engineers, future inspectors, county bridge owners, and the public. Also, defect notes must be thorough enough to update the current load rating. Detailed inspection and documentation requirements are covered in Chapter 3.

Once the Inspector has completed the inspection report, it is forwarded to an independent reviewer. The Reviewer will have the same qualifications as a Team Leader. The Reviewer will check the inspection report for completeness, accuracy, and compliance with MDT/FHWA standards. The reviewer will complete an Inspection Report Review Checklist (see Appendix 2B) prior to sending the report back to the Inspector to address any review comments. The Inspector will address any Reviewer comments and forward the report back to the Reviewer. Once the Reviewer is satisfied that all comments have been properly addressed, the report is considered completed.

Inspectors are required to finalize NBI/Element bridge inspection data in the database within two weeks of the date that the bridge was inspected. Inspectors must complete data verification within four weeks of the inspection date. Note that if inspection data is not entered into SMS before the bridge is due for inspection, the bridge will show up on the late inspection list. All bridges are to be inspected on or before their due date. Due date is the end of the calendar month of the proposed inspection date.

For state-maintained structures, a discussion of the structure after an inspection with state maintenance forces may be required to resolve any maintenance needs. For State-maintained bridges, the Reviewer will forward completed inspection reports to the appropriate Maintenance divisions, as dictated by MDT020, so that they are aware of maintenance recommendations made by the inspectors.

For bridges that are not maintained by the state, a letter from the Reviewer will accompany a copy of the inspection report sent to local authorities responsible for the bridges inspected. This letter will summarize any serious problems found with the local authority's structures and will stress that MDT does not assume responsibility for bridge maintenance on these structures or for warning the public if these bridges are unsafe. The inspection reports are intended to give them guidance in the maintenance, repair, and replacement of their structures and will provide some basis for possible future funding from state and federal monies.

2.14.5 Significant Change / Problem Reporting

Special reporting is required whenever a significant change or problem is noted. A significant change or problem is any issue that involves structural concerns, damage, or safety concerns. Structural concerns are items that may require re-rating the bridge, load limits and clearance posting, or a significant change in condition state. Damage may be new or old. These bridge defects are considered just below the threshold for critical findings. Safety concerns could be any condition that is considered a pedestrian or vehicular hazard, such as a trip hazard, loose joint armor, or the need for replacement of missing or knocked down object markers. Inspectors will have an option to request a load rating review. A call, text or email notification and SMS upload is required within 24 hours.

Issues on state-maintained bridges will also be reported by the Inspector to the District Bridge Inspection Manager, the Maintenance Chief, and others as appropriate. The Work Items listed in the Bridge Management System may suffice for a part of this notification.

Issues with bridges not maintained by the state will be reported by the Inspector to the bridge's owner and the District Bridge Inspection Manager. Verbal notification by the Inspector to the Owner will be done as soon as is reasonable after the inspection. These issues must be specifically included in the letter accompanying the inspection reports to the Owner.

2.14.6 Guidance for Adding Repair Suggestions

Intent

Repair Suggestions placed in SMS should be limited to maintenance level type activities. They are intended to be used by MDT Maintenance and County maintenance forces, so they can quickly and easily, find and prioritize necessary maintenance level repairs. The Repair Suggestions included should be able to be completed by Maintenance personnel, with or without the assistance of the Bridge Maintenance Engineer or County Engineers. They should also be actions that can be completed and closed out, i.e. – “Monitor element for…” is *not* an appropriate Repair Suggestion.

Repair Suggestions in SMS are *NOT* intended to be used by designers and engineers for querying Federal Aid project level repair and rehab activities. Rather, Federal Aid project developers (engineers, designers, and consultants) determine the scope of bridge rehabilitation and replacement activities by querying general bridge and element level conditions. Although engineers and developers will include Repair Suggestions that have been input into SMS in Federal Aid rehab projects, they are not used in initial project development.

Examples of Repair Suggestions to include in SMS:

- Object marker repair/replace
- Approach Guardrail repairs
- Potholes/ deck spalls
- Missing bolts
- Loose nuts
- Clean debris out of deck drains
- Reset Elastomeric bearings
- Repairs to rotten, deteriorated, or shifted Timber elements (cap, piles, decks, girders, rails, etc.)
- Loose steel joints or guard angles (sliding plates and other embedded type joints and headers that pose a safety hazard when they come out)
- Repair impact damage (rails, posts, prestress or steel beams, etc.)
- Remove channel debris on piers/abutments
- Cracks in Steel members (these may or may not be critical; may require an immediate call to Helena)
- Clean debris out of joints
- Clean debris off caps/bearings
- Remove vegetation or clear trees that prevent inspection of bridge elements, grow within the shadow of the bridge, restrict traveler’s visibility, or could fall and damage the bridge
- Wingwall/backwall issues (including erosion under or around the wingwall)
- Approach roadway settlement or side slope erosion near the bridge
- Scour or erosion issues that can be mitigated with small scale operation to place rip-rap. These would typically be small, county owned structures (but possibly State owned) on small streams or washes.

Examples of Repair Suggestions *NOT* to include in SMS:

- Scour Issues that are on large bridges over large waterways that require hydraulic engineering and a major project to mitigate.
- Deck seal or deck overlay
- Monitor…
- Larger repair items that Maintenance does not have the resources to complete

There are many gray areas, so please do not be afraid to call Helena and ask if something specific is appropriate to be included as a Repair Suggestion in SMS.

Procedures for inputting Repair Suggestions:

Here are some basic guidelines to follow when inputting Repair Suggestions:

TYPE:

- Designate the repair suggestion Type as "Repair Suggestion" for normal items that are of Low or High priority. This should be the vast majority of the items you input into SMS.
- Designate the repair suggestion Type as "IMMEDIATE REVIEW ITEM" when you feel the issue needs an urgent review from someone in Helena or the item may be Critical (See Critical Findings Chapter).

REPAIR STATUS:

- All new Repair Suggestions input into SMS should be designated as "Open".
- If you notice during an inspection or are notified by the County or MDT Maintenance that an item has been completed, change the Repair Status to "Work Complete". This also triggers/requires the following:
    - In the Comments section, add a quick description of the work done, who did the work (or who notified you), and when it was done (or when you noticed it was complete).
    - Include photos of completed work in the inspection report if completed work was noticed during an inspection. If photos are sent you from MDT Maintenance or County, upload them to the repair item.
    - Any documents, repair details, or correspondence that you feel is relevant should be put in the documents tab of the repair.
    - Make sure to check the box "Exclude from reports" in the Properties tab of the Repair. This prevents completed repair items from showing up on final reports.

PRIORITY:

- Use judgement to prioritize repair items in either Low, Medium or High.
- Low Priority examples: Clean joints, repair curb, repair cap spall, etc…
- Medium Priority examples: Repair / replace heavily damaged object markers or posting signs, etc.
- High Priority examples: Replace missing object markers, Repair rotten timber cap, Repair loose sliding plate joint, remove debris on pier, etc.
- If you feel something is more urgent that a High priority, call someone in the Bridge Management Section to discuss (See Critical Findings Chapter).
- Only Bridge Management Section personnel can officially designate something as a Critical Finding in SMS.

COMPONENT:

- Attach all Repair Suggestions to a bridge element, unless it is a "bridge level" type repair activity. Some example of bridge level activity would be: replace hazard markers, repair void in roadway approach, cut brush/vegetation, etc.

COMMENTS:

- Include a one or two sentence description of the repair issue. Include a description of the location (specific span, bent, pile, joint, etc.)

2.14.7 Critical Finding Guidance

Definitions:

Official Code of Federal Regulations Definition:

Title 23, Subpart C, 650.305 – A Critical Finding is a structural or safety related deficiency that requires immediate follow-up inspection or action. This can be further defined to note that immediate attention or follow-up is needed because the condition of the structure is a current or imminent danger or safety hazard to the traveling public.

To Simplify:

A Critical Finding is declared when a defect on or related to a bridge is causing a current or imminent danger or safety hazard to the traveling public.

Overview:

Critical Findings are documented in the Repairs tab in SMS. Only Bridge Management Personnel in Helena can *officially* designate an issue as a Critical Finding in SMS.

Critical Findings are to be documented on State and non-State-owned structures.

Procedure:

The following procedures should be followed when a suspected Critical Finding is discovered:

1. Immediately contact Bridge Management personnel in Helena to make a verbally notification and discuss. If you are unsure if something is a Critical Finding, we can help make that determination when you call the Bridge Bureau. If you feel the bridge needs to be closed immediately because of imminent danger to the public, contact the Montana Highway Patrol or Sheriff's office for assistance.

Helena MDT call down list:

- Bridge Maintenance Engineers:
  - 444-6320 (Dave)
  - 444-3535 (Jarrod)
  - 439-1472 (Dave - cell)
  - 461-2118 (Jarrod - cell)
- Bridge Management Engineer
  - 406-444-9221 (Andy)
  - 406-781-6929 (Henry – cell)

- Other Bridge Management Section Engineers
    - 444-7641 (Mary)
    - 444-6470 (Chaz)
- Other
    - ________________________
    - ________________________
    - ________________________
    - ________________________

2. If an immediate closure is being implemented, contact the local MDT Maintenance Chief and/or MDT Maintenance Superintendent, or the appropriate County or City personnel for non-State-owned structures, so appropriate traffic control can be installed. Inform them of the urgency of the situation and whether the situation is urgent enough to require the immediate assistance of the MHP or Sheriff.

Local Contact Numbers:

- MDT Maintenance/District Personnel
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________
    - _________________________

3. Document the finding:
    - You can send photos by text to our cell phones or work e-mail for discussion.
    - When documenting a new issue that is suspected to be a Critical Finding, create a new Repair and designate the "Type" of repair as an "IMMEDIATE REVIEW ITEM". Upload this information to the SMS as soon as possible.
        - Take plenty of photos of the issue
        - Document the location of the issue
        - Take measurements of the element or defect

Examples of Critical Findings:

- Large cracks in steel girders
- Cracks in any Fracture Critical steel member
- Buckling or major out of plane distortion of truss compression members
- Major impacts to steel or prestress girders
- Missing, severely damaged, or failed timber piles

- Failed timber caps
- Holes in timber or concrete decks
- Settlement of a bridge pier or abutment
- Approach roadway voids in the travel way (this is not really a bridge issue, but we treat it the same as a Critical Finding)
- Scour on a “Probe and Wade” inspection that indicates loss of bearing under a large portion of the footing
- Any other damage or deterioration to an element that severely impacts the capacity or stability of a structure or culvert or endangers the traveling public

2.14.8 Bridge Records

Comprehensive bridge records are maintained, both at the District level, and in the Bridge Management Section in Helena. New files are now mainly electronic, but archives do include hard copies of plans, past load ratings, sketches, inspection reports, etc. for some structures. These files must be kept up-to-date and include the following:

2.14.8.1 Bridge Management Section Files

- E-signed, approved copy of the bridge inspection report in SMS
- Copy of any critical finding summaries and repair reports
- Any sketches made by the inspector
- Fracture Critical and/or Underwater Diving Inspection Plan(s)
- Bridge measurements, hard copy plans, electronic non-MDT plans by reference or stored in SMS, MDT plans by reference or MDT plans electronically in SMS
- Load rating calculation summaries
- Repair recommendations and repair actions taken
- General correspondence
- Channel cross-section information when required (stored electronically in SMS)
- Other relevant information

2.14.8.2 District Files

- Copies of current and previous bridge inspection reports with photos.
- Any sketches made by the inspector
- Repair recommendations and other actions taken
- General Correspondence
- Other relevant information
- All future records will be kept electronically in SMS

2.15 Quality Control / Quality Assurance

Metric 20 requirement: Systematic quality control (QC) and quality assurance (QA) procedures are used to maintain a high degree of accuracy and consistency in the inspection program.

QC/QA procedures include periodic field review of inspection teams, periodic refresher training, and independent review of inspection reports and computations.

The Quality Control / Quality Assurance processes are a vital part of the Bridge Inspection Program. MDT requires a high level of data integrity in order to meet its needs and responsibilities. Quality Control is a District function. Quality Assurance is a function of the Bridge Management Section in Helena.

2.15.1 Quality Control (by Districts)

Quality Control is the steps each District takes to monitor the accuracy of inspections and confirm that data collection is complete. Proper Quality Control will ensure the inspection data gathered is consistent and meets guidelines established by MDT.

The District Bridge Inspection Manager is responsible for administering the District Quality Control plan. The quality control plan may be customized to fit the procedures of the District, but must include the following minimum items.

<u>Data Verification</u>

An independent second party Reviewer who meets the qualification of Team Leader will review each inspection report. This person will review the report for accuracy, completion, consistency, and the reasonableness of the inspection. Any errors noted or problems identified will be addressed with the individual who performed the inspection. If the issues cannot be resolved, the discussion may be elevated to the Bridge Management Section.

<u>On-Time Inspections and Reporting</u>

Ensure that bridge inspections are performed within the required intervals, inspection data is entered and reviewed within the time specified, and the inspection reports are signed and sent to the Bridge Management Section in Helena once data entry and quality control checks are complete.

<u>Rotation of Inspectors</u>

Each year, the district will rotate a minimum of 10% of its bridges to another inspector in that district. These bridges are to include a variety of bridge types with a diverse combination of material and design types. When significant differences are identified from one inspector to the next, the inspectors will schedule a meeting and discuss the differences.

<u>Element Spot Check</u>

Each year, the District Bridge Inspection Manager will randomly choose 5% of the district's bridges to review. These structures are to include a diverse combination of material and design types. This review will assess the accuracy and completion of the inspection. Data review will include element identification, environmental state, quantities, condition states, and all NBI and non-NBI fields the inspectors are responsible for. The Manager will also review consistency from inspection to inspection and throughout the district. Spot checks are an ongoing process that occurs throughout the year.

<u>Internal Quality Assurance</u>

District level Quality Assurance is a check on the administration and operation of the Quality Control plan. District Quality Assurance is performed on a semi-annual to annual basis. At the completion of the review, a compliance report is prepared that describes area of conformity and non-conformity and any corrective action taken. The report is sent to the Bridge Management Engineer and the District Bridge

Inspection Manager retains a copy on file. These are intended to be learning opportunities in an ongoing process improvement.

2.15.2 Quality Assurance (by Bridge Management Section, Helena)

The purpose of the quality assurance review program is to evaluate program effectiveness, uniformity, and compliance with federal and state rules relating to bridge inspections. Quality assurance reviews may recommend program improvements and may require changes in a program. Inspector training is an integral part of the quality assurance process and helps ensure uniformity of inspections throughout the state. The quality assurance review program, under the direction of the Bridge Management Section, involves two different levels of review: office review and field review.

<u>Office Review</u>

An office review consists of reviewing information such as inspection reports and bridge measurements submitted to the Bridge Management Section. These reviews occur on a random sample of at least 5 percent of inspections as inspection data arrives in the Bridge Management Section.

<u>Field Review</u>

The Bridge Management Section personnel will conduct a quality assurance inspection review of NBI/Element inspections performed by each district. Every year, a random sample of NBI/Element inspections will be reviewed for consistency and conformance with State and Federal policy and procedures. The Bridge Management Section will perform a yearly field review on the NBI/Element inspections of at least 2 percent of each District's bridges.

The District Bridge Inspection Manager, Assistant Bridge Inspection Manager, and at least one of Bridge Management Section's Bridge Conditions and Operations Engineers are required review team members. Other inspection personnel from the District being reviewed should also attend. Bridge Inspection staff from other districts may rotate onto the team as well as any new Bridge Management Section staff. Bridge design personnel are encouraged to participate in the Quality Assurance Review process as guest inspectors.

The quality assurance team will generate a totally independent inspection report for those bridges selected. The team will then compare their inspection report to the latest inspection reports and information. The accuracy of the condition ratings and the comments are reviewed to ensure they reflect the actual conditions of the bridge. Discrepancies are documented and discussed with the bridge inspector.

On-site inspector training is provided during these reviews as training needs are identified. The Bridge Management Section conducts this training and will tailor the training to the needs of each district. Training needs are identified through the Office Review process and on previous Field Reviews.

<u>Internal Quality Control</u>

Bridge Management Section personnel will check for errors as they work and update the SMS as required. At the end of each Quality Assurance Field Review, the engineers involved in the review will go through the file for each bridge reviewed to make sure all relevant information is in the file and to remove any duplicate information.

2.16 Consultant Inspections

MDT contracts with consultants to perform specialty and regular inspections. MDT does not have the resources or in-house expertise to perform diving (Underwater) or climbing inspections and certain types of non-destructive testing (NDT). Consultants are also utilized when MDT resources are not available to complete all regularly scheduled inspections on time.

2.16.1 Specialty Inspections

MDT uses the following process to complete specialty consultant inspections.

- Consultants are hired using MDT's Consultant Design Section processes and access is granted to the SMS. See requirements below for external user access.
- The consultant performs bridge inspection.
- An electronic draft inspection is uploaded to SMS. The consultant performs Quality Control of a specialty inspection in alignment with the MDT inspection contract provisions.
- Consultant transmits inspection documents to MDT.
- MDT reviews the draft inspection and inspection documents. MDT requests correction and resubmittal as necessary. The consultant loads final inspection documents into the SMS and e-signs inspection, for approval by Bridge Management Section.
- Bridge Management Section approves the final signed and reviewed electronic inspection. The SMS application stores historical bridge inspection data and can generate a signed legal hard or electronic copy of an inspection report.
- Bridge Management Section distributes either electronic or hardcopy signed bridge inspection reports to bridge owners and entities responsible for bridge maintenance.

2.16.2 Regular Inspections

MDT uses the following process to complete a regular inspection performed by consultants.

- Consultants are hired using MDT's Consultant Design Section processes and access is granted to the SMS. See requirements below for external user access.
- The consultant performs bridge inspection.
- Consultant uploads the bridge inspection data into SMS, ensuring the data entered meets quality control guidelines established by MDT Bridge Management Section. Consultant electronically signs the bridge inspection report and forwards to the District Bridge Inspection Manager (DBIM) for final acceptance.
- DBIM completes quality control on bridge inspection and then sends it back to the consultant for correction and resubmittal, if necessary. DBIM accepts the final signed and reviewed electronic inspection. QC and QA of consultant regular inspections follow the processes outlined above.
- DBIM distributes either electronic or hardcopy signed bridge inspection reports to bridge owners and entities responsible for bridge maintenance.

2.16.3 Statewide Inspector Meetings

At least biannually, the Bridge Management Section will host a Bridge Inspector's Meeting to provide training to the inspectors based on training needs identified during QA Reviews and any new changes to the NBIS or Element Inspection standards. Also, the findings of Quality Assurance reviews will be discussed, and any questions or concerns the inspectors have will be addressed.

2.17 Element Descriptions and Identification

This section covers the main structural elements used in element inspection and coding. This is not all-inclusive, but will give the inspector an idea of how a structure should be coded. The elements are listed by their generic names. Unless otherwise noted, these descriptions are for all material types.

Deck/Slab Elements

Deck

The deck is the part of the bridge that the vehicle drives on. It transfers the vehicle wheel loads to the superstructure.

Slab

A slab is a deck that acts as a superstructure. There are no other superstructure elements present with a slab. A slab transfers the vehicle load directly to the substructure.

Top Flange

The top flange is the portion of a tee-beam or box beam type structure that carries the traffic loads. This is defined as the part of the beam from the web fillet up to the riding surface and is shaded gray in Figure 2.16-1.

Superstructure Elements

Girder / Stringer

Girders are longitudinal members that are primary load carrying members of a superstructure and span from substructure to substructure. In the past, beams on short span bridges have been called stringers. Stringers are described below.

Since it is rather difficult to inspect girders that are enclosed, girder quantities are determined from the number of girders that can be seen from the underside of the bridge. This is done to simplify the inspection assessment since the inside of box girders cannot sometimes be seen.

For box girders and tee-beam bridges, two elements will be required to be coded, as follows. Girders that make up the riding surface will require coding of two elements. The riding surface will be coded as a Top Flange. The web and bottom flange will be coded as a girder (below the top flange/web fillet). This is the unshaded area of the girders in Figure 2.16-1.

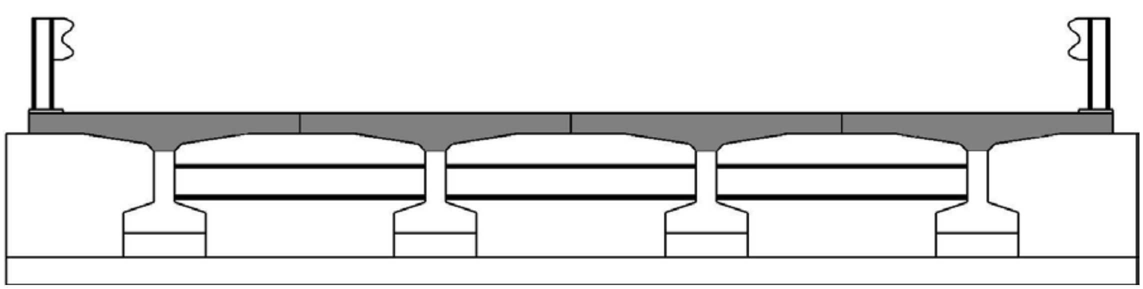


Figure 2.16-1 Typical Bulb-Tee Girders

Truss

A truss is a longitudinal main load carrying member that is made up of a top chord, bottom chord, verticals, and diagonals, which when connected form triangles. There are through trusses, partial-through trusses, pony trusses, and deck trusses.

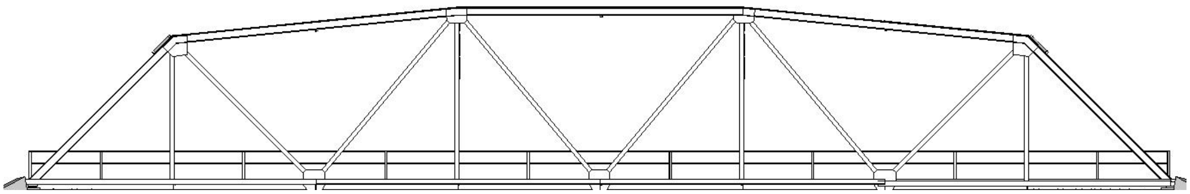


Figure 2.16-2 Typical Through Truss

Arch

An arch is a longitudinal main load carrying member that is shaped like an arc and is always in compression.

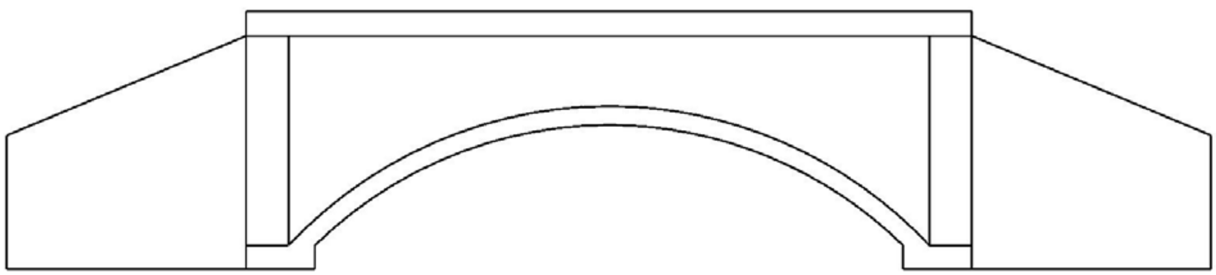


Figure 2.16-3 Typical Simple Arch

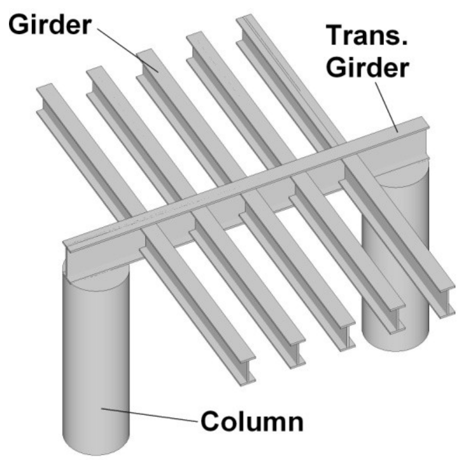


Figure 2.16-4 Typical Transverse Girder

Stringer

A stringer is a longitudinal element that transfers loads from the deck to the Floorbeams or Transverse Girders.

Floorbeam
A floorbeam is a transverse element that transfers loads from the deck and/or stringers to the main longitudinal superstructure members (girders, truss, or arch).

Transverse Girder
A transverse girder is an element that carries the load from the deck or stringers directly to the substructure through the bearings.

Substructure Elements
Column
A column is an element that transfers loads from a pier cap and / or directly from a superstructure bearing to the footing or pile cap. Columns differ from piles, in that columns are not mechanically driven into the ground.

Pier Wall
A pier wall is a wall that transfers loads either directly from the superstructure or from the pier cap to the pile cap, footing, or piles. Web walls are not pier walls, and should not be coded as pier walls, since they are typically not designed to transfer gravity loads.

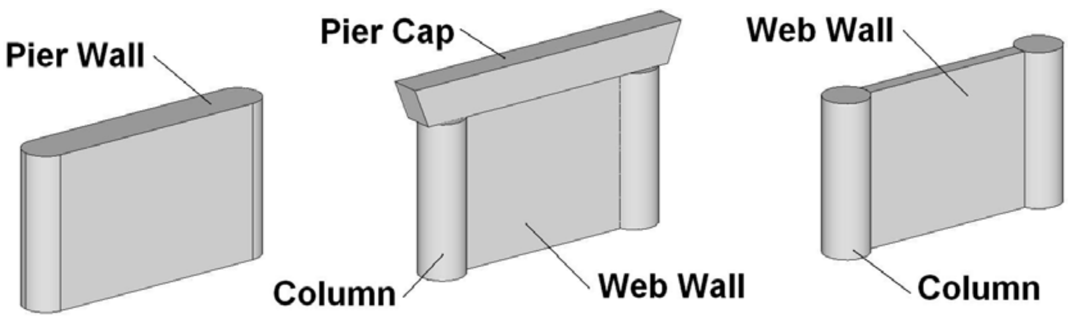


Figure 2.16-5 Typical Concrete Pier with Walls

Pier Cap
A pier cap is an element that transfers loads from the girder bearing devices to the column, pier wall, or piles. Bump outs on top of pier walls are not considered pier caps.

Pile Cap
A pile cap is an element that transfers the loads from the pier wall or columns to the piles or from the bearings to the piles, in the case of piles that extend up to the underside of the superstructure.

Footing
A footing is an element that transfers the loads from the pier wall or columns directly to the ground.

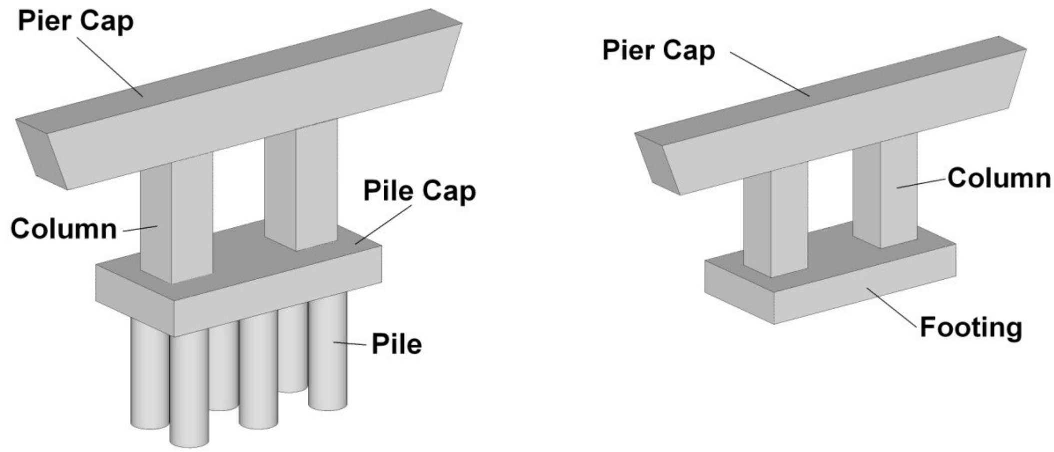


Figure 2.16-6 Typical Concrete Pier with Columns

Piles

Piles are elements that transfer load from a pile cap or pier cap to the ground. They are mechanically driven into the ground, as opposed to columns, which are not driven. Note that portions of piles above the ground and water surface are referred to as pile extensions and are coded as Piles.

Abutment

An abutment is the support element that is at the beginning and ending of the structure. It transfers loads from the superstructure to the ground. Concrete abutments include the cap, piles, wingwalls, and backwall. Timber and steel abutments include the backwall, wingwalls, and wingwall piles. The caps and piles are coded separately for timber and steel abutments.

- For abutments with a load-bearing breastwall: The abutment element is the area between the first breastwall and wingwall joints.
- For abutments with piles/columns, cap and backwall: The abutment element is backwall between the first breastwall and wingwall joints.
- Integral wingwalls (no joints between abutment stem and wingwalls) are rated under the abutment stem element.
- Non-integral wingwalls are not rated under the abutment elements and are not considered elements. These should be coded under ADE elements 911 – 915 (Non-structural retaining walls).

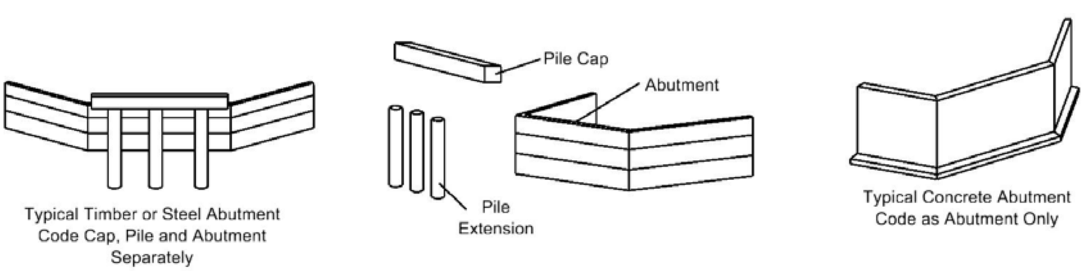


Figure 2.16-7 Typical Abutments

Column Tower (Trestle)
A column tower or trestle is a built up or framed tower support. The steel version is a tower and the timber version is a trestle.

Submerged Pile
A submerged pile is the section of the pile that is below the water line. Note that this element is only used when there is an Underwater inspection, not for probe and wades.

Submerged Column
A submerged column is the section of the column that is below the water line. Note that this element is only used when there is an Underwater inspection, not for probe and wades.

Submerged Pier Wall
A submerged pier wall is that portion of the pier wall that is below the water line. This element does not apply to web walls between two or more columns. Note that this element is only used when there is an Underwater inspection, not for probe and wades.

Submerged Footing/Pile Cap
This element is for footings and pile caps that are underwater and are exposed by design or by scour of the soil around them. Note that this element is only used when there is an Underwater inspection, not for probe and wades.

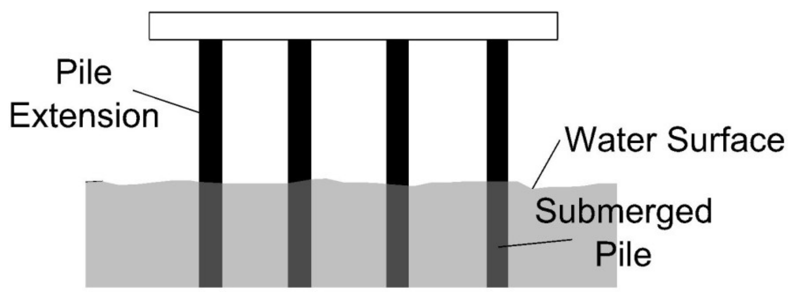


Figure 2.16-8 Submerged Piles

This section includes a matrix of all bridge elements including National Bridge Elements (NBE), Bridge Management Elements (BME) and Agency Defined Elements (ADE) as well as a matrix for element defects. Underlined elements are the Agency Defined Elements unique to MDT.

2.17.1 Decks, Slabs, Top Flanges, and Related Elements

Detailed descriptions of the Deck, Slab, and Top Flange elements along with their related elements – Joints, Approach Slabs, and Bridge Rail – can be found in Chapter 2.

Material	Units	Element Number (Decks)	Element Number (Slab)	Element Number (Top Flange)
Reinforced Concrete Deck/Slab	sq ft	12	38	16
Prestressed Concrete Deck/Slab	sq ft	13	39	15
Steel - Open Grid	sq ft	28		
Steel - Concrete Filled Grid	sq ft	29		
Steel - Corrugated/Orthotropic/Etc.	sq ft	30		
Timber	sq ft	31	54	
Other	sq ft	60	65	

Element	Units	Element Number
Joints		
Strip Seal Expansion Joint	ft	300
Pourable Joint Seal	ft	301
Compression Joint Seal	ft	302
Assembly Joint/Seal (modular)	ft	303
Open Expansion Joint	ft	304
Assembly Joint w/o Seal	ft	305
Other Joint	ft	306
Approach Slabs		
P/S Concrete Approach Slab	sq ft	320
Reinforced Concrete Approach Slab	sq ft	321
Bridge Railings		
Metal Bridge Railing	ft	330
Reinforced Concrete Bridge Railing	ft	331
Timber Bridge Railing	ft	332
Other Bridge Railing	ft	333
Masonry Bridge Railing	ft	334
Protective System		
Wearing Surfaces	sq ft	510
Steel Protective Coating	sq ft	515
Corrosion Resistant Reinforcing System – Metallic	sq ft	990
Corrosion Resistant Reinf System – Non-Metallic	sq ft	991
Concrete Reinforcing Steel Protective System	sq ft	520
Concrete Protective Coatings	sq ft	521

2.17.2 Superstructure Elements

Detailed descriptions of superstructure elements can be found in Chapter 3.

Element	**Units**	**Steel**	**P/S Concrete**	**Reinf. Concrete**	**Timber**	**Masonry**	**Other**
Open Girder/Beam	ft	107	109	110	111		112
Closed Web/Box Girder	ft	102	104	105			106
Stringer	ft	113	115	116	117		118
Truss	ft	120			135		136
Arch	ft	141	143	144	146	145	142
Floor Beam	ft	152	154	155	156		157
Transverse Girder	ft	810	811				812
Railroad Car	ft	815					
Cable – Primary	ft	147					
Cable – Secondary	Each	148					149
Gusset Plate	Each	162					
Pin, Pin and Hanger Assembly, or Both	Each	161					
Truss Vertical Cross-Frame	ft	820					
Curved Girder Diaphragm	ft	821					
Post-Tensioning Anchor	Each	825					

Protective Systems		
Steel Protective Coating	sq ft	515
Concrete Protective Coating	sq ft	521

Bearings		
Elastomeric Bearing	Each	310
Movable Bearing (roller, sliding, etc.)	Each	311
Enclosed/Concealed Bearing	Each	312
Fixed Bearing	Each	313
Pot Bearing	Each	314
Disk Bearing	Each	315
Other Bearing	Each	316

2.17.3 Substructure Elements

Detailed Descriptions of Substructure Elements can be found in Chapter 4.

Element	**Units**	**Steel**	**P/S Concrete**	**Reinf. Concrete**	**Timber**	**Masonry**	**Other**
Column	Each	202	204	205	206		203
Column Tower (Trestle)	ft	207			208		
Pier Wall	ft			210	212	213	211
Abutment	ft	219		215	216	217	218
Pile	Each	225	226	227	228		229
Pier Cap	ft	231	233	234	235		236
Pile Cap/Footing	ft			220	855		
Submerged Column	Each	860	861	862	863		864
Submerged Pier Wall	ft			870	871	872	873
Submerged Pile	Each	880	881	882	883		884
Submerged Pile Cap/Footing	ft			890	891		
Non-Structural Retaining Wall	ft	911		912	913	914	915

Other Substructure Elements	**Units**	**Element Number**
Scour	Each	900
Scour Countermeasures	Each	901

GRS-IBS Retaining Wall	ft	910

2.17.4 Culverts

CULVERTS Chapter 4 Element	Units	Steel	P/S Concrete	Reinf. Concrete	Timber	Masonry	Other
Culvert	ft	240	245	241	242	244	243

2.17.5 Off-Bridge Elements

Element	Units	Steel	P/S Concrete	Reinf. Concrete	Timber	Masonry	Other
Approach Guardrail	ft	950		951	952		953
Approach Guardrail Ends	ft	960					

2.17.6 Material Defects

Defect Name (Number)	Used to Report	Material(s) / Application
Corrosion (1000)	Corrosion of metal and other material elements.	Steel/Metal
		Other Materials
Cracking (1010)	Cracking in metal and other material elements.	Steel/Metal
		Other Materials
Connection (1020)	Connection distress in metal, timber and other material elements.	Steel/Metal
		Timber
		Other Materials
Delamination/Spall/Patched Area (1080)	Spalls, delamination, and patched areas in concrete, masonry, and other material elements.	Prestressed Concrete
		Reinforced Concrete
		Masonry
		Other Materials

Defect Name (Number)	Used to Report	Material(s) / Application
Exposed Rebar (1090)	Exposed conventional reinforcing steel in reinforced and prestressed concrete.	Prestressed Concrete
		Reinforced Concrete
Exposed Prestressing (1100)	Exposed prestressing steel in concrete elements.	Prestressed Concrete
Cracking (PSC) (1110)	Cracking in prestressed concrete elements.	Prestressed Concrete
Efflorescence/Rust Staining (1120)	Efflorescence/rust staining in concrete, masonry and other material elements.	Prestressed Concrete
		Reinforced Concrete
		Masonry
		Other Materials
Cracking (RC and Other) (1130)	Cracking in reinforced concrete and other materials.	Reinforced Concrete
		Other Materials
Decay/Section Loss (1140)	Decay (section loss) in timber elements.	Timber
Check/Shake (1150)	Checks and shakes in timber elements.	Timber
Crack (Timber) (1160)	Cracking in timber elements.	Timber
Split/Delamination (Timber) (1170)	Splits/delaminations in timber elements.	Timber
Abrasion/Wear (Timber) (1180)	Abrasion/wear in timber elements.	Timber
Abrasion/Wear (Concrete) (1190)	Abrasion/wear in prestressed and reinforced concrete elements.	Prestressed Concrete
		Reinforced Concrete
Deterioration (Other)	General deterioration in elements constructed of other materials such as	Other Materials

Defect Name (Number)	Used to Report	Material(s) / Application
(1220)	fiber reinforced plastics or similar.	
Mortar Breakdown (Masonry) (1610)	Breakdown of masonry mortar between brick, block or stone.	Masonry
Split/Spall (Masonry) (1620)	Splits or spalls in brick, block or stone.	Masonry
Patched Area (Masonry) (1630)	Masonry patched areas.	Masonry
Masonry Displacement (1640)	Displaced brick, block or stone.	Masonry
Distortion (1900)	Distortion from the original line or grade of the element; used to capture all distortion regardless of cause.	Steel/Metal Prestressed Concrete
Movement (2210)	Movement of bridge bearing elements.	Bearings
Alignment (2220)	Misalignment of bridge bearing elements.	Bearings
Bulging, Splitting or Tearing (2230)	Bulging, splitting or tearing of elastomeric bearing elements.	Bearings
Loss of Bearing Area (2240)	Loss of bearing area for bridge bearing elements.	Bearings
Leakage (2310)	Leakage through or around sealed bridge joints.	Joints
Seal Adhesion (2320)	Loss of adhesion in sealed bridge joints.	Joints
Seal Damage (2330)	Damage to rubber in bridge joint seals.	Joints

Defect Name (Number)	Used to Report	Material(s) / Application
Seal Cracking (2340)	Cracking within joint seals.	Joints
Debris Impaction (2350)	Accumulation of debris in bridge joint seals that may or may not affect the performance of the joints.	Joints
Adjacent Deck or Header (2360)	Concrete deck damage in the area anchoring the joint.	Joints - Concrete
Metal Deterioration or Damage (2370)	Metal damage or deterioration in the bridge joint.	Joints - Steel / Metal
Delamination/Spall/Patched Area/Pothole (Wearing Surfaces) (3210)	Spalls, delaminations, patched areas, and potholes in wearing surface elements.	Wearing Surfaces
Crack (Wearing Surface) (3220)	Cracking in wearing surface elements.	Wearing Surfaces
Effectiveness (Wearing Surface) (3230)	Loss of effectiveness in the protection provided to the deck by the wearing surface elements.	Wearing Surfaces
Chalking (Steel Protective Coatings) (3410)	Chalking in steel protective coatings.	Steel/Metal Protective Coatings
Peeling/Bubbling/Cracking (Steel Protective Coatings) (3420)	Peeling, bubbling or cracking in steel protective coatings.	Steel/Metal Protective Coatings
Oxide Film Degradation Color/Texture Adherence	Oxide film degradation of texture in steel protective coatings.	Steel/Metal Protective Coatings

Defect Name (Number)	Used to Report	Material(s) / Application
(Steel Protective Coatings) (3430)		
Effectiveness (Steel Protective Coatings) (3440)	Loss of effectiveness of steel protective coatings.	Steel/Metal Protective Coatings
Wear (Concrete Protective Coatings) (3510)	Wearing of concrete protective coatings.	Concrete Protective Coatings
Effectiveness (Concrete Protective Coatings) (3540)	Loss of Effectiveness of concrete protective coatings.	Concrete Protective Coatings
Effectiveness – Protective System (e.g. Cathodic) (3600)	Loss of Effectiveness of internal concrete protective systems (epoxy rebar, cathodic protection, etc.).	Concrete Reinforcing Steel Protective Systems
Settlement (4000)	Settlement in substructure or approach elements.	Steel/Metal
		Prestressed Concrete
		Reinforced Concrete
		Masonry
		Timber
		Other Materials
Damage (7000)	Impact damage.	Steel/Metal
		Prestressed Concrete
		Reinforced Concrete
		Masonry
		Timber
		Other Materials

Defect Name (Number)	Used to Report	Material(s) / Application
		Wearing Surfaces
		Steel/Metal Protective Coatings
		Concrete Protective Coatings
		Concrete Reinforcing Steel Protective Systems

2.17.7 Defect Hierarchy

In some cases, there may be multiple overlapping defects noted for an element. In those overlapping cases, all defects will be recorded. When calculating the amount in each condition state for the parent element, only the prevailing defect will be used to determine the quantities in each condition state. When there are two or more defects in the same area, then the defect in the worst condition state will be used to determine the condition state of the parent element. If the worse defect in an area is in condition state 3, then that portion of the element is in condition state 3 regardless of how many other condition state 2 defects share that space.

However, if there are defects that are in the same condition state, the inspector needs to know how to determine the "most important" defect to use in determining the condition state quantities of the parent element. In order to be consistent through the districts, the following hierarchy will be followed. Only the most common issues with defect overlaps are shown.

There may be additional defects that need to be added based on the judgement of the inspector.

2.17.7.1 Concrete

For concrete elements regardless of location use the following priority list:

Defect Number	Defect Name
1100	Exposed Prestressing
1090	Exposed Reinforcing
1080	Spalls/Delams/Patches
1120	Efflo/Rust Staining
1110/1130	Cracking
1190	Abrasion
7000*	Damage

2.17.7.2 Steel

For steel elements regardless of location use the following priority list:

Defect Number	Defect Name
1010	Cracking
1900	Distortion
1000	Corrosion
1020	Connections
7000*	Damage

2.17.7.3 Timber

For timber elements regardless of location use the following priority list:

Defect Number	Defect Name
1160	Cracks
1140	Decay/Section Loss
1170	Split/Delamination
1020	Connections
1150	Check/Shake
1180	Abrasion
7000*	Damage

2.17.7.4 Masonry

For Masonry elements use the following priority list:

Defect Number	Defect Name
1640	Displacement
1620	Split/Spall
1080	Spalls/Delams/Patches
1610	Mortar Breakdown
1120	Efflor/Rust Staining
1630	Patched Area
1900	Distortion
7000*	Damage

2.17.7.5 Bearings

For bearings on concrete and steel structures use the following priority list:

Defect Number	**Defect Name**
2220	Alignment
2210	Movement
2240	Loss of Bearing Area
2230	Bulging, Splitting or Tearing
1000	Corrosion
1020	Connection
7000*	Damage

2.17.7.6 Joints

For joints on concrete and steel structures use the following priority list:

Defect Number	**Defect Name**
2310	Leakage
2320	Seal Adhesion
2340	Seal Cracking
2330	Seal Damage
2370	Metal Deterioration or Damage
2360	Adjacent Deck or Header
2350	Debris Impaction
7000*	Damage

*Note that the Damage defect is considered a sub-defect and is used only in conjunction with another defect and assumes the quantity of that other defect.

2.18 MDT Inspection Items

Other items that the inspector needs to collect and record when visiting a bridge site include posting of bridge load limit signs, Transporter Erector (TE) Routes and Defense Highway designations. The Structure Management System (SMS) will require collection of the following information specific to Montana.

<u>MDT 001: Agency Structure Name</u>

This is the name the owner gives to the bridge. For example, counties sometimes name their bridges using an alpha-numeric system. On state-owned bridges, this field is typically left blank.

MDT 004: Crew Hours
The number of hours it takes to complete an inspection on the bridge. This includes office time preparing for the inspection and data entry after the inspection. It does not include travel time to and from the bridge.

MDT 005: Date Last QA
This is used to code the last date that a field or office quality audit was performed.

MDT 006: Deck Area
SMS will be updated to automatically calculate this item. Inspectors are not allowed to enter anything into this field.

MDT 007: Departmental Route
This will be addressed in the Final 2022 BIRM.

MDT 008: Depth of Cover (inches)
This field is used by the rating engineers to determine how much dead load should be added to a bridge. It is measured in inches from the top of the original deck surfacing to the top of the existing surface. See Figure 2.17-1 for illustrations of this measurement on different types of bridges.

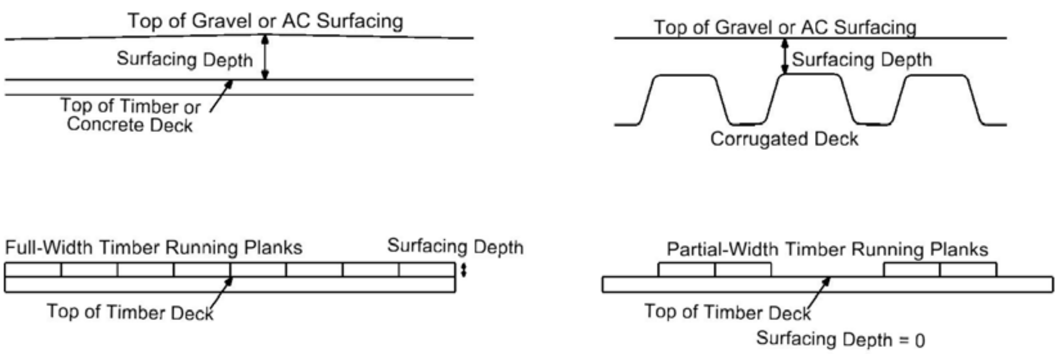


Figure 2.17-1

MDT 009: Detour Speed
Code the average speed in MPH of the detour route.

MDT 010: FC Inspection Details
This field is to show various fracture critical configurations or fatigue prone details. Select from a drop down list of options.

MDT 011: FC Next Inspection Date
This is the next date scheduled for a Fracture Critical inspection.

MDT 012: Flagger Hours
The number of hours that flaggers are needed to complete a regular inspection of the bridge.

MDT 013: Assistant / Trainee Hours
The number of hours required for any personnel in addition to the inspection crew, such as administrative assistants and other helpers.

MDT 014: Interchange Indicator
Select either “1” if it is part of an interchange or “0” if it is not from a drop down list of these two options.

MDT 015: Interstate Ramp Indicator
Select either “1” if it is on an interstate ramp or “0” if it is not, from a drop down list of these two options.

MDT 016: Load Rating Date
The date the current load rating was completed. The load rater is responsible for populating this field.

MDT 017: MDT Original Construction Project Number
The MDT construction project number the bridge was constructed or reconstructed under.

MDT 018: MDT Original Construction Station
The station where the bridge is located within the MDT construction project limits. This is usually listed on the bridge’s General Layout plan sheet.

MDT 019: MDT Original Drawing Number
This field is for the drawing number the Bridge Bureau assigns to the General Layout plan sheet for bridges constructed under an MDT contract. It should not have a Q at the end. Drawing numbers with a Q at the end are for the quantity sheet, not the general layout.

The general layout for a bridge typically has the same number as the quantity sheet, but without the Q. This is not always the case, however.

MDT 020: MDT Maintenance Division
Select the Maintenance Division from a drop down list of options.

MDT 021: MDT UPN
This is for coding the Uniform Project Number from the design plans for the structure…..

MDT 022: Name of Load Rater
Initials of the person who completed the load rating. The load rater is responsible for populating this field.

MDT 023: Next Inspection Date
This is for coding the date of the next scheduled Routine Inspection.

MDT 027: On/Off System
This indicates whether the bridge is on-system or off-system. See Chapter 1 for a description of on-system and off-system bridges. Select from a drop down list of options.

MDT 028: Other Inspection Details
This is for coding bridge elements / details to be inspected during Other Special inspections. Select from a drop down list of options.

MDT 029: Other Inspection Next Date
This is for coding the date of the next Other Special inspection.

MDT 030: Posted Speed Limit (MPH)
This field is for the posted speed of vehicles traveling on the roadway.

MDT 031: Railroad Over/Underpass
Select whether the bridge is a railroad over or underpass from a drop down list of options.

MDT 032: Railroad Owner
Select not applicable or the appropriate railroad from a drop down list of options.

MDT 034: Request Review of Load Rating
Select "0" for No, or select the appropriate choice from the drop down list for Yes.

MDT 035: Road Name
The name of the roadway that serves the bridge, including directional suffix (ie. I-15 NB). This field is printed in theinspection report to help locate the bridge.

MDT 036: SU4 Truck Inventory Rating
The Calculated Inventory Rating for the AASHTO SU4 truck. The load rater is responsible for populating this field.

MDT 037: SU4 Truck Operating Rating
The Calculated Operating Rating for the AASHTO SU4 truck. The load rater is responsible for populating this field.

MDT 039: SU5 Truck Inventory Rating
The Calculated Inventory Rating for the AASHTO SU5 truck. The load rater is responsible for populating this field.

MDT 040: SU5 Truck Operating Rating
The Calculated Operating Rating for the AASHTO SU5 truck. The load rater is responsible for populating this field.

MDT 042: SU6 Truck Inventory Rating
The Calculated Inventory Rating for the AASHTO SU6 truck. The load rater is responsible for populating this field.

MDT 043: SU6 Truck Operating Rating
The Calculated Operating Rating for the AASHTO SU6 truck. The load rater is responsible for populating this field.

MDT 045: SU7 Truck Inventory Rating
The Calculated Inventory Rating for the AASHTO SU7 truck. The load rater is responsible for populating this field.

MDT 046: SU7 Truck Operating Rating
The Calculated Operating Rating for the AASHTO SU7 truck. The load rater is responsible for populating this field.

MDT 049: UBIV Hours

This is for coding the number of hours of underbridge inspection vehicle (UBIV) that is required for inspection.

MDT 050: UBIV Required

Selecting “Y” or “N” from a drop down list indicates if an underbridge inspection vehicle (UBIV) is required for regular inspection of the bridge. *Note drop down is currently greyed out.*

MDT 052: Special Crew Hours

The number of hours that a special crew such as a climbing inspection team needs to conduct a regular inspection. District inspection personnel do not need to enter data into this field.

MDT 053: Special Equipment Hours

This is the number of hours that special equipment is required to perform an inspection.

MDT 056: Special Inspection Next Date

This is the date of the next scheduled special inspection.

MDT 058: FHWA Bridge Condition

This item is used to show if the bridge is structurally deficient or functionally obsolete. This field is auto-filled by SMS.

MDT 059: TE Route

Certain Urban, Secondary and Local routes are designated as TE routes and are used to transport missiles to various sites within a one-hundred-mile radius of Malmstrom Air Force Base in Great Falls. These routes are identified on county maps that are on file in the Bridge Management Section in Helena. FHWA guidelines require those structures between 8 and 20 feet in length also be inspected on these routes, including culverts as outlined in Section 1 of this manual. Selecting “1” from a drop down list will record the bridge as being on a TE route and “0” will indicate not on a TE route.

MDT 060: Traffic Volume Class

This field is automatically updated by the Bridge Information Management System. Inspectors don’t need to enter anything into this field.

MDT 061: Cross-Section / Probe and Wade Inspection Required

This field is used to show if a Cross-Section / Probe and Wade inspection is required. Select the “check” box if a Cross-Section / Probe and Wade inspection is required.

MDT 062: Cross-Section / Probe and Wade Inspection Date

This field is the current Cross-Section / Probe and Wade inspection date.

MDT 063: Cross-Section / Probe and Wade Inspection Frequency (months)

This field is the Cross-Section / Probe and Wade inspection frequency, typically 24 months.

MDT 064: Cross-Section / Probe and Wade Inspection Next Date

This field is the next scheduled Cross-Section / Probe and Wade inspection date and should coincide with the next biennial inspection.

MDT 065: Type 3 Truck Inventory Rating

The Calculated Inventory Rating for the AASHTO Type 3 truck. The load rater is responsible for populating this field.

MDT 066: Type 3 Truck Operating Rating

The Calculated Operating Rating for the AASHTO Type 3 truck. The load rater is responsible for populating this field.

MDT 067: Type 3 Truck Posting

If this bridge is posted for the AASHTO Type 3 truck, the posted load is entered here. The inspector is responsible for this field. See SMS Load Postings Tab for examples of the posting signs.

MDT 068: Type 3-3 Truck Inventory Rating

The Calculated Inventory Rating for the AASHTO Type 3-3 truck. The load rater is responsible for populating this field.

MDT 069: Type 3-3 Truck Operating Rating

The Calculated Operating Rating for the AASHTO Type 3-3 truck. The load rater is responsible for populating this field.

MDT 070: Type 3-3 Truck Posting

If this bridge is posted for the AASHTO Type 3-3 truck, the posted load is entered here. The inspector is responsible for this field. See SMS Load Postings Tab for examples of the posting signs.

MDT 071: Type 3S2 Truck Inventory Rating

The Calculated Inventory Rating for the AASHTO Type 3S2 truck. The load rater is responsible for populating this field.

MDT 072: Type 3S2 Truck Operating Rating

The Calculated Operating Rating for the AASHTO Type 3S2 truck. The load rater is responsible for populating this field.

MDT 073: Type 3S2 Truck Posting

If this bridge is posted for the AASHTO Type 3S2 truck, the posted load is entered here. The inspector is responsible for this field. See SMS Load Postings Tab for examples of the posting signs.

MDT 074: Underwater Inspection Details

This will be addressed in the Final 2022 BIRM. Note drop down is currently greyed out. Baker can't see the drop-down choices

MDT 075: Roadway System

This will be addressed in the Final 2022 BIRM.

MDT 076: Deck Condition

This will be addressed in the Final 2022 BIRM…

MDT 077: Structure Condition

This will be addressed in the Final 2022 BIRM.

<u>MDT 078: MDT Maintenance Section</u>
This field is the MDT Maintenance Section with responsibility for maintenance of the bridge. There is a drop down list to identify the various sections. Code it as “None” for bridges not maintained by MDT.

<u>MDT 079: Truck Type 3 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type 3 truck. The load rater is responsible for populating this field.

<u>MDT 080: Truck Type 3-3 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type 3-3 truck. The load rater is responsible for populating this field.

<u>MDT 081: Truck Type 3S2 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type 3S2 truck. The load rater is responsible for populating this field.

<u>MDT 082: Truck Type SU4 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type SU4 truck. The load rater is responsible for populating this field.

<u>MDT 083: Truck Type SU5 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type SU5 truck. The load rater is responsible for populating this field.

<u>MDT 084: Truck Type SU6 LRFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type SU6 truck. The load rater is responsible for populating this field.

<u>MDT 085: Truck Type SU7 LFFR Rating</u>
The Calculated LRFR Rating for the AASHTO Type SU7 truck. The load rater is responsible for populating this field.

<u>MDT 086: Underwater Next Inspection Date</u>
This is the date of the next scheduled underwater inspection.

<u>MDT 087: Decimal Mile Post</u>
This will be addressed in the Final 2022 BIRM.

<u>MDT 089: Asset Approved</u>
This will be addressed in the Final 2022 BIRM.

<u>MDT 090: Climbing Inspection Required</u>
Select “Y” if required or “N” if not.   Note drop down is currently greyed out.

<u>MDT 091: EV2 Truck Inventory Rating</u>
The Calculated Inventory Rating for the EV2 truck. The load rater is responsible for populating this field.

<u>MDT 092: EV3 Truck Inventory Rating</u>
The Calculated Inventory Rating for the EV3 truck. The load rater is responsible for populating this field.

MDT 093: EV2 Truck Operating Rating
The Calculated Operating Rating for the EV2 truck. The load rater is responsible for populating this field.

MDT 094: EV3 Truck Operating Rating
The Calculated Operating Rating for the EV3 truck. The load rater is responsible for populating this field.

MDT 095: Truck Type EV2 LRFR Rating
The Calculated LRFR Rating for the EV2 truck. The load rater is responsible for populating this field.

MDT 096: Truck Type EV3 LRFR Rating
The Calculated LRFR Rating for the EV3 truck. The load rater is responsible for populating this field.

MDT 097: Plans in SMS?
Select "Y" if plans are in SMS or "N" if plans are not in SMS.

MDT 098: Shop Drawings in SMS
Select from a dropdown list of several options.

MDT 099: MDT Rehab Project Numbers
This field is for entering in the project numbers which the bridge has been rehabilitated.

MDT 100: MDT Rehab Stations
The station where the bridge is located within the MDT rehab construction project limits.

MDT 101: MDT Rehab UPNs
This is the Uniform Project Number from design plans for the structure.

MDT 102: Years Rehabilitated
This field is for entering in the years in which the bridge has been rehabilitated.

MDT 103: MDT Rehab Drawing Numbers
This field is for the drawing number the Bridge Bureau assigns to the General Layout plan sheet for bridges constructed under an MDT contract.

MDT 104: Bridge Deck Seal
This will be addressed in the Final 2022 BIRM.

MDT 105: Polymer Overlay
This will be addressed in the Final 2022 BIRM.

MDT 106: Mill and Overlay
This will be addressed in the Final 2022 BIRM.

MDT 107: New Bridge Deck
This will be addressed in the Final 2022 BIRM.

MDT 108: Experimental Deck
This will be addressed in the Final 2022 BIRM.

MDT 109: Bridge Deck Overlay Type
This will be addressed in the Final 2022 BIRM.

MDT 110: Bridge Being Rated by Consultant
This is to code which consultant and contract period the bridge was load rated, if applicable. Select from a drop down list of options.

MDT 111: NBI Id of Previous Structure
This will be addressed in the Final 2022 BIRM.

MDT 112: Completed Rating Model?
This will be addressed in the Final 2022 BIRM.

MDT 113: Station Mile Post
This will be addressed in the Final 2022 BIRM.

MDT 114: MPO
This is to code if the bridge is part of a Metropolitan Planning Organization, like Billings, Great Falls or Missoula. Select from a drop down list of options.

MDT 115: MDT Administrative District
This is the administrative district where the bridge is located. Select from a drop down list of options.

MDT 116: MDT Financial District
Select the appropriate Financial District from a drop down list of options.

MDT 117: Border Bridge – Neighboring County Code
This is to code the neighboring county code. Select from a drop down list of options.

MDT 118: Underwater Consultant
This is to code the underwater Consultant   Note drop down is currently greyed out.

MDT 119: Date Bridge Opened/Re-Opened to Traffic
This will be addressed in the Final 2022 BIRM.

MDT 120: Environment
This will be addressed in the Final 2022 BIRM.

MDT 121: Field Functional Needs
This will be addressed in the Final 2022 BIRM.

MDT 122: Rail Type
This will be addressed in the Final 2022 BIRM.

MDT 123: Approach Section Rail Type
This will be addressed in the Final 2022 BIRM.

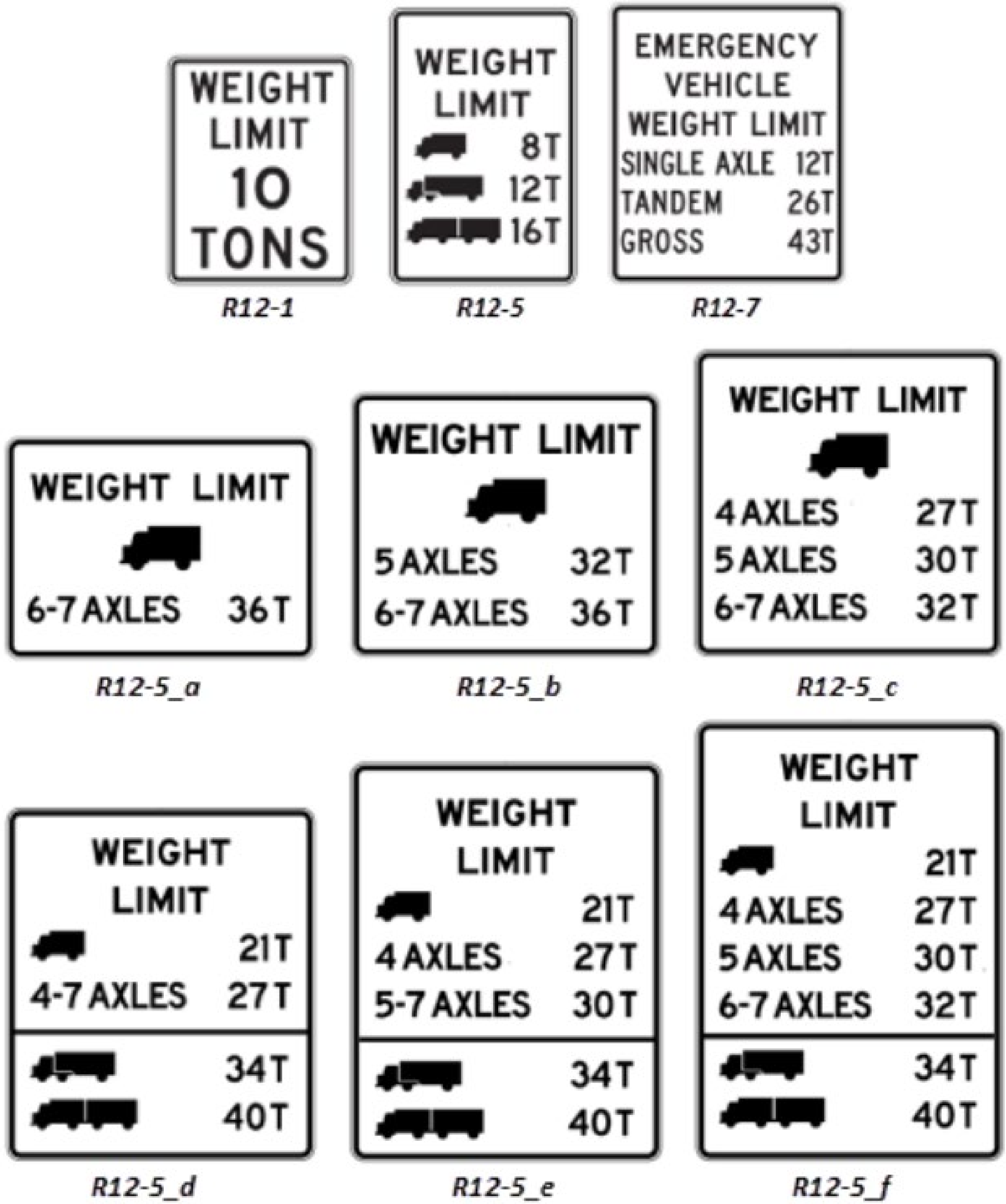
MDT 133: Bridge Within Reasonable Access of Interstate
Code "Y" for yes, "N" for no or "3" if not certain, from a drop down list of options.

MDT 134: UBIV Frequency (months)
This is to code how often an underbridge inspection vehicle is required.

MDT 135: Posting Sign Type
Statutory law governs the maximum weight of vehicles legally allowed to use the highways without special permits in order to serve the public interest in safety as well as economic concerns. When bridges do not have the capacity to carry legal loads they are required by law to be load posted. One requirement of the NBIS is that each bridge inspected will be rated as to its safe load carrying capacity. If the maximum legal load of 40 tons for the AASHTO Type 3-3 truck exceeds its operating rating, the bridge must be posted in accordance with AASHTO requirements, found in the Manual for Bridge Evaluation (MBE).

In addition, any change in the posting status of a structure must be entered into the bridge inspection database within 180 days. Title 23, Section 1.36 of the Code of Federal Regulations allows FHWA to withhold federal funds to any jurisdiction not in compliance. For this reason, the Bridge Management Section established the County Posting Program. The current program used Metric number 14 as the definitive guide. When a bridge requires posting, a letter is sent to the county. The letter states MDT's requirement that the structure be posted at the inventory rating level, and includes the proper signing and placement instructions. At a minimum, the bridge must be posted for the Type 3 truck. The preferred option, though it is not required, is for the county to post for all three truck types. The county is instructed to sign and return the letter to MDT when the bridge has been posted. As soon as possible, but no later than the next regular inspection of the structure, weight-restriction posting signs will be confirmed with photos. Specialized Hauling Vehicle (SHV) ratings will be shown in the database, but at this time there is no specific requirement to post a bridge based on the load ratings for these vehicles.

Select from the drop down list of sign types, shown in the diagram below.



<u>MDT 136: Line 1 Number of Axles Posting</u>
This is the number of axles for Line 1.

MDT 137: Line 1 GVW Posting
This is the posted tonnage for Line 1.

MDT 138: Line 2 Number of Axles Posting
This is the number of axles for Line 2.

MDT 139: Line 2 GVW Posting
This is the posted tonnage for Line 2.

MDT 140: Line 3 Number of Axles Posting
This is the number of axles for Line 3.

MDT 141: Line 3 GVW Posting
This is the posted tonnage for Line 3.

MDT 142: EV Single Axle Posting
This is the posted tonnage for EV Single axle.

MDT 143: EV Tandem Axle Posting
This is the posted tonnage for EV Tandem axle.

MDT 144: EV Gross Weight Posting
This is the posted tonnage for EV gross weight.

MDT 145: Bridge Inventory Direction
Select the log direction of the route being carried by the bridge from a drop down list of options.

MDT 146: Bridge within a Reservation Boundary
If the bridge is within a reservation, then select the appropriate Reservation from a drop down list of options. If it is not in a Reservation, then select “1” for No.

MDT 147: Posting Implementation Category
This will be addressed in the Final 2022 BIRM. Note drop down is currently greyed out.

Chapter 2 Appendices

Appendix 2A
Field Inspection Checklist

Field Inspection Checklist **Bridge No.___________**

General:

_____ Bridge is labeled correctly, following the labeling priorities in MDT's guidance.
_____ Reviewed the entire latest report before inspection *and* before leaving site (all previous notes addressed)?
_____ TL/Assistant discussed any issues before leaving the field (especially if working independently)?
_____ All required general/condition photos were taken, including work items, repaired items & CS3-CS4 conditions?

Work items and Significant Changes to NBI Ratings:

_____ Notified the area manager about any critical or significant findings at the time of inspection? Photos taken?
(Examples: Cracks in main members, failing members, missing posting signs, vehicular/ped. hazards)
_____ Previous work items were updated where applicable (do not create redundant items)?
_____ Notified area manager about possibly lowering main NBI item condition rating(s) by more than 1 (Items 58-67)?

Signage and posting:

_____ Were clearance forms completed?
_____ Were discrepancies in vertical/lateral clearances double-checked (Items 10, 47, 51, 53, 54, 55, 56)?
_____ Is vertical clearance posting required (<16' over Interstates or <15' over other routes)
____ At-bridge and advance signs are in place? ____ Defects noted? _____ Photos taken?
_____ Load posting signs in place if required?
____ At-bridge and advance signs are in place? ____ Defects noted? _____ Photos taken?
_____ Object marker defects are noted in the report? ____ Photos taken?
_____ Speed limit posting sign near bridge (__ MPH).

Deck/Approaches:

_____ Average curb reveals/ballast depth were measured (when possible)?
_____ Item 36 coding was verified at leading edges?
_____ Excluded Element 950 (Guardrails) at corners <50' long? (End 50' is covered at Element 960).
_____ Do not include wearing surface element for gravel riding surfaces.

Superstructure:

_____ Section loss sketches were generated for losses difficult to describe with words?
_____ Do all losses have 3 dimensions and location from a fixed point?
_____ Are section loss notes detailed enough to update a load rating?
_____ Spot checked original sizes in field and checked for tapered flanges in the event of section losses?
_____ Measured length of the sole plate and web overhang behind the bearing for buckling section loss calculations?

Substructure:

_____ Exposed footings have 3 dimensions (i.e. exposed up to 10” high x 6’ long x up to full width across top)?

_____ Is there any tipping/settlement? Global bearing over-contraction/expansion may be a clue there’s settlement.

____ Used a level or plumb bob to measure tipping?

_____ Boring Inspections:

____ Located the limits of rot in the caps (end section loss measurement less than 10%)

____ Section loss percentages are given or can be computed in the office from field measurements?

Channel:

- Probe and Wade Inspections:

____ Included comments in the general notes section of SMS for channel deficiencies? Required if Item 61 < 7.

____ Were channel measurements taken at the upstream fascia?

____ Was the Probe and Wade section of the Appraisal tab filled out in SMS?

- For structures with Underwater Inspections on a different cycle than the biennial:

____ Were the previous underwater inspection channel notes reviewed?

____ Were any additional defects evident at the biennial inspection noted?

Miscellaneous:

_____ Measurement forms were completed for bridges with missing or outdated plans/measurement forms?

_____ Geometric coding items were spot-checked in the field to ensure plans/measurements forms are current?

_____ NBE original quantities were spot-checked in the field?

____ Followed coding for proper original quantity for sistered girders/stringers?

____ Verified integral versus non-integral wings? Use Element 916 for ALL wings, regardless of mat’l.

____ Mat bearing original quantity should be coded as # of contact points.

____ Ignored bearings that are more than 50% encased in the NBE quantity?

____ Followed proper use of columns versus piles for NBE selection (piles are driven, columns are not)?

____ Updated NBE qtys, as req’d, if new msmnt forms were created or existing forms were updated?

_____ Total of CSs for individual defects does not exceed 100% (i.e. Abut Cracking CS1+CS2+CS3+CS4 ≤ 100%)?

_____ Overlapping defects were included and rolled up properly?

_____ Utility defects are noted in General Notes section of SMS?

Appendix 2B
Inspection Report Review Checklist

Inspection Report Review Checklist   Bridge No.________________

General:

- ____ Bridge is labelled correctly, following the labeling priorities in MDT's guidance.
- ____ All field personnel are included in SMS?
- ____ Inspection dates and future dates are correct?
- ____ Follow-up inspection required/scheduled for excessive snow, etc.?
- ____ Clearance coding matches clearance diagram or clearance measurement form?
  - ____ Vertical clearance is above 16' over interstates or above 15' over other routes?
  - ____ Vertical clearance posting signs in place, if req'd? Posting sign deficiencies are noted in report?
- ____ Load posting signs are in place if required? Any deficiencies are noted in report?
- ____ Object markers are in place? Any deficiencies are noted in the report?
- ____ Did inspector generate new measurement forms due to missing or outdated plans/measurement forms?
- ____ Geometric coding items match plans and/or measurement forms?
- ____ Did the inspector lower any major NBI item ratings by more than 1 (NBI Items 58, 59, 60, 61, 62, 67)?
- ____ Does Reviewer feel any major NBI item rating should be reduced by more than 1?

Channel:

- ____ Probe and wade channel notes are included in general notes section of the report, if Item 61 < 7?
- ____ Probe and wade procedures/measurements completed?
- ____ Was the Probe and Wade section of the Appraisal tab filled out in BrM?
- ____ For bridges with underwater inspections (previous Type 2), is there a scour appraisal on file?
- ____ Was the underwater report referenced? Are there other defects evident during this off-cycle inspection?

Work Items & Serious/Critical Findings:

- ____ Work items were reviewed after the entire report was completely reviewed?
- ____ Previous work items were updated, if needed? No redundant work items for previously open items?
- ____ Were any critical or serious findings reported by the inspector? Were protocols followed?
- ____ Does the reviewer feel there are any other conditions that might be critical or serious findings?

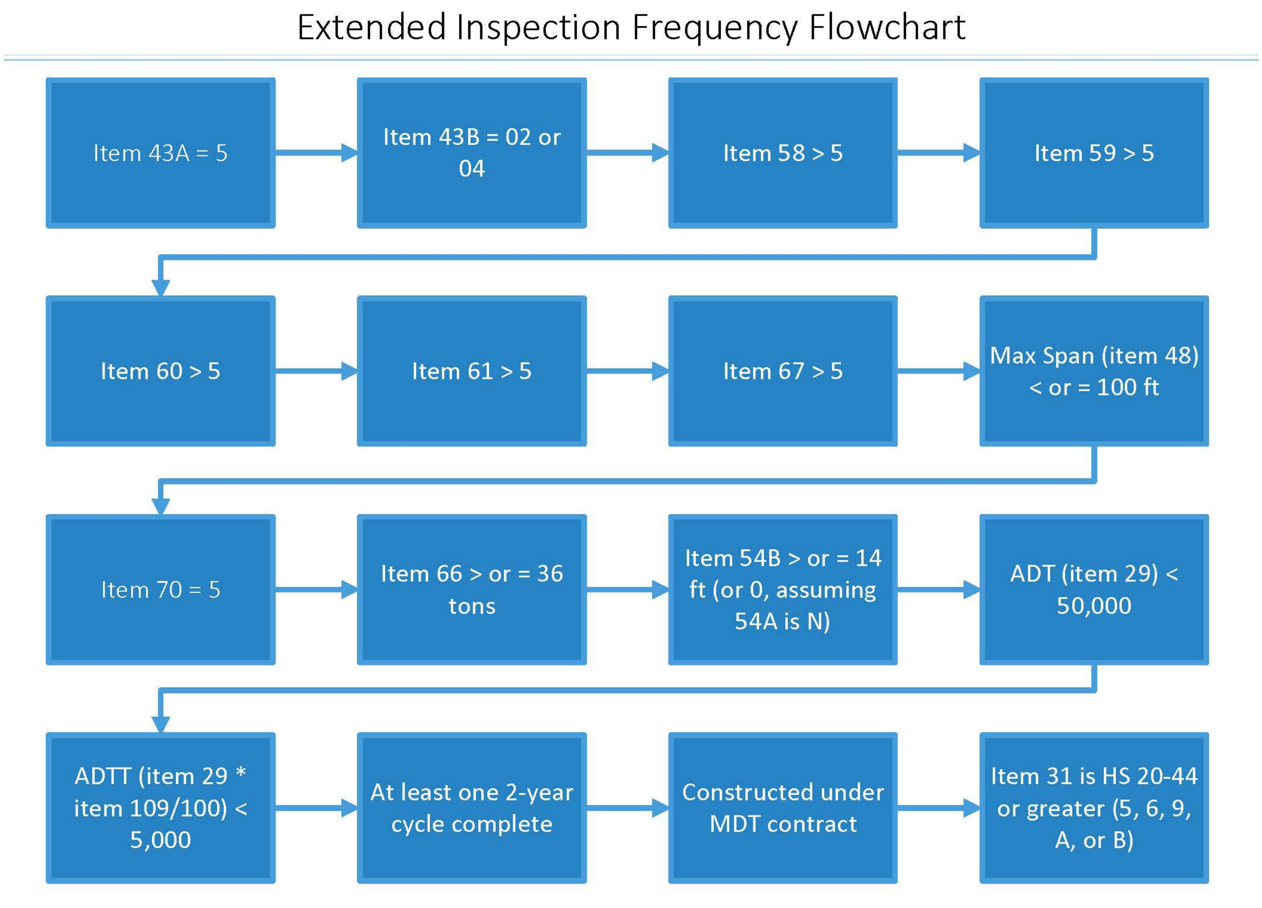
NBE, General:

- ____ General photos included (profile, bridge from approach, underside, upstream downstream)?
- ____ Section loss sketches are included for losses difficult to describe with words?
- ____ Inspection defect notes coincide with correct condition state?
- ____ Defects have dimensions and locations (not just stating CS-2 checks, etc.)?
- ____ Total of CSs for individual defects does not exceed 100%?
- ____ Overlapping defects included and rolled up properly?
- ____ Previous defects were addressed in current report? Repairs noted if any?
- ____ Photos included for CS-3 & CS-4 defects?
- ____ Proper photo documentation procedures were followed.

Other NBE Items:

- ____ Added wearing surface (paved width x structure length)? Do not include this element for gravel surfaces.
- ____ Protective Coating:
  - ____ Gen: Used only Effectiveness for paint/galv or Oxide Film for weathering steel if patina formed?
  - ____ Railings: Used typical railing cheat sheet for railing protective coating original quantity?
- ____ Bearings: Entire bearing should only be in one CS for each defect and paint/protective coating.
- ____ If msmt. forms were updated or new ones were created, were the NBE original quantities also updated?

Appendix 2C
Extended Inspection Interval Criteria



The flowchart above is used to determine if a bridge would qualify for a 4-year inspection cycle. If all conditions in every box are met, then a bridge would qualifor to be on a 4-year inspection cycle.

Appendix 2D
NBI Items - Inspector Responsibility Table

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
1A	State Code/FIPS State	Yes	Inventory - Admin	Location
1B	FHWA Region	Yes	Inventory - Admin	Location
2	Highway Agency District/Inspection District	Yes	Inventory - Admin	Location
3	County (Parish) Code	Yes	Inventory - Admin	Location
4	Place Code	Yes	Inventory - Admin	Location
5A	Inventory Route/Roadway/Position/Prefix	Yes	Inventory - Roads	Identification
5B	Kind Hwy (Rt prefix)	Yes	Inventory - Roads	Identification
5C	Designated Level Service	Yes	Inventory - Roads	Identification
5D	Route Number	Yes	Inventory - Roads	Identification
5E	Suffix	Yes	Inventory - Roads	Identification
6A	Features Intersected	Yes	Inventory - Admin	Location
7	Facility Carried by Structure	Yes	Inventory - Admin	Location
8	Structure Number/NBI Structure No	Yes	Inventory - Admin	Structural Identification
9	Location	Yes	Inventory - Admin	Location
10	Inventory Route, Minimum Vertical Clearance	Yes	Inventory - Roads	Clearances
11	Kilometer Point/Accumulated Miles	Yes	Inventory - Roads	Highway Networks & Service Classification
11	Milepoint	No	Cross Sections	Bridge Details
12	Base Highway Network/National Base Net	Yes	Inventory - Roads	Highway Networks & Service Classification
13A	LRS Inventory Route	Yes	Inventory - Roads	Highway Networks & Service Classification
13B	Subroute Number	Yes	Inventory - Roads	Highway Networks & Service Classification
14	(Reserved)			
15	(Reserved)			
16	Latitude	Yes	Inventory - Admin	Location
17	Longitude	Yes	Inventory - Admin	Location
18	(Reserved)			
19	Bypass, Detour Length	Yes	Inventory - Roads	Detours

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
20	Toll Facility	Yes	Inventory - Roads	Highway Networks & Service Classification
21	Maintenance Responsibility	Yes	Inventory - Admin	Operation
22	Owner	Yes	Inventory - Admin	Operation
23	(Reserved)			
24	(Reserved)			
25	(Reserved)			
26	Functional Classification of Inventory Route	Yes	Inventory - Roads	Highway Networks & Service Classification
27	Year Built	Yes	Inventory - Admin	Age and Service
27	Year Built	Yes	Inventory - Design	Construction
28A	Lanes on the Structure	Yes	Inventory - Roads	Traffic
28B	Lanes Under the Structure	Yes	Inventory - Admin	Age and Service
29	Average Daily Traffic/Recent ADT	Yes	Inventory - Roads	Traffic
30	Year of Average Daily Traffic	Yes	Inventory - Roads	Traffic
31	Design Load	No	Appraisal	NBI Load Ratings
31	Design Load	No	Load Ratings	Reported Rating
32	Approach Roadway Width	Yes	Inventory - Roads	Widths
33	Bridge Median	Yes	Inventory - Design	Deck
34	Skew	Yes	Inventory - Design	Spans
35	Structure Flared	Yes	Inventory - Design	Spans
36A	Traffic Safety Features - Bridge Railings	Yes	Appraisal	Structural Appraisal
36B	Traffic Safety Features - Transitions	Yes	Appraisal	Structural Appraisal
36C	Traffic Safety Features - Approach Guardrail	Yes	Appraisal	Structural Appraisal
36D	Traffic Safety Features - Approach Guardrail Ends	Yes	Appraisal	Structural Appraisal
37	Historical Significance	Yes	Inventory - Admin	Classification Information
38	Navigation Data/Navigation Control Exists	Yes	Appraisal	Clearances
39	Navigation Data/Navigation Vertical Clearances	Yes	Appraisal	Clearances
40	Navigation Data/Navigation Horizontal Clearances	Yes	Appraisal	Clearances
41	Structure Open, Posted, or Closed to Traffic	Yes	Appraisal	Structural Appraisal

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
42A	Type of Service on	Yes	Inventory - Admin	Age and Service
42B	Under	Yes	Inventory - Admin	Age and Service
43A	Structure Type/Main Spans Material	Yes	Inventory - Design	Spans
43B	Main Spans Design	Yes	Inventory - Design	Spans
44A	Structure Type/Approach Span Material	Yes	Inventory - Design	Spans
44B	Approach Span Design	Yes	Inventory - Design	Spans
45	Number of Spans in Main Unit	Yes	Inventory - Design	Spans
46	Number of Approach Spans	Yes	Inventory - Design	Spans
47	Inventory Route, Total Horizontal Clearance	Yes	Inventory - Roads	Clearances
48	Length of Maximum Span	Yes	Inventory - Design	Length
49	Structure Length	Yes	Inventory - Design	Length
50A	Curb or Sidewalk Width/Left	Yes	Inventory - Design	Deck
50B	Curb or Sidewalk Width/Right	Yes	Inventory - Design	Deck
51	Bridge Roadway Width, Curb-to-Curb	Yes	Inventory - Roads	Widths
52	Deck Width, Out-to-Out	Yes	Inventory - Design	Deck
53	Minimum Vertical Clearance/Over Structure	Yes	Appraisal	Clearances
54A	Minimum Vertical Clearance/Under (Reference)	Yes	Appraisal	Clearances
54B	Minimum Vertical Clearance/Under Clearance	Yes	Appraisal	Clearances
55A	Minimum Lateral Clearance/Reference Feature	Yes	Appraisal	Clearances
55B	Minimum Lateral Clearance/Right Side	Yes	Appraisal	Clearances
56	Minimum Lateral Clearance/Left Side	Yes	Appraisal	Clearances
57	(Reserved)			
58	Deck	Yes	Condition	Condition Ratings
59	Superstructure	Yes	Condition	Condition Ratings
60	Substructure	Yes	Condition	Condition Ratings
61	Channel and Channel Protection	Yes	Condition	Condition Ratings
62	Culverts	Yes	Condition	Condition Ratings
63	Method Used to Determine Operating Rating/Operating Type	No	Appraisal	NBI Load Ratings
64	Operating Rating	No	Appraisal	NBI Load Ratings
65	Method Used to Determine Inventory Rating/Inventory Type	No	Appraisal	NBI Load Ratings
66	Inventory Rating	No	Appraisal	NBI Load Ratings
67	Structural Evaluation	No	Appraisal	Calculated Appraisal Ratings

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
68	Deck Geometry	No	Appraisal	Calculated Appraisal Ratings
69	Underclearances, Vertical and Horizontal	No	Appraisal	Calculated Appraisal Ratings
70	Bridge Posting/Legal Load Status	No	Appraisal	NBI Load Ratings
70	Bridge Posting/Legal Load Status	No	Load Ratings	Reported Rating
70	Bridge Posting/Legal Load Status	No	Load Postings	Load Posting Requirements
71	Waterway Adequacy	No	Condition	Condition Ratings
72	Approach Roadway Alignment	Yes	Appraisal	Structural Appraisal
73	(Reserved)			
74	(Reserved)			
75	Type of Work			
76	Length of Structure Improvement			
77	(Reserved)			
78	(Reserved)			
79	(Reserved)			
80	(Reserved)			
81	(Reserved)			
82	(Reserved)			
83	(Reserved)			
84	(Reserved)			
85	(Reserved)			
86	(Reserved)			
87	(Reserved)			
88	(Reserved)			
89	(Reserved)			
90	Inspection Date	Yes	Schedule	Schedule
91	Designated Inspection Frequency	No	Schedule	Schedule
92AA	Critical Feature Inspection/Fracture Critical (Required)	No	Schedule	Schedule
92AB	Critical Feature Inspection/Fracture Critical (Frequency)	No	Schedule	Schedule
92BA	Critical Feature Inspection/Underwater (Required)	No	Schedule	Schedule
92BB	Critical Feature Inspection/Underwater (Frequency)	No	Schedule	Schedule
92CA	Critical Feature Inspection/Other Special (Required)	No	Schedule	Schedule
92CB	Critical Feature Inspection/Other Special	No	Schedule	Schedule

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
	(Frequency)			
93A	Critical Feature Inspection Date/Fracture Critical		Schedule	Schedule
93B	Critical Feature Inspection Date/Underwater		Schedule	Schedule
93C	Critical Feature Inspection Date/Other Special		Schedule	Schedule
94	Bridge Improvement Cost			
95	Roadway Improvement Cost			
96	Total Project Cost			
97	Year of Improvement Cost Estimate			
98AA	Border Bridge	No	Inventory - Admin	Location
98B	Share (%)	No	Inventory - Admin	Location
98AB	Border FHWA Region	No	Inventory - Admin	Location
99	Border Bridge Structure Number	No	Inventory - Admin	Location
100	STRAHNET Highway Designation/Defense Highway	Yes	Inventory - Roads	Alternate Classifications
101	Parallel Structure Designation	Yes	Inventory - Admin	Classification Information
102	Direction of Traffic	Yes	Inventory - Roads	Highway Networks & Service Classification
103	Temporary Structure Designation	Yes	Inventory - Admin	Classification Information
104	Highway System of the Inventory Route/Nat. Hwy System	Yes	Inventory - Roads	Alternate Classifications
105	Federal Lands Highways	Yes	Inventory - Roads	Alternate Classifications
106	Year Reconstructed	Yes	Inventory - Admin	Age and Service
106	Year Reconstructed	Yes	Inventory - Design	Construction
107	Deck Structure Type	Yes	Inventory - Design	Deck
108A	Wearing Surface/Protective System	Yes	Inventory - Design	Deck
108B	Deck Membrane Type	Yes	Inventory - Design	Deck
108C	Deck Protection	Yes	Inventory - Design	Deck
109	Average Daily Truck Traffic/Truck %	Yes	Inventory - Roads	Traffic
110	Designated National Network/Nat. Truck Network	Yes	Inventory - Roads	Alternate Classifications
111	Pier or Abutment Protection (for Navigation)	Yes	Appraisal	Structural Appraisal
112	NBIS Bridge Length	Yes	Inventory - Admin	Classification

NBI Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
				Information
113	Scour Critical Bridges	No	Appraisal	Structural Appraisal
114	Future Average Daily Traffic	Yes	Inventory - Roads	Traffic
115	Year of Future Average Daily Traffic/Full Year	Yes	Inventory - Roads	Traffic
116	Navigation Data/Minimum Vertical Lift Clearances	Yes		Clearances

Appendix 2E
MDT Items - Inspector Responsibility Table

MDT Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
MDT001	Agency structure name	Yes	Inventory - Admin	Structural ID
MDT004	Crew Hours	Yes	Schedule	Inspection Resources
MDT005	Date Last QA			
MDT006	Deck Area	Yes	Inventory - Design	Deck
MDT007	Departmental Route	Yes	Inventory - Roads	Identification
MDT008	Depth of Cover (inches)	Yes	Inventory - Design	Deck
MDT009	Detour Speed	Yes	Inventory - Roads	Detours
MDT010	Fracture Critical Details	Yes	Appraisal	Structural Appraisal
MDT011	FC Next Inspection Date	Yes	Schedule	Schedule
MDT012	Flagger Hours	Yes	Schedule	Inspection Resources
MDT013	Helper Hours	Yes	Schedule	Inspection Resources
MDT014	Interchange Indicator	Yes	Inventory - Admin	Age and Service
MDT015	Interstate Ramp Indicator	Yes	Inventory - Admin	Age and Service
MDT016	Load Rating Date	No	Load Ratings	Current & Reported Ratings
MDT017	MDT Original Construction Project Number	Yes	Inventory - Design	Construction
MDT018	MDT Original Construction Station	Yes	Inventory - Design	Construction
MDT019	MDT Original Drawing Number	Yes	Inventory - Design	Construction
MDT020	MDT Maintenance Division	Yes	Inventory - Admin	Operation
MDT021	MDT UPN	Yes	Inventory - Design	Construction
MDT022	Name of Load Rater	No	Load Ratings	Current & Reported Ratings
MDT023	Next Inspection Date	Yes	Schedule	Schedule
MDT027	On|Off System	Yes	Inventory - Admin	Operation
MDT028	Other Inspection Details	Yes	Schedule	Summary - Type Insp
MDT029	Other Inspection Next Date	Yes	Schedule	Schedule
MDT030	Posted speed limit (MPH)	Yes	Inventory-Roads	Traffic
MDT031	Railroad Over/Underpass	Yes	Inventory - Admin	Age and Service
MDT032	Railroad Owner	Yes	Inventory - Admin	Operation
MDT034	Request Review of Load rating	No	Load Ratings	Current & Reported Rtgs
MDT035	Road Name	Yes	Inventory - Roads	Identification
MDT036	SU4 Truck Inventory	No	Load Ratings	Load Rating

MDT Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
	Rating			Reports
MDT037	SU4 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT038	SU4 Truck Posting			
MDT039	SU5 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT040	SU5 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT042	SU6 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT043	SU6 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT045	SU7 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT046	SU7 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT049	UBIV Hours	Yes	Schedule	Inspection Resources
MDT050	UBIV Required	No	Schedule	Inspection Resources
MDT052	Special Crew Hours	Yes	Schedule	Inspection Resources
MDT053	Special Equipment Hours	Yes	Schedule	Inspection Resources
MDT056	Special Inspection Next Date	Yes	Schedule	Schedule
MDT058	FHWA Bridge Condition			
MDT059	TE Route			
MDT060	Traffic Volume Class	No	Inventory-Roads	Traffic
MDT061	Cross Section / Probe and Wade Required	Yes	Schedule	Schedule
MDT062	Cross Section / Probe and Wade Date	Yes	Schedule	Schedule
MDT063	Cross Section / Probe and Wade Frequency (months)	Yes	Schedule	Schedule
MDT064	Cross Section Inspection Next Date	Automatic	Schedule	Schedule
MDT065	Type 3 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT066	Type 3 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT067	Type 3 Truck Posting	Yes	Load Postings	Operational Status

MDT Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
MDT068	Type 3-3 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT069	Type 3-3 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT070	Type 3-3 Truck Posting	Yes	Load Postings	Operational Status
MDT071	Type 3S2 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT072	Type 3S2 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT073	Type 3S2 Truck Posting	Yes	Load Postings	Operational Status
MDT074	Underwater Inspection Details	No	Schedule	Inspection Resources
MDT075	Roadway System			
MDT076	Deck Condition			
MDT077	Structure Condition			
MDT078	MDT Maintenance Section	Yes	Inventory - Admin	Operation
MDT079	Truck Type 3 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT080	Truck Type 3-3 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT081	Truck Type 3S2 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT082	Truck Type SU4 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT083	Truck Type SU5 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT084	Truck Type SU6 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT085	Truck Type SU7 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT086	Type 2 Underwater Next Inspection Date	Yes	Schedule	Schedule
MDT087	Decimal Mile Post	Yes	Inventory - Roads	Mile Post
MDT089	Asset Approved			
MDT090	Climbing Inspection Required	No	Schedule	Inspection Resources
MDT091	EV2 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT092	EV3 Truck Inventory Rating	No	Load Ratings	Load Rating Reports
MDT093	EV2 Truck Operating Rating	No	Load Ratings	Load Rating Reports
MDT094	EV3 Truck Operating	No	Load Ratings	Load Rating

MDT Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
	Rating			Reports
MDT095	Truck Type EV2 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT096	Truck Type EV3 LRFR Rating	No	Load Ratings	Load Rating Reports
MDT097	Plans in SMS?	Yes	Inventory - Design	Construction
MDT098	Shop Drawings in SMS	Yes	Inventory - Design	Construction
MDT099	MDT Rehab Project Numbers	Yes	Inventory - Design	Construction
MDT100	MDT Rehab Stations	Yes	Inventory - Design	Construction
MDT101	MDT Rehab UPNs	Yes	Inventory - Design	Construction
MDT102	Years Rehabilitated	Yes	Inventory - Design	Construction
MDT103	MDT Rehab Drawing Numbers	Yes	Inventory - Design	Construction
MDT104	Bridge Deck Seal	No		
MDT105	Polymer Overlay	No		
MDT106	Mill and Overlay	No		
MDT107	New Bridge Deck	No		
MDT108	Experimental Deck	No		
MDT109	Bridge Deck Overlay Type	No		
MDT110	Bridge being Rated by Consultant	No	Load Ratings	Current & Reported Ratings
MDT111	NBI ID of Previous Structure	Yes	Inventory - Admin	Location
MDT112	Completed Rating Model?			
MDT113	Mile Post	Yes	Inventory - Roads	Mile Post
MDT114	MPO	Yes	Inventory - Admin	Location
MDT115	MDT Administrative District	Yes	Inventory - Admin	Operation
MDT116	MDT Financial District	Yes	Inventory - Admin	Operation
MDT117	Border Bridge - Neighboring County Code	Yes	Inventory - Admin	Location
MDT118	Type 2 Underwater Consultant	No	Schedule	Inspection Resources
MDT119	Date Bridge Opened|Re-Opened to Traffic	Yes	Inventory - Design	Construction
MDT120	Environment			
MDT121	Field Functional Needs	No	Appraisal	Calculated Appraisal Ratings
MDT122	Rail Type			

MDT Items - Inspector Responsibility Table				
Item No.	Name	Inspector Responsible	BrM Input Tab	Tab Sub-Group
MDT123	Approach Section Rail Type			
MDT133	Bridge Within Reasonable Access of Interstate	Yes	Inventory - Admin	Location
MDT134	UBIV Frequency (months)	No	Schedule	Inspection Resources
MDT135	Posting Sign Type	Yes	Load Postings	Operational Status
MDT136	Line 1 Number of Axles Posting	Yes	Load Postings	Operational Status
MDT137	Line 1 GVW Posting	Yes	Load Postings	Operational Status
MDT138	Line 2 Number of Axles Posting	Yes	Load Postings	Operational Status
MDT139	Line 2 GVW Posting	Yes	Load Postings	Operational Status
MDT140	Line 3 Number of Axles Posting	Yes	Load Postings	Operational Status
MDT141	Line 3 GVW Posting	Yes	Load Postings	Operational Status
MDT142	EV Single Axle Posting	Yes	Load Postings	Operational Status
MDT143	EV Tandem Axle Posting	Yes	Load Postings	Operational Status
MDT144	EV Gross Weight Posting	Yes	Load Postings	Operational Status
MDT145	Bridge Inventory Direction	Yes	Inventory - Admin	Location
MDT146	Bridge within a Reservation Boundary	Yes	Inventory - Admin	Location
MDT147	Posting Implementation Category	No	Load Postings	Load Posting Requirements
SR	Sufficiency Rating	No	Appraisal	Calculated Appraisal Ratings
SRa	Asterisk Field in SR			
MDT ID	MDT Bridge ID Number	Yes	Inventory - Admin	Structural ID

Note: For random MDT Items, only the names of the MDT items are shown in BrM (MDT#s are not shown).

Chapter 3 – Inspection and Documentation Procedures

3.1 General

There is an acronyms list in Chapter 1 for reference.

3.1.1 Purpose – Introduction

The importance of proper inspection and documentation for bridge safety inspection cannot be overstated. The introduction and implementation of Element-Level Inspection requires a more granular defect inspection and documentation. The resulting data and report information is critical for ensuring the safety of the traveling public and for asset management and investment decisions to maintain and protect our infrastructure. Therefore, the goal and purpose of this chapter is to clarify and describe in detail the various procedures, methods and requirements for inspection and documentation for all portions of a bridge in Montana. It also provides forms and templates to be used, when required, for documentation. It includes bridge numbering convention, inventory clarification, component labeling, and obtaining clearance dimensions. References and methodology for proper inspection of various materials and material deficiencies are included for the below portions of bridges and culverts:

- 3.2 – Decks
- 3.3 – Superstructures
- 3.4 – Substructures
- 3.5 – Waterways
- 3.6 - Culverts

Each of the above sections includes reference to the relevant FHWA Bridge Inspector's Reference Manual (2022 Update) section(s) and to other appropriate reference documents, as well as specific requirements for inspection and documentation for each of the various types of inspection (Initial / Inventory, Routine, Underwater, Fracture Critical, Damage, and Follow-up). Note that Initial / Inventory Inspection is basically the first Routine Inspection for a structure and involves initial coding for all inventory items and elements. Follow-up Inspection is treated as an update to the inspection with which it was associated. These requirements include the proximity and extent of visual and physical inspection and when forms and photos are recommended or required. They also include report review requirements, and maintenance considerations. Special Inspections will be unique to the reason for these inspections, and so procedures and requirements vary on a case-by-case basis. Montana also has other Inspection types, in addition to the standard NBIS inspection types. They include Pin & Hanger NDT Inspections and Cross-Section (Probe and Wade) inspection procedures which are addressed in Chapters 7 and 9.

The last part of Chapter 3 (3.7 – Alternative Supplemental Inspection Methods) focuses on the benefits, methods and procedures for both Climbing/Rope Access and Unmanned Aerial Systems (UAS) for difficult access locations. It reviews best practices for Level A, B and C climbing and UAS inspection and includes certification, safety, equipment, and industry references.

3.1.2 Bridge Numbering, Inventory Direction and Nomenclature

3.1.2.1 Bridge Numbering

Each structure has two main identifiers: its NBI and MDTSID number. The MDTSID number is an agency-assigned identification number that indicates the spatial location of a structure crossing. The NBI structure number is official identification number that's reported to Federal Highways. Each bridge is required to have a unique NBI structure number, and once it's established will never change over the life of the bridge. To summarize the comparison, MTSID is site specific and NBI number is structure specific. One structure that replaces another in the same location will have the same MDTSID, but must have a unique NBI number.

Structures that meet identifying requirements are given a unique structure identifier. The federal and state regulations are listed below.

Federal Requirements

The National Bridge Inventory (NBI) has the following requirements:

- Structure numbers must be unique.
- An official structure number must be recorded for all highway bridges twenty feet or greater in length.
- Structures with Closed Medians will be considered one structure.

State Requirements

Montana recently established a new bridge numbering system to be used going forward for all new bridges. Note that existing bridges have a different numbering system, which will remain in place until those bridges are replaced.

An official, unique structure number is recorded for all inspectable structures that impact the traveling public, as follows:

- Structures meeting NBI requirements (greater than twenty (20) feet and carrying public highway traffic) are given a number. MDT calls these “Major Structures”.
- These structures are part of the NBI and are reported to the FHWA.
  - Note: Structure Length is measured parallel to and along the centerline of roadway, as directed in the FHWA Recording and Coding Guide.
- Certain Non-NBI structures between eight (8) feet and twenty (20) feet in length are inventoried and inspected by the State. MDT calls these “Minor Structures”.
- See Section 1.2 for more detail on these structures.
- NBI number will be “six zeros+XXXX+MDTSID”

Where XXXX denotes a placeholder for the year the asset was created.

3.1.2.2 Bridge Inventory Direction

This section addresses how to code or establish the Inventory (or log) direction of the route carried by the structure following a priority list. Most structures (with previous inspections) will be addressed by the first priority below.

1st Priority: Bridge inventory direction that has been used in previous inspections will be perpetuated forward. This will be done even if the bridge has been inspected using an unconventional bridge inventory direction in the past. If a bridge has been inspected using an unconventional bridge inventory direction in the past, add a note in the general bridge notes using the nomenclature guidance below and update the Bridge Inventory Direction SMS attribute.

- **2nd Priority:** For routes with mile posts, bridge inventory direction is defined in order of increasing mile post or stationing. For example, if mile post 1 is South of the bridge and mile post 2 is North of the bridge, bridge inventory direction would be oriented from South to North.

- **3rd Priority:** For routes with no obvious defined stationing, bridge inventory direction will be assigned using the direction on the plans. When plans are not available, stationing will be assigned using the inspector's best judgement but will generally be oriented from South to North or West to East.

Enter a description of the bridge inventory direction in the inspection notes for **every** inspection using suggested nomenclature below. Once bridge inventory direction is determined, if not already defined, select the appropriate direction from the drop-down box in the SMS attribute named Bridge Inventory Direction (MDT145) located in Chapter A of the Attributes tab. MDT has ArcGIS available to help define stationing when mile posts are not present.

3.1.2.3 Bridge Nomenclature

Once bridge inventory direction is defined at a bridge, use nomenclature such as "North", "East", etc…

to describe which direction the bridge is being inventoried in. In addition, terms such as "upstream" and "downstream" may be used to describe the orientation relative to features crossed or features near the structure (utilities, erosion, approaches, etc…). This is especially important to clarify if there is a new bridge being inventoried, anytime that there has been a change in bridge inventory direction in the past, or if the bridge inventory direction conflicts with as-builts.

Once bridge inventory direction has been established and defined, bridge elements will be defined in the following manner:

- Bridge bents will be numbered starting with Abutment 1 then moving up the inventory direction to subsequent bents (i.e. Abutment 1, Bent 2 (or Pier 2), Bent 3 (or Pier 3), Abutment 4).
- Substructure units (abutments and bents) will have their number / label written with sharpie or paint stick near their centerlines by inspectors (i.e. A1, B2, B3, etc….).
- Bridge elements (girder, piles, etc.…) are numbered looking in the direction of the inventory (starting at Abutment 1 looking to subsequent bents). Numbering is then done from left to right starting with #1 (Pile 1 and Girder 1 is the left most element, then Pile 2, Pile 3, etc.…). Never refer elements starting from the right (i.e. second girder from the right). Note: Piles that do not directly carry load from the superstructure (wingwalls, return walls, etc.) will not be counted.
- Girder spans with sister girders (most common with timber) will have the following naming convention: The original girder number will always remain the same; however, the sister girder will have a name corresponding to the original girder number and the side (right or left) the sister girder is on. For example, if the original Girder 7 has a sister girder on the right, the sister girder will have the name G7R. The sister girder will have this name regardless of the condition

of the original timber girder and whether the original girder is included in the element quantities. Right and left denotations are determined when looking in the direction of the bridge inventory direction.

- For Trusses, the bottom chord nodes will be labeled L0, L1, L2, L3, etc. all the way to the other end. The upper chord nodes should match the number of the bottom chord node directly below it, but be labeled U1, U2, U3, etc…. See Chapter 7 for examples of Truss labeling conventions.

3.1.3 Measuring Clearances and Standard Clearance Forms

Standard clearance form(s) must be on file for all spans of a bridge which have an underclearance roadway or railway. These standard clearance forms give the necessary horizontal and vertical clearance information needed to complete the coding items required by the FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges (Ref. FHWA Coding Guide Items 10, 47, 50, 51, 53, 54, 55, 56). These measurements provide important information on maximum size vehicles that can pass under or through the bridge structure. Where these measurements are less than legal minimums, they are used for establishing posted limits on the bridge.

The appropriate standard clearance form will be completed according to the number of underclearance lanes or tracks the bridge spans. Roadside or trackside restrictions including barriers, non-mountable curbs, substructure elements, top or toe of slopes steeper than 3:1, etc., will be noted. Minimum dimensions that are to be coded for the FHWA Items above, will be labeled on the standard form. See the example in Figure 3.1.3-1 and 3.1.3-2.

For multi-span bridges, it is necessary to provide individual standard clearance forms for each span that intersects a roadway or railway. For through type structures, (like a truss) or if the bridge is located in a multi-level interchange with roadways overhead, the clearances for over-bridge clearances will be noted at the bottom of the standard form under Additional Inspectors Notes.

The appropriate standard clearance forms will be completed and uploaded to SMS during the first/Initial Inspection. The forms will be checked and updated as necessary during every subsequent Routine Inspection. A new standard clearance form will also be required if there is not one currently on file, or at any time a change to the superstructure or roadway or railway at the bridge causes measurements to change. These changes could include replacement, rehabilitation or retrofit of the superstructure, the roadway being overlaid or milled, lane positions being relocated/adjusted, the addition or relocation of guide rail or traffic barriers, the addition of a new sign bridge over the structure, etc.

On Routine Inspections, a copy of the most recent clearance form will be updated and included in the inspection report. All minimum clearance coding items will be verified in each span of the bridge and appropriate observations will be made to verify that changes to the roadway (i.e.: lane relocation, overlaying, etc.) have not taken place. The controlling vertical and horizontal clearances in each span will be verified during every Routine Inspection. Any changes to clearances must be verified in the field.

3.1.3.1 Vertical Clearance Measurements

Vertical clearances must be measured in accordance with the FHWA coding guide items 10, 53, and 54B. For spans over railroads, take vertical clearances at each rail of each track and at both fascias of each span that crosses tracks. For spans over roadways, vertical clearances will be taken at each painted line marking (one at the center of double lines), each curbline, at the edge of pavement, and at all visible breaks in grade where the cross slope on the road changes direction. These measurements are duplicated at both fascias in each span that crosses a roadway. See Figure 3.1.3-1 at the end of this section and as shown on all bridge clearance forms in the Appendix.

When there are no pavement markings on a paved roadway, measurements will be taken at the centerline of roadway (half way between curbs or edge of pavement), at each curbline (or edge of pavement) and also at 12' offsets from the measured centerline of road for roadways greater than 24'.

For unpaved roadways, measure as noted above for paved roadways, except the edge of roadway must be estimated as the outer edge of stable shoulders.

Measurements for over-bridge clearances are taken to the underside of the above structure (including truss portals/overhead bracing) and sign structures over the roadway. Clearance measurements are not taken to light standards, telephone poles, trees, or overhead wires; however, these smaller ancillary objects will be noted as to their impact on safety or access for inspection within the report.

It is important to remember that the objective of these measurements is to locate a minimum clearance. As such, it may be necessary to take different or additional measurements when minimum clearances are not at the usual edge of lane or fascia locations.

Example:

- The roadway beneath the bridge may have a cross slope with a crown that is not located right on a lane line. Take the clearance at the crown of the road.
- If the roadway beneath the bridge has a rise beneath the bridge or is on a vertical crest curve that peaks beneath the bridge, the minimum vertical clearance may be located near the middle of the bridge rather than at the fascias. Be aware of this possibility particularly on very wide bridges.
- If the road beneath the bridge dips significantly at the bridge, it may be possible for long vehicles to get stuck under the structure due to "bridging" of the truck chassis. If it is suspected that this potential exists, additional investigation will be requested. Surveying may be necessary to determine the effective vertical clearance.
- If the roadway beneath the bridge is on a grade, the vertical clearance to one side of a fascia beam may be less than the other. Check the fascia edge and interior edge. This will be more prominent on wide beams like box beams.
- If a bridge beam has a bolted splice or other attachment to the underside that protrudes from the bottom of the structure, the vertical clearance at this location will be checked.
- Always check and record the vertical clearances at locations of impact damage on the bridge.

Item #10 in the FHWA coding guide is intended to identify the largest (tallest) vehicle that can move beneath the structure within a 10' lane width. Locate the maximum vertical clearance along each fascia at the largest (tallest) lane opening under the bridge. Take an additional vertical clearance measurement 10' to either side of each maximum clearance, then code the lowest of these two dimensions.

When measuring vertical clearances, a vertical measuring rod or digital laser will be used. Bridges with clearances in excess of 25' will be noted as >25'. The rod must be held vertical to get the proper measurement. The rod may be swept back and forth to ensure that the minimum clearance is obtained. Vertical measurements will be recorded to the nearest tenth of a foot, always rounding down (i.e.:

14.48’ (14’-5 ¾”) is recorded as 14.4’).

3.1.3.1.1 Posting of Vertical Clearances

Below are the Low Clearance Posting requirements. Need for posting signs and/or proper posting values must be verified every inspection.

Low Clearance Signing Requirements

<u>Bridges Over Interstate Routes:</u>

Sign any actual vertical clearance over an Interstate route of 16 feet, 0 inches or less, for the actual vertical clearance, minus 6 inches as shown in the examples below.

Actual Vertical Clearance*	Subtract Buffer	Signed Clearance
16 ft, 0 in	6 in	15 ft, 6 in
15 ft, 7 in	6 in	15 ft, 1 in

<u>Bridges Over MDT Owned/Maintained Non-Interstate Routes:</u>

Sign any measured vertical clearance over a Non-Interstate Primary, Secondary, Xroute or other state owned/maintained route of 15 feet, 0 inches or less, for the actual measured clearance, minus 6 inches as shown in the examples below.

Actual Vertical Clearance*	Subtract Buffer	Signed Clearance
15 ft, 0 in	6 in	14 ft, 6 in
13 ft, 10 in	6 in	13ft, 4 in

<u>Bridges owned by MDT over local (Non-MDT owned/maintained) Routes:</u>

Low Clearance signing for these bridges will be done on a case-by-case basis. If a Low Clearance sign is deemed necessary, sign according to the clearance criteria for Bridges Over MDT Owned/Maintained Non-Interstate Routes outlined above.

<u>Non-State Owned Structures:</u>

Some bridges that cross over State owned highway routes are not owned by the State (railroad bridges, etc.). Approval from the bridge owner is required before placing Low Clearance signs on these structures. In some cases, separate signing may be necessary.

<u>Multiple Structures at One Site:</u>

There are many cases in which a route crosses under a set of multiple, parallel structures, spaced close together (such as under a set of interstate bridges or multiple urban bridges). In these cases, if a vertical clearance sign is required on any one or more bridges in the set of bridges, place the vertical clearance sign on (or before) the first bridge encountered, but signed to the lowest controlling vertical clearance for the set of bridges.

Inspectors to be aware that when bridges require clearance posting, there will be two signs posted for each direction of travel underneath the low clearance. One will be at the bridge and the other will be an advanced posting, providing time and space for over-height vehicles to take a different route, exit or safely turn around. It is also possible and common to have a different posted height for each travel direction under a bridge. Note that missing, illegible or incorrect clearance posting signs are not considered Critical Findings, but still need to be called into MDT and reported in SMS within 24 hours.

3.1.3.2 Horizontal Clearance Measurements

Lateral clearances must be measured in accordance with the FHWA coding guide items 47, 51, 55 and 56. All lane widths, shoulder widths, distances to guide rails, fences, and substructure units or toe/top of slope (greater than 3:1) will be measured and shown. Lateral clearance measurements from the edge of travel way to a roadside obstruction or substructure unit will be taken at each fascia of the bridge to locate the minimum in case the roadway is skewed to the bridge or curved. When measuring clearances at railroad tracks, measure from the nearest trackside obstruction to the centerline of track. Caution: Do not lay metallic measuring tapes across railroad tracks, as they can affect rail signal systems.

When measuring lane widths, note that standard highway designs and normal paving equipment produce standard size lane widths such as the 12' lane. Minor deviations in lane striping will not be used to show atypical lane configuration if plans are available to indicate that standard sizes were intended. In general, indicate the typical lane widths if actual measurements are within 0.3’. Lateral clearance measurements from the edge of the traveled way (not the shoulder) to the nearest roadside or trackside obstacle will be recorded exactly as measured.

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES INVENTORY DATA SHEET
For Two Lane Roadway

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 56B / 55B:	/

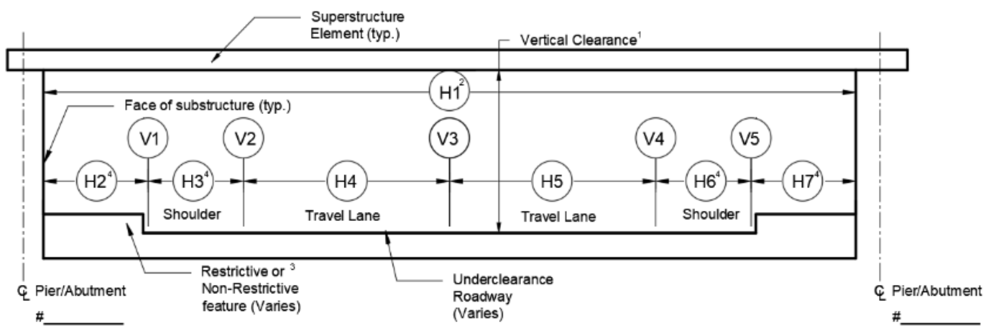
Instructions:

<u>Vertical Clearance Measurements:</u>

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the roadway. Measure starting at the edge of the roadway near the lowest designated substructure element at the following locations:
   a. At each curb line
   b. At each shoulder line
   c. At each travel lane line
2. If a curb or shoulder line does not exist for the roadway, assume 12' width of lanes.
3. For bridges intersecting a divided highway, use a separate sheet for each direction

<u>Horizontal Minimum Clearances:</u>

1. Measure and record horizontal minimum clearances from the lowest designated substructure at the following locations:
   a. Sidewalk or edge of roadway
   b. Shoulder
   c. Travel lane
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') – at Locations Above				
	V1	V2	V3	V4	V5

Elevation	Horizontal Clearances (XX.X') – at Locations Above						
	H1	H2	H3	H4	H5	H6	H7

Notes:

1. Item 10: Code the greatest of the vertical clearances that a 10' wide truck could pass through for the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: record and code the minimum vertical clearance for the roadway (travel lanes only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the roadway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the roadway.
3. Item 47: Underbridge roadways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.
4. Item 55B/56B: If this form is used for one way roadway. The minimum of the minimum lateral clearances should be recorded.

Additional Inspector Notes:

Figure 3.1.3-1 Example Standard Two-Lane Roadway Clearance Form.

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES INVENTORY DATA SHEET
For Railroad

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/ NA

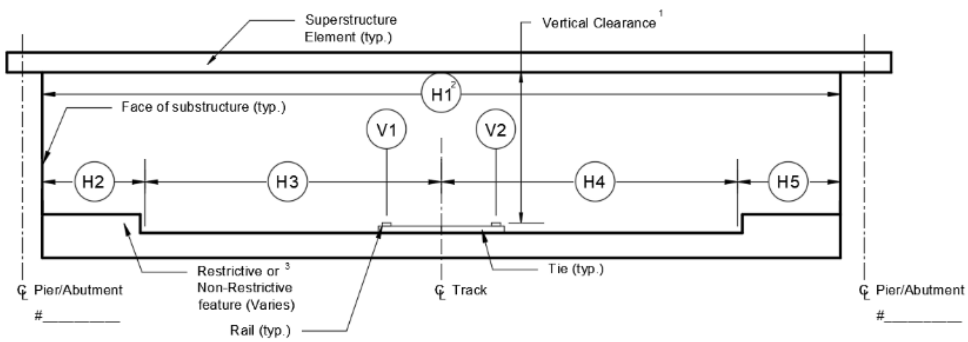
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the Track. Measure starting at the rail near the lowest designated substructure element.
2. For bridges intersecting a divided railway, use a separate sheet for each track

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances between the limits shown below.
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') – at Locations Above				
	V1	V2			

Elevation	Horizontal Clearances (XX.X') – at Locations Above						
	H1	H2	H3	H4	H5		

Notes:

1. Item 10: Code the greatest of the vertical clearance over the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: record and code the minimum vertical clearance for the track (rails only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the railway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the railway.
3. Item 47: Underbridge railways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.

Additional Inspector Notes:

Figure 3.1.3-2 Example Standard One Track Clearance Form.

3.1.3.3 Clearances and Safety Inspection for Railroad Bridges over Roadways

Whenever a railroad bridge passes over a roadway; vertical and horizontal clearances will be taken using the same vertical clearance roadway templates provided above. Posting will also follow the same standard procedures covered in 3.1.3.1.1.

In addition to taking and documenting clearances, the inspection team must also inspect for any other conditions that could impact the safety of the roadway and vehicles or pedestrians below. Examples include but are not limited to any loose overhead components or materials (i.e. signage, ice, utilities, concrete, steel, ballast and/or track components if open track) or defects or signs of distress impacting the structural capacity of main load carrying members.

3.1.4 Other Federal Coding Item Clarification

3.1.4.1 Railing Coding (Item 36)

Item 36 consists of a four-digit code with each digit represented by each of the four parts bulleted below along with the options for possible coding allowed by MDT:

- 36A – Bridge Rail (0 or 1)
- 36B – Transitions (0 or 1)
- 36C – Approach Rail (0, 1 or N)
- 36D – Guardrail Ends (0 or 1)

Where “0”=No, “1”=“Yes” and “N”=Not Applicable

The Yes and No coding is to represent whether a section of rail meets current standards (per NCHRP 350), and has nothing to do with the physical condition or damage to the rail (this is considered and captured under the ADE Element condition state rating). One must assume that the condition is good when coding this item. In other words, if the deteriorated or damaged rail section(s) were to be replaced with the same system would it meet standards, yes or no? For simplicity, Montana has decided to apply the same crash test standard of Test Level 3 (TL-3), per NCHRP 350, to all bridge railing systems. This will mean that numerous off-system and county bridges will be coded “0” and if in doubt, code it a “0” to be conservative.

Item 36A – Bridge Rail

In Montana, only the Wyoming Box Rail, T-101 Rail (with back tubes and concrete decks), and original Concrete Barrier Rail (not retrofitted) meet crash test requirements.

Figure 3.1.4-1 T-101 Rail on Concrete Deck: Code 1

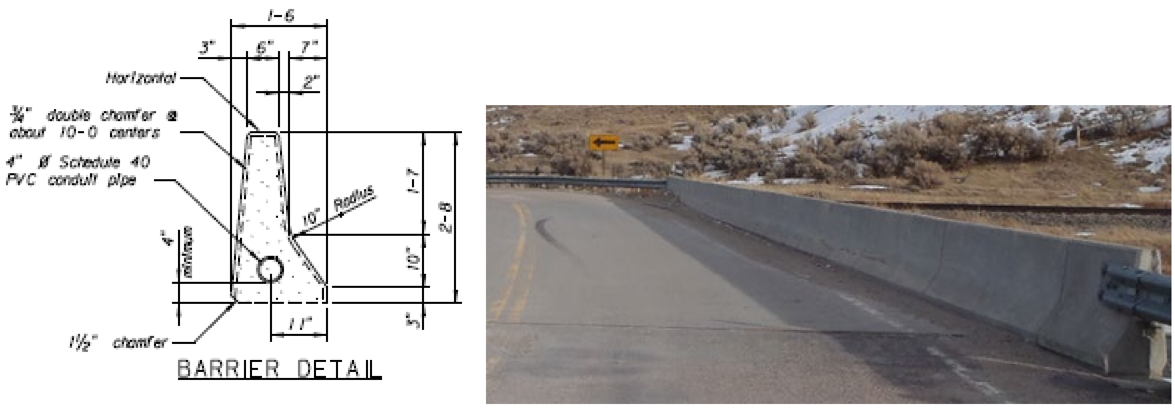


Figure 3.1.4-2 Concrete Barrier Rail: Code 1

Figure 3.1.4-4 W740 and W830 – Wyoming Box Rail: Code 1

Figure 3.1.4-3 Any Rail Attached to Timber: Code 0 (NOT Crash Tested)

Median Barrier:

- 2-loop connection - NOT crash-tested: Code 0
- 3-loop connection - OK: Code 1

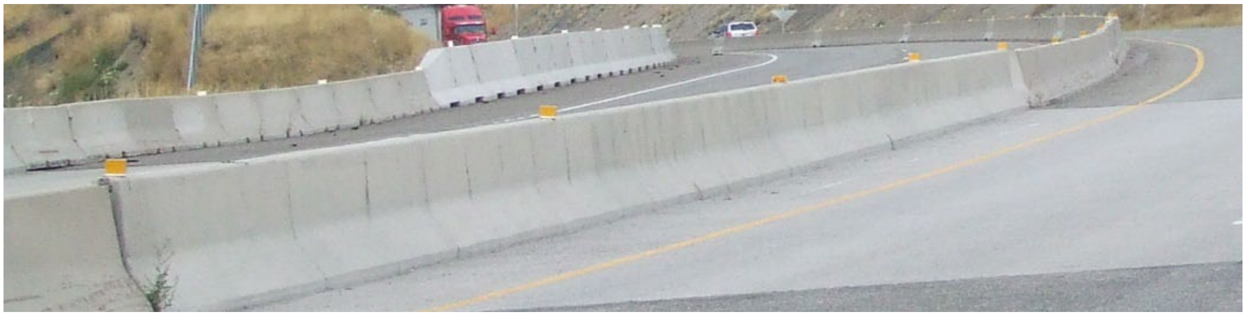


Figure 3.1.4-5 Concrete Median Barrier

Everything else is Coded "0". This includes all bridge rails on timber structures and all retrofitted bridge rails (steel, timber, or concrete barrier). Code "N" is not allowed on Item 36A.

Item 36B Transition Rail

The Transition Rail length is 25 feet.

For a Transition Rail to be coded a "1", the following conditions must be met:

- The transition must be well connected to the bridge rail. If in doubt, code it "0".
- The approach rail in the transition zone must get progressively stiffer by either spacing the posts closer together, using larger posts, or using stiffer rail sections such as doubled up w-rail, thrie beam, etc.
- There must be blocking between the posts and rails.
  - For timber posts, blocking made of wood and plastic is acceptable.
  - For steel posts, blocking made of wood, plastic, and steel is acceptable.
- For The height to the top of a W-Beam must be between 27 ¾" and 33".
- The height to the top of a Box-Beam must be between 26" - 28".

If concrete posts are used in the transitions section of the guardrail: Code 0

Item 36B must be coded a "1" or "0". A code of "N" is not allowed.

Item 36C – Approach Rail

If Approach Rail is not present, then Item 36C is coded “N”. To determine whether Approach Rail exists, consider the first 25 feet to be the Transition Rail and the last 50 feet to be the Guardrail End treatment. Therefore, if the total length of the rail in anyone location is less than 75 feet, then there considered to be no Approach Rail at that location and Item 36C must be coded “N”.

If there is Approach Rail:

For a W-Beam rail to the meet the standard for Item 36C, all of the following conditions must be met:

- The top of W-Beam height must be between 27 ¾” and 33”.
- The post spacing must be less than 6’-3” and the posts must be timber or steel.
- There must be blocking between the posts and rails.
    - For timber posts, blocking made of wood and plastic is acceptable.
    - For steel posts, blocking made of wood, plastic, and steel is acceptable.

For a Box-Beam rail to meet the standard for Item 36C, all of the following conditions must be met:

- The Box-Beam rail height must be 26” - 28”.
- The post spacing must be less than 6’-3” and the posts must be timber or steel.

If concrete posts are used in the approach section of the guardrail: Code 0

Item 36D – Guardrail Ends

To determine the proper code for Guardrail Ends, refer to the FHWA’s *Roadside Terminal* guide which can be accessed at this website.
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/roadsideterminals.pdf

Using FHWA’s *Roadside Terminals* guide, determine if the Guardrail End meets NCHRP 350 Test Level 3 (TL-3):

- If it meets TL-1 or TL-2: Code 0
- If it meets TL-3 or greater: Code 1

In addition to checking the NCHRP 350 Test Level, the roadside feature(s) at the location of each Guardrail end needs to be checked to ensure that it is used appropriately. Again, using the FHWA’s *Roadside Terminals* guide, refer to the “Location Can Be Used” column. If the guardrail end is not used in the appropriate location: Code 0.

Example of FHWA Roadside Terminal Table illustrating the Test Level and Location columns to be checked. See Figure 3.1.6.

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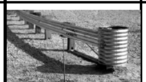
Roadside Terminals

Proper grading in advance of the system and a traversable runout area beyond the beginning of the system is required for all terminals. When the unshielded upstream roadside is similar to the area downstream of the terminal and it is impractical to extend the barrier, a lesser runout area may be permissible. Refer to AASHTO Roadside Design Guide

NAME	MANUFACTURER		PERFORMANCE CHARACTERISTICS		TEST LEVEL		FLARED	TANGENT	31-inch Height (option)	DISTINGUISHING CHARACTERISTICS	LOCATIONS CAN BE USED
			Energy Absorbing	Non Energy Absorbing	NCHRP 350	MASH					
Vermont G1-d		Generic		X	TL-2		X			No impact head. Shop-bent w-beam 5 ft flare. Concrete anchor block with steel rod connecting at post 3.	Driveway turnouts
Modified Eccentric Loader Terminal (MELT)		Generic		X	TL-2		X			No impact head. Rail installed on parabolic curve. Strut between the steel tube foundation for the two end posts to act together to resist the cable loads. All wood posts.	Should be installed at locations where runout area exists behind and downstream of the terminal. End of W-beam rail with offset of 4'-0".
Buried-in-Backslope Terminal		Generic		X	TL-3		X			No impact head. Height of W-beam rail should be held constant in relation to the roadway shoulder elevation until barrier crosses the ditch bottom. Rubrail should be added below the w-beam.	Cut sections of a roadway When the road transitions from a cut to a fill.
Eccentric Loader Terminal (ELT)		Generic		X	TL-3		X			End consists of a fabricated steel element inside a section of corrugated steel pipe. Rail installed on parabolic curve. Strut between the steel tube foundation for the two end posts to act together to resist the cable loads. All wood posts.	Should be installed at locations where runout area exists behind and downstream of the terminal. End of W-beam rail with offset of 4'-0".
Slotted Rail Terminal (SRT-350) http://www.highwayguardrail.com/products/et-srt350.html		Trinity Highway Products, LLC		X	TL-3		X		X	No impact head. Longitudinal slots on W-beam rail element. Strut and cable anchor bracket between post 1 and 2 act together to resist the cable loads. Slot Guards on downstream end of slots. Steel and wood post options available. Parabolic flare on wood post. Straight line flare on all SYTP steel post version and HBA steel/wood post version.	Should be installed at locations where runout area exists behind and downstream of the terminal. End of W-beam rail with offset of 4'-0". Wood post option has 3'-0" to 4'-0" offset.

U.S. Department of Transportation Federal Highway Administration

The safety systems shown on this chart are eligible for reimbursement under the Federal-Aid Highway Program. This reference is for informational purposes only, and was created by KLS Engineering under FHWA Contract, DTFH61-10-D-00021, Roadside Safety Systems Installers and Designers Mentor Program. For further information on an individual system please refer to the manufacturers' website.

KLS Engineering

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Figure 3.1.6 Example FHWA Roadside Terminal Table illustrating the Test Level and Location Columns

If the rail is continuous between two bridges, or if it is excessively long, not because of the bridge but due to roadway slope protection or an obstacle, etc. then Item 36D: Code 1.

Item 36D must be coded a "1" or "0". A code of "N" is not allowed.

3.1.4.2 Bridge and Maximum Span Lengths (Items 48 & 49)

Item 48 - Maximum span length will be coded from centerline to centerline of bearings along the baseline / centerline of the bridge (assuming bearings exist and are shown in the plans or can be measured to in the field). If bearings don't exist (i.e., concrete arches or are concealed), then code the clear distance from substructure to substructure.

Item 49 - For bridges with backwalls, bridge Structure Length will be coded as the length from back of backwall to back of backwall along the baseline / centerline of the roadway being carried.

3.1.4.3 Scour When Over Canals (Item 113)

For all bridges with single spans over irrigation canals (i.e., no substructures within the channel) Federal Coding Item 113 will be coded "8". This is based on the following rationale. Contraction scour at these crossings will be negligible since channels are designed and constructed to be of uniform width and depth. Abutment scour at these crossings will be negligible since there is no overbank flow at these crossings. Channel flows are controlled and velocities are typically low, such that scouring will be minimized and may not occur. Channels are constructed with cohesive materials to limit infiltration and water losses. As a result, these channels are more resistant to scour and erosion.

Montana also has approximately 110 multi-span bridges over canals with substructure unit(s) within the channel. Some of these bridges have plans and scour evaluations, when foundations are known. Those with unknown foundations and pile configurations at the piers were also analyzed and based on that analysis, it is recommended that all of these structures (listed in Appendix 3D) must have Item 113 coded “5”. For those with unknown foundations that are not piles, if the scour is calculated to be greater than 4’, code Item 113 “3”, unless investigation or further analysis warrants increasing of the coding.

If observed scour levels at the time of inspection exceed the coding guidance noted above, then Item 113 coding needs to be lowered appropriately to match the observed scour relative to the substructure.

3.1.5 Measurement Forms

If plans with sufficient geometric information are not available to code inventory bridge geometrics, then a Measurement Form must be used to document these measurements. If neither exist for a particular bridge then the inspector needs to fill out a measurement form at the next scheduled inspection. When a Measurement Form exists, then the dimensions within it will be verified against any available plans and field measurements every ten years.

3.1.6 Note Taking, Narrative Fields and Correspondence

Whenever a CS-3 or CS-4 condition exists for any element, at minimum a narrative comment and at least one photo is required. See sections 3.2 through 3.6 for other procedures and requirements. Narrative fields in SMS will be via bullets as much as is practical. To avoid redundancy, notes from the previous inspection will not be copied and then repeated within narrative fields.

Correspondence and related documents for Critical Findings, Hydraulics Inspection Procedures, Load Posting, Load Ratings, Plans, Shop Drawings and Measurement Forms and Work Candidates will be uploaded to the Multimedia portion of SMS. Documents will be printed to pdf before being uploaded to SMS. However, if spreadsheets are intended to be used again, they will be uploaded in xlsx format, but if they are a one-time thing not intended to be used by future inspectors, they will be printed to pdf before being uploaded. Anything permanent that shouldn’t be changed by someone must be uploaded in pdf format.

3.1.7 NBI Condition Coding Guidelines for Repaired or Rehabilitated Components

Repaired and rehabilitated components can and will increase NBI condition ratings; however, no repaired component is to be rated higher than 7. Components that are replaced are typically rated 8 or 9. Also repairs intended to be temporary in nature, like bituminous patches in concrete decks will not be considered to improve condition. Repairs that do not fix the defect and only slow down deterioration (such as painting) will not be considered to improve the condition.

3.1.8 Pedestrian Bridges

Certain bridges which are designed for and used by pedestrians are also part of Montana’s inspection inventory and include bridges that are state owned or over the state Right of Way. Also note that bridges that are privately owned and are over the state Right of Way are also inspected. These bridges will be inspected and documented in the same manner as a highway bridge. Naming convention for pedestrian bridges is different – there is a P in front of the ID number (ex: P1234). They will not have an NBI id because they aren’t reported to FHWA. They will typically not have a load rating.

3.1.9 Object Markers

Object Marker defects will be noted in the Inspection Notes section of SMS, especially when there is a work item associated with it. See Section 2.14.6 for additional guidance for adding Repair Suggestions.

3.2 Deck Inspection

3.2.1 Timber Decks

Most State-owned timber decks in Montana were constructed between the mid-1920's and early 1950’s. They are nominal 2x4 nail-lam construction (Douglas Fir/Larch) with the occasional plank widening and almost all have an asphalt overlay.

Non-State owned (usually County) timber decks consist of a variety of construction types (nail-lam, plank, glue-lam panels, etc...) and may be bare, covered in gravel or asphalt, or have timber or metal running planks.

References: BIRM Section 8.3
MDT Timber Bridge Inspection Guide

3.2.1.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the deck in accordance with BIRM Sections 8.3.5 and 8.3.6.
- Inspect the top and edges of deck visually observing the condition of the top surface or overlay. See Section 3.2.4 for inspection and documentation requirements for overlays. The entire top and edge surfaces will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Inspect the entire underside of deck checking for signs of decay, weathering, and damage. Normally, observation of the decking during the course of the superstructure inspection will provide an adequate inspection distance.
- Sound with a hammer or probe with a pick, all exposed top surface, soffit, and sides of the timber decking, any discolored, damp, or water-stained areas, areas covered with moss or fungus growth, and other areas of suspected decay to determine the presence or extent of internal decay or voids. Be aware of frozen timber that may have internal deterioration but sounds solid due to water frozen in internal cavities.
- Examine the laminated surface on laminated timber decks for separation.
- Examine fasteners connecting the decking to the girders or support system for loosening.

Documentation

- Measurement forms for the deck and the superstructure will be completed during the initial inspection, any time the deck is replaced or any time the curb and/or rail is replaced or revised.
- Organize deck notes in a span-by-span manner and in such a fashion that it is possible to account for “overlapping” defects on both the top and bottom of deck, so that the roll-up condition state quantities will be correct.
- For the top surface and underside of timber decking, note the size and location of severe (CS-4) checks and shakes, splits, cracks, breaks and decay. Also note the location of loose attachments to the floor system and the cause of this condition (wood shrinkage, decay, crushing). Where

these cannot be described narratively, provide a custom sketch showing the size and location of the defect.

- Document significant changes in condition state or discovery of critical findings and report in accordance with Section 2.13 of this manual.
    - Accurately specify the location of the defect on the deck by referencing the span, lane, relation to a bent, etc... Provide custom sketches as necessary to aid in locating defects.
    - Take typical photos of defects that are noted in the element descriptions.
    - Provide photos of decks on County owned timber structures to aid Load Rating Engineers in determining the grade of lumber.

Figure 3.2.1-1 Deterioration of timber plank deck surface.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Timber deck elements that have been damaged by fire may require a widespread visual and physical examination including the removal of charred surfaces, sounding, and probing. Damage caused from vehicle live loads, such as a single cracked or broken timber deck plank, may require a visual examination at only one location.
- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any deck element that has been damaged. Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.

- As stated in Section 2.6.5 of this manual, information obtained during damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.2.1.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Compare the present inspection to past inspection reports to determine if the pattern, quantity and severity of the defects found support the numerical condition rating given.

3.2.1.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing any accumulations of sand or debris to allow visual or sounding evaluation of the deck.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - Repair rotten decking
    - Recommendation to clear drains

3.2.2 Concrete Decks

Concrete decks are the most common deck element on Montana bridges. Generally, the expected design life is at least 30 years. Documenting the defects and deterioration of concrete decks properly will ensure that any maintenance or rehabilitation work necessary can be scheduled and performed at the optimum time to extend the service life of the deck.

Reference: BIRM Section 8.1 and Appendix 3C “Transverse Cracks and Jump Cracks” Memorandum

3.2.2.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the deck in accordance with BIRM Sections 7.1.6, 7.1.9, and 8.1.5.
- Also inspect and document per Appendix 3C “Transverse Cracks and Jump Cracks”. Jump cracks are deck cracks that run perpendicular to transverse cracking and can extend from one transverse crack to the next. A set of parallel jump cracks between two transverse cracks will form a rectangular “concrete island”, which is prone to becoming loose.
- Walk the top of deck visually inspecting its condition. Observe the entire top of deck from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity. Normally this can be done safely from the shoulders without the need for traffic control operations. However, if the roadway is narrow or traffic speed or volume considerations make it unsafe to walk the deck without protection, coordinate and schedule lane closures with the bridge owner.
- View and inspect the underside of deck from a distance and with sufficient lighting to detect CS-2 level defects. Normally, observation of the deck during the course of the superstructure inspection will provide an adequate inspection distance.

- Sound with a hammer, areas of suspected delamination on the underside of the deck and at least 10% of those areas showing cracking, scaling, moisture, efflorescence, or staining to determine concrete soundness.
- For precast deck slabs, inspect the deck panel anchorages and connections in addition to the normal concrete deck inspection).
- On bridges with stay-in-place forms, follow the inspection procedures for concrete decks. Note any rusting visible on the underside of the deck that may indicate deterioration or corrosion of the anchorages or connections. On bridges with severely rusted forms, the forms may be removed in spot locations to facilitate inspection of the concrete.

Documentation

- For decks with bituminous overlays, see Section 3.2.4.
- For bare concrete decks and the underside of all decks, note the size and location of cracks (including "jump cracks"), spalls, delaminations, etc., along with any signs of efflorescence, rusting, leakage, water-staining etc... Where these cannot be described narratively, provide a custom sketch showing the size and location of the defects.
- The plan sketch may also include notes for the sidewalk, curb, railing, median, parapets, lighting standards and drainage system as applicable.
- Organize deck notes in a span-by-span manner and in such a fashion that it is possible to account for "overlapping" defects on both the top and bottom of deck, so that the roll-up condition state quantities will be correct.
- Document any significant changes in condition state or discovery of critical findings and report in accordance with Section 2.13 of this manual.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Concrete decks without a wearing surface overlay serve as the riding surface and are more susceptible to some types of damage than concrete decks with a wearing surface overlay.
- The inspection methods outlined under section: Initial / Inventory Inspections & Routine Inspections on the previous page apply here.
- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.
- Focus the inspection on directly damaged and surrounding areas that may have been indirectly damaged to determine extent and severity of damage.

Documentation

- Include thorough documentation of the condition of any deck element that has been damaged. Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, information obtained during damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.2.2.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Compare the present inspection to past inspection reports to determine if the pattern, quantity and severity of the defects found support the numerical condition rating given. Presence of any "jump cracks" will be accounted for in condition state rating of the deck per the defect table in Appendix 3C.

3.2.2.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
  - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the deck.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance or County forces, such as:
  - Spall or delamination repairs in the deck
  - Potential Class B repairs (full depth) in the deck
  - Installation of drains or modifications of the approach or overlay to mitigate ponding on the bridge.
  - Recommendation to clear drains
- Areas of Full depth jump cracks resulting in concrete islands will be identified for repair.

Figure 3.2.2-1 Top of Bare Concrete Deck with Patched, Spalled and Hollow Areas.

Figure 3.2.2-1 Typical Underside of Concrete Deck. Note Cracking with Efflorescence and Formwork Remaining from Full Depth Patching.

3.2.3 Metal Decks

At this time, with the exception of structure metal deck pans (Corrugated Metal Decks), metal deck elements are rare in Montana.

Reference: BIRM Section 8.2

3.2.3.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the deck in accordance with BIRM Section 8.2.
- Inspect the top of the deck visually observing the condition. The entire top surface will be viewed from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Perform a “hands on” inspection of at least 10% of the bearing areas and connections. If this inspection reveals significant defects, then additional "hands-on" inspection is required.
- Inspectors must differentiate between Stay-In-Place (SIP) forms used to construct some concrete decks versus structural corrugated steel decking (aka “Corrugated Metal Decks” or "deck pans").

- SIP forms support the uncured concrete deck when it is originally placed. After approximately 28 days, the reinforced concrete deck hardens and becomes the structural deck system that carries the traffic loads on the bridge. At which point the SIP forms could be removed since they provide no structural support to the structure.
- Corrugated steel flooring is only filled with asphalt, gravel, or non-structural concrete to form a wearing surface. In this case, the steel flooring is the structural deck that carries the traffic loads on the bridge.
- Rusting of corrugated steel flooring is a more serious structural deterioration, whereas rusting of SIP forms is not structurally significant in and of itself.
- Rusting of SIP forms may indicate leakage through the concrete deck with possible deterioration of the concrete above. Sections of SIP forms can be removed to inspect the condition of the concrete deck hidden behind the forms.

Figure 3.2.3-1 Underside of Corrugated Metal Deck

- Orthotropic decks have a large number of smaller members connected together to form the deck system. The connections are normally made by welding, resulting in a large number of intersecting welds. The intersecting welds, or the cope areas in members to avoid intersecting welds, will be checked for fatigue cracking that may originate at these locations.
- Open grid decks are prone to rusting because water, salt, sand, and debris can pass through the deck and collect on top of the supporting members and hold moisture that accelerates deterioration in these areas. Concentrate inspection efforts in these areas of likely deterioration where debris accumulates against bearing bars on top of the supporting members. This condition will generally be most common at the approach ends of the bridge where vehicles carry dirt, sand, and debris, etc... onto the bridge from the approaches.
- Aluminum isotropic decks are made-up of individual extrusions welded together into panels in a shop. These panels are then bolted together in the field to form the deck. Inspect the welds between extruded sections for fatigue cracking, the bolted splices between panels for proper connection, and the connection of the panels to the supporting beams where possible.

Documentation

- Deck measurement forms and new superstructure measurement forms are required during every initial inspection, every time the deck is replaced and every time the curb and/or rail is replaced or revised.
- For gravel filled decks, note any areas of thin overlay that could be caught by a grader blade and any areas with rips or holes due to blades or other damage.
- For filled grid decks with a bare top surface, note the condition of the top surface of the concrete. Note areas of heavy scale and soft concrete. Where these cannot be described narratively, provide a custom sketch showing the size and location of the defects.
- Organize deck notes in a span-by-span manner and in such a fashion that it is possible to account for "overlapping" defects on both the top and bottom of deck, so that the roll-up condition state quantities will be correct.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage caused from vehicle live loads, such as a single cracked or broken member, may require a visual examination at only one location.

Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any deck element that has been damaged. Provide photographs of the damaged areas. Custom sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, information obtained damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.2.3.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Compare the present inspection to past inspection reports to determine if the pattern, quantity and severity of the defects found support the numerical condition rating given.
- If areas of severe rusting, deterioration, or damage are noted that result in steel section loss, a structural evaluation recommendation may be warranted.

3.2.3.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the deck.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:

- Repair of concrete infill or overlay material that has spalled or is unsound
- Repair of cracked, broken, or damaged structural metal decking (grids, structural deck pans, orthotropic, etc...)
- Loose connections between deck panels or between deck and support elements

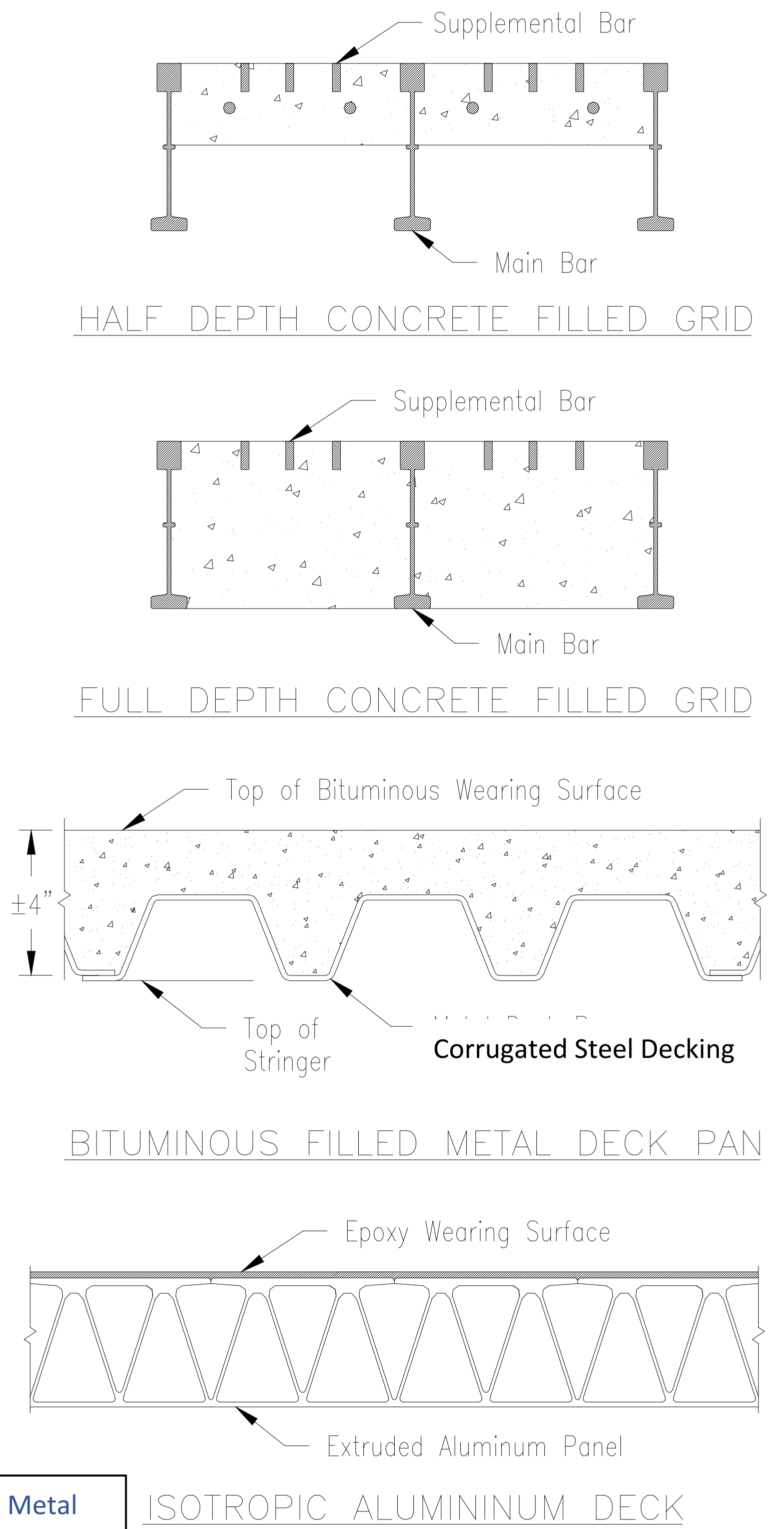


Figure 3.2.3-2 Metal Deck Cross Sections

3.2.4 Overlays (Wearing Surfaces)

Reference: BIRM Sections 8.1.2, 8.2.2, 8.3.2 and 8.4.2

Overlays are designed to provide a smooth riding surface for motorists, absorb the wear and tear of the passing vehicular and/or pedestrian traffic and protect the structural deck below. Deterioration of the overlay, and subsequently the deck (i.e. potholes and rough surfaces), increases localized impact stresses, accelerates deterioration of the overlay and deck, and can present safety hazards to the traveling public.

3.2.4.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the bridge overlay and wearing surface in accordance with BIRM Sections 8.1.2, 8.2.2, 8.3.2 and 8.4.2.
- The entire overlay will be viewed from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.

For Timber Wearing Surfaces

- Look at the timber wearing surface for wear, cracking, splitting, splintering, weathering, decay (especially in areas exposed to drainage or near curbs that hold debris), impact damage (snowplows), areas of ponding, debris build-up, loose or missing fasteners, crushing, and other defects.
- Common safety hazards include loose running planks and protruding fasteners.
- Evaluate the condition of the overlay and its effectiveness in protecting the deck.
- While visually identifying defects on the top of a deck that is visually covered by an overlay, look for any defects that indicate defects in the structural deck below.

For Concrete Overlays

- Unless contract plans, previous inspection reports, or other forms of documentation explicitly indicate that a bridge has a concrete overlay, assume the concrete riding surface to be an integral part of the structural deck.
- Look at the concrete overlay for cracking, scaling, spalling, exposed reinforcement with or without corrosion (or measurable section loss), delamination, excessive wear, rutting in the wheel lines, impact damage, or other defects. Account for spalls over 2" in depth and any spall that exposes reinforcement in the overall condition rating of the deck.
- Look for flexure cracks in areas of negative bending.
- Evaluate the effectiveness of the overlay to direct water to the drainage system and whether ponding occurs. Look at areas near drainage inlets for general deterioration.
- Look at cold joints for cracking, spalling or other defects.
- Examine repaired areas to determine if repair materials are in place and functioning as designed. Hammer-tap patched areas to determine if the patch is sound and adhering to the base material.
- Areas of suspected deterioration will be inspected using physical inspection methods, such as sounding with a hammer or chain drag, to determine the limits of deterioration. (Note that traffic control may be required to implement these methods safely.)

- While visually identifying defects on the top of a deck that is visually covered by an overlay, look for any defects that indicate defects in the structural deck below.

For Polymer, Elastomeric, or other non-Cementitious Overlays

- Look at the overlay for cracking, scaling, spalling, exposed reinforcement with or without corrosion (or measurable section loss), delamination, excessive wear, rutting in the wheel lines, impact damage, or other defects. Account for spalls that extend below the overlay and into the concrete and any spall that exposes reinforcement in the overall condition rating of the deck.
- Look for flexure cracks in areas of negative bending.
- Note any reflective cracking in the overlay from Class A or B repairs in the concrete deck under the overlay.
- Evaluate the effectiveness of the overlay to direct water to the drainage system and whether ponding occurs. Inspect areas near drainage inlets for general deterioration.
- Look at cold joints for cracking, spalling or other defects.
- Examine repaired areas to determine if repair materials are in place and functioning as designed. Hammer-tap patched areas to determine if the patch is sound and adhering to the base material.
- Areas of suspected deterioration or delamination will be inspected using physical inspection methods, such as sounding with a hammer or chain drag, to determine the limits of deterioration and delamination. (Note that traffic control may be required to implement these methods safely.)
- While visually identifying defects on the top of a deck, look for any defects that indicate defects in the structural deck below.

For Bituminous Concrete (Asphalt) Overlays

- Look at bituminous concrete overlays for cracking, rutting, excessive wear, raveling, impact damage, deflections under live load, potholes, and other defects.
- Look at areas near drainage inlets for general deterioration.
- Look for flexure cracks in areas of negative bending and near joints.
- Evaluate the effectiveness of the overlay to direct water to the drainage system and whether ponding occurs.
- Measure the curb reveal at spot locations to verify the thickness of the bituminous concrete overlay. If the field calculated thickness of the bituminous concrete layer, based on the curb reveal, is greater than plans or maintenance records indicate, perform additional testing to determine the actual overlay thickness for dead load analysis and the need for a new load rating will be evaluated.
- While visually identifying defects on the top of a deck that is visually covered by an overlay, look for any defects that indicate defects in the structural deck below.

Documentation

- Document defects such as cracking, spalling, potholes, rutting, excessive wear, raveling, impact damage, deflection under live load, exposed reinforcing bars, scaling, decay, pest infiltration, weathering, debris build-up, etc. Note the surface area dimensions, depth of loss, and the relative location on the deck for all defects.
- Document repairs and evaluate the condition of the repair and whether the repair material is adhering to the base material and performing as intended.

- Document all ponding on wearing surface due to depressions, spalls or potholes and whether debris build-up prevents adequate drainage.
- Provide a custom sketch of defects when a written description is not sufficient to convey all necessary information. This plan sketch may also include notes for the sidewalk, curb, railing, median, parapets, lighting standards and drainage system as applicable.
- Provide a plan view photo of the deck area showing the locations of all significant problems or problems that cannot be adequately documented with words. Wearing Surfaces are Bridge Damage Inspections

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Overlays that have been damaged due to fuel spills or fire damage may require a widespread visual and physical examination including sounding and probing to determine the integrity of the overlay. Isolated defects such as cracks, potholes, and raveling may require a visual examination at only a few locations.

Documentation

- Include thorough documentation of the condition of any overlay element that has been damaged. Photographs of the damaged areas are required, and custom sketches are encouraged if text alone cannot easily convey the scope of the damage.

3.2.4.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- Compare past and present inspection reports to determine if patterns of deterioration or progressive deterioration are taking place.

3.2.4.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the deck.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - Repair or replacement of timber running planks or loose or protruding connectors
    - Repair of concrete, polymer, or asphalt spalls or delaminations.
    - Installation of drains or modifications of the approach or overly to mitigate ponding on the bridge.
    - Recommendation to clear drains

3.2.5 Curbs

Curbs are generally meant to delineate a travelway and may fall into one of multiple categories, depending on their design. Non-mountable curbs are designed to deflect errant vehicles and keep them within the travel lane boundaries of the bridge. Mountable curbs are designed so that vehicles can cross them readily when required. Barrier curbs are relatively high and steep-faced, designed to inhibit or at least discourage vehicles from leaving the roadway.

Reference: BIRM Section 4.1.6

3.2.5.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the curbs in accordance with BIRM Section 4.1.6.
- Look at curb components from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Inspect the curbs for defects such as:
    - Stone Masonry - Crushed, spalled, weathered, chemically damaged, displaced, or cracked stones, lost joint mortar.
    - Concrete - Cracked, scaled, spalled, delaminated, displaced, or crushed concrete.
    - Steel - Rust, section loss, cracks and loose, bent or displaced members.
    - Timber - Fungus growth, fire damage, weathering, warping, splitting, checking, crushed or displaced members and chemical damage. Check for adequate attachment to the deck.
- Look at curbs for impact damage or elements that stick up presenting tripping hazards to pedestrians or snagging hazards to passing traffic.
- Look at the curb/overlay interface for cracks or openings through which water may pass to the deck.
- Perform spot measurements of the curb reveal to determine if it is constant over the length of the bridge and consistent with the as-built value.
- Look at expansion joints for exposed blunt ends that could present a hazard to passing vehicles. If plates, covers, or other devices are in place to provide continuity between the two curbs, check for adequate anchorage.
- Evaluate the ability of the curb to direct water runoff to the drainage system and whether there is evidence, like dampness or staining, indicating leakage occurs through the curb or curb/deck interface.

Documentation

- Document defects found on the curbs. These notes may be incorporated into the field notes for the railing. Documentation will include the size, description and relative location on the bridge for the noted defect.
- Note the condition of curb expansion devices and whether the joint opening seems reasonable for the ambient temperature.
- Document the current condition of previously noted problems or defects.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. An extensive visual and physical inspection may be required after a significant traffic accident has occurred and caused widespread damage to the curbs. An isolated visual inspection may suffice to inspect the condition of curb after an incident has occurred causing localized damage.
- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any curb element that has been damaged. Photographs of the damaged areas are required and custom sketches are encouraged if text alone cannot easily convey the scope of the damage.

3.2.5.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes, and photographs to ensure they are mutually supportive of their documentation.
- Review the inspection findings to determine if any defects exist that present a safety hazard to the traveling public (vehicular or pedestrian).
- Check current measurements against the last inspection to verify if the deck has been overlayed. If the deck has a new overlay since the previous inspection, the need for a new load rating will be evaluated.

3.2.5.3 Mountable Curbs

Mountable curbs are designed so that vehicles can cross them readily when required. Barrier curbs are relatively high and steep-faced, designed to inhibit or at least discourage vehicles from leaving the roadway.

In general, mountable curbs will have the following features:

- Front face sloped to some degree.
- Top corner well rounded.

Typical bituminous concrete lip curbing is considered mountable.

The following curb features are typically associated with barrier curbs (non-mountable):

- Granite curbs - faces typically vertical, no radius on top corner.
- Concrete curbs that have vertical or close to vertical face.
- Jersey type barriers.

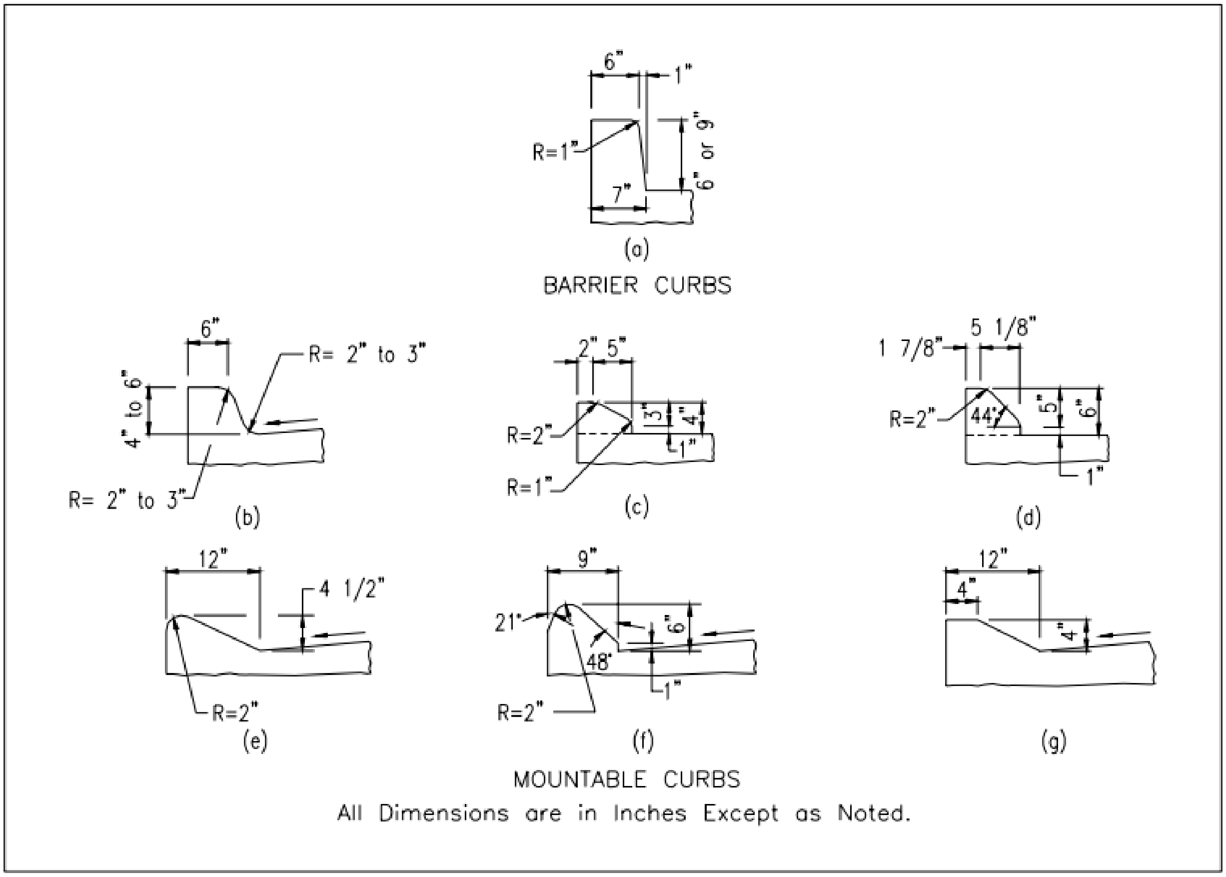


Figure 3.2.5-1 Types of Mountable Curbs

Figure 3.2.5-2 Typical Concrete Curb with Safety Walk

3.2.5.4 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the curbs.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - For Non-Mountable curbs, any condition such as spalled or cracked stone or concrete, decayed, infested or split timber, rusted steel or other defects that negate the ability of the curb to defect errant vehicles.
    - For all curbs, any curb that is deteriorated to the point where they are breaking up or displaced into traffic and presenting a potential hazard to vehicles or pedestrians.
    - Impact damage
    - Damaged curb joints with metal assemblies.

3.2.6 Medians

Reference: BIRM Section 8.6.6

3.2.6.1 Inspection and Documentation Requirements

Initial / Inventory, Routine, Damage, Follow-up Inspections

Inspection & Documentation

- Inspect the median system in accordance with the Inspection and Documentation Requirements, Report Review and Maintenance Considerations guidelines as outlined below:
    - Median Curbs: Use Section 3.2.5 Curbs
    - Median Barriers: Use Section 3.2.8 Parapets or Section 3.2.9 Railings
    - Asphalt Raised Median: Use Section 3.2.4 Overlays
    - Concrete Raised Median: Use Section 3.2.7 Sidewalks
    - Steel Grid Median: Use Section 3.2.3 Metal Decks
- Deterioration on the underside of a median is typically part of the structural deck system and will be evaluated as part of that inspection.

3.2.7 Sidewalks

Reference: BIRM Section 4.1.6

3.2.7.1 Inspection and Documentation Requirements

For all sidewalk inspection and documentation, consult the requirements under decks, as Montana considers sidewalks as part of the deck.

Figure 3.2.7-1 Concrete Sidewalk with Pedestrian Fence and Traffic Divider.

3.2.8 Parapets

Reference: BIRM Section 8.6.5

Parapets are designed to redirect errant vehicles to protect the vehicle occupants or pedestrians on walkways outside of the travel way. Deterioration, spalls, impact damage, impact displacement, loose joint assemblies, or other defects may diminish the ability of the parapet to perform its design function of redirecting errant vehicles.

3.2.8.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect all parapet components in accordance with BIRM Section 8.6.5.
- Look at parapets from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity. Perform a "hands-on" inspection of all problem areas.
- Look at the parapet system for cracking, scaling, delamination, spalling, exposed reinforcement, or other defects, such as rusting on steel parapets.
- Look at parapet components for impact damage, and displacements that present exposed, blunt ends or snagging hazards to passing vehicles.
- Look at parapet expansion joint devices for integrity and proper function. Note if expansion joint elements are missing, exposing the blunt ends of the parapets on either side of the joint.
- Look for openings at joints that may be large enough to constitute a pedestrian hazard (especially for children). Consider any opening greater than 4" in parapets that form part of a pedestrian barrier along sidewalks or in areas where there is significant pedestrian traffic to be a hazard.

Documentation

- Document defects found on the parapets. Incorporate these notes onto the custom sketches made as part of the top of deck inspection if necessary. Documentation will include the size and relative location along the bridge of noted defects.
- Document the condition of the parapet expansion joint devices and whether the joint opening appears reasonable for the ambient temperature.
- Document the current condition of all previously noted defects.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. An extensive visual and physical inspection may be required after a significant traffic accident has occurred and caused widespread damage to the parapets. An isolated visual inspection may suffice to inspect the condition of a parapet after an incident has occurred causing localized damage.
- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any parapet element that has been damaged. Provide photographs of the damaged areas and custom sketches are encouraged if text alone cannot convey the scope of the damage.

3.2.8.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes, and photographs to ensure they are mutually supportive of their documentation.
- Review the inspection findings to determine if any defects exist that present a safety hazard to the traveling public (vehicular and/or pedestrian).
- Review the parapet configuration for compliance with current MDT standards for traffic and/or pedestrian barriers depending on bridge site usage and note the results of the review.

Figure 3.2.8-1 Concrete Parapet with Metal Pipe Railing. Note Spalling with Exposed Reinforcing Steel.

3.2.8.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
  - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the deck.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
  - Spalls, impact damages, or delamination repairs in the parapet concrete.
  - Loose or protruding joint assembly components
  - Loose, damaged, or protruding pedestrian rail components attached to the parapet.

3.2.9 Bridge Railings

Reference: BIRM Section 8.6

Railings are designed to deflect errant vehicles and keep them within the travel lane boundaries of the bridge. They rely on their position, integrity, and firm attachment to the deck or sidewalk to perform this function.

3.2.9.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect all railings in accordance with BIRM Section 8.6.
- Look at rail components from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity. Perform a “hands-on” inspection of problem areas.
- Look at components of the railing system for cracks, scaling, spalls, rust, section loss, loose or broken fasteners, cracked welds, weathering, splitting, checking, impact damage, or other defects.
- Look for impact damage, missing components or displacement that present exposed, blunt ends or snagging hazards to passing vehicles and/or pedestrians.
- Look for openings at joints that may be large enough to constitute a pedestrian hazard (especially for children). Consider any opening~~s~~ greater than 4" in parapets that form part of a pedestrian barrier along sidewalks or in areas where there is significant pedestrian traffic to be a hazard.
- Look at rail post anchorages to determine if the railing is securely fastened to the deck or parapet.
- Look at railing expansion joint devices or end treatments to see if they are in place and functioning properly.
- Look for any dips or raised areas along the length of the railing. These could be indicative of a larger problem with the superstructure or substructure.

Documentation

- Document defects found on the railings. Incorporate these notes onto the custom sketches made as part of the top of deck inspection if necessary. Documentation will include the size and relative location along the bridge of noted defects.
- Document the condition of railing expansion joint devices and end treatments, and whether the joint opening appears appropriate for the ambient temperature.
- Document the current condition of all previously noted defects.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. An extensive visual and physical inspection may be required after a significant traffic accident has occurred and caused widespread damage to the bridge railings. An isolated visual inspection may suffice to inspect the condition of a bridge railing after an incident has occurred causing localized damage.

- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any parapet element that has been damaged. Provide photographs of the damaged areas and custom sketches are encouraged if text alone cannot easily convey the scope of the damage.

3.2.9.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive in their documentation.
- Review the inspection findings to determine if any defects exist that present a safety hazard to the traveling public (vehicular and pedestrian).

Figure 3.2.9-1 Steel Bridge Railing Post with Corrosion

3.2.9.3 Maintenance Considerations

- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
  - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the deck.

- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - Spalls, impact damage, or delamination repairs in concrete.
    - Rail post or rail repair of impact damage or deterioration.
    - Debris removal from rail post base areas.

Figure 3.2.9-2 Pedestrian Fence atop Concrete Parapet.

3.2.10 Deck Joints

Reference: BIRM Section 8.5

Bridge joints are necessary elements on most bridges to ensure that the bridge can function properly under the stress of external forces. They allow the brides to expand and contract due to the daily and seasonal temperature changes and allow for rotations of the superstructure and deck under live loads.

Although the condition of bridge joints are not directly incorporated into the condition rating of the deck, superstructure, and substructure, their condition and ability to perform their designed function can influence those ratings.

3.2.10.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect all joints in accordance with BIRM Section 8.5.
- Look at joint components on top of the deck from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity. Inspect any problem areas found up-close and from the underside, if necessary.
- Look at all joints and supporting elements for deterioration due to corrosion, impacted rust, cracks, excessive vibration.
- Check joints for loose fasteners, loose floorplates, loose assemblies, or damaged, or broken components. These may present hazards to the traveling public in the form of protrusions that may puncture tires or become snagging hazards, or sections of which may come loose and present an impact hazard.
- Look for cracked welds.
- Look for impact damage from snowplows.
- Look to see if the joint is paved over and the condition of the pavement above the joint.
- Look for vertical displacement across the two halves of the joint in the direction of traffic.
- Look to see if open joints are clogged with debris that may affect the ability of the joint to open and close with expansion and contraction of the bridge or to pass water to the drainage system below.
- Look to see if joint sealant is in place and operating as designed, if there are signs of leakage through the joint (closed joint), or any other notable defects. Also observe if water backs up around the joint on the deck due to the inadequacy or blockage of the primary drainage system.
- Look for ruptured or torn seals, glands, and segmental components.
- Look for any concrete deterioration adjacent to the joint supports or faces. Sound the concrete around the joints to check for delamination.
- Listen for any unusually loud noises when traffic passes over the joint that indicates loose elements or full assemblies.
- Look at the joint when traffic passes over for excessive movement and deflection.
- Look to see if the joint gap is what you would expect for the current ambient temperature (i.e. hot weather = smaller gap; cold weather = larger gap). An excessively open or closed joint for the ambient temperature condition may indicate possible problems with the expansion bearings, movement of the substructure, or improper installation of the joint. The existence of

this problem warrants further investigation such as frozen, damaged, or failed bearings, other joints that are blocked and forcing all movement to another joint, bents or abutments that are shifting or settling, etc...

Documentation

- Report joint devices as a Critical Finding that present a current or imminent safety hazard such as steel assembly joints or steel joint headers that are excessively loose or broken and that move under traffic and/or have the potential to break free.
- Document any defects discovered during the inspection
- Document all steel losses by noting the area and depth of the loss as well as its relative location along the length of the joint measured from a fixed point. Steel losses include scrapes in the steel from snowplows.
- Document locations of all loose bolts, rivets, or broken welds found.
- Document locations and lengths of all fatigue cracks found. Mark these locations on the joint with a permanent marker. Note the date found and the extent of the crack in such a manner that subsequent inspections may determine the extent of crack propagation.
- Document any deteriorated conditions in the concrete adjacent to the steel joint assemblies or steel headers where they are anchored.
- Document any increased quantity or size of defects that have changed since the last inspection. If the condition rating has changed from the last inspection, provide a photograph and explanation of why the rating has changed in the inspection report.
- Describe the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. An extensive visual and physical inspection may be required after a significant traffic accident has occurred and caused widespread damage to the deck joints. An isolated visual inspection may suffice to inspect the condition of a deck joint after an incident has occurred causing localized damage.
- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Include thorough documentation of the condition of any parapet element that has been damaged. Provide photographs of the damaged areas and custom sketches are encouraged if text alone cannot easily convey the scope of the damage.

3.2.10.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- Compare past and present inspection reports to determine if patterns of deterioration or progressive deterioration are taking place.

3.2.10.3 Maintenance Considerations

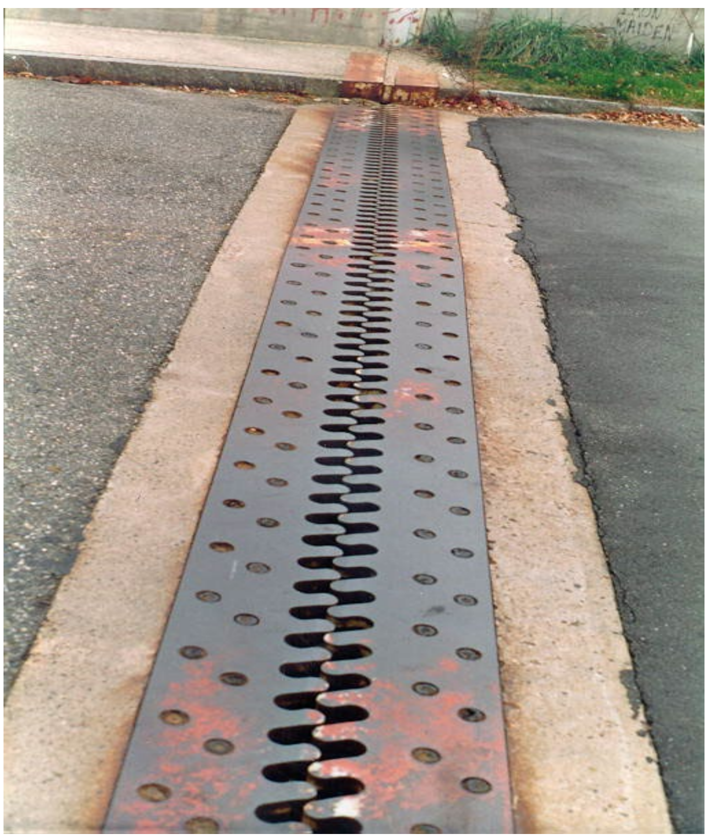
- Only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing any accumulations of sanding material or debris to allow visual or sounding evaluation of the joints.
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - Repair of damaged, loose, or cracked steel joint assemblies, steel joint headers, or individual components of steel joint assemblies. This also includes propagation of previously noted fatigue cracks.
    - Repair of damaged or deteriorated concrete anchoring joint assemblies.
    - Removal of debris built up in joint openings.
    - Repair of concrete joint headers.
    - Replacement of pourable or compression joint seals or any joint that shows signs of leaking and is contributing to the accelerated deterioration of beams, bearings, or substructure components.
    - 

Figure 3.2.10-1 Steel Finger Joint.

    -

Figure 3.2.10-2 Asphaltic Plug Expansion Joint.

Figure 3.2.10-3 Modular Type Expansion Joint Replacement.

3.3 Superstructure Inspection

3.3.1 Bearings

References: BIRM Chapter 13
MDT Hands on Inspection of Steel Members

Expansion Bearings

Bridges are continually moving due to thermal expansion and contraction, deflections under loads, unanticipated substructure movements, and other forces. These movements are accommodated by bearings. Expansion bearings must be free to move as designed if the bridge is to function properly. Movement may be absorbed within the structure if the span length is short. However, frozen bearings on longer bridges will impart thermal forces into the bridge members and force the movement to occur at points where movement was not anticipated. One or more spans may move together, exerting forces on abutments, piers, or connections for which they were not designed. Nearly all types of bearings are susceptible to freezing. Freezing, as applied to bridge bearings, means that movement has been prevented by corrosion, mechanical binding, intrusion of dirt or other interference to the point that the bearing does not operate properly or is held in a rigid condition. Normally, a frozen bearing will exhibit no signs of movement. Movement can usually be detected by the presence of polished surfaces on the visible sliding surfaces, broken paint between the fixed and moveable part of the bearing, crushed material under a rocker bearing, etc. The only true method to determine if a bearing is frozen, however, is to compare bearing measurements taken at different temperatures (i.e., measurements taken during warm weather should be different from those taken during cold weather.)

The most common types of expansion bearings are self-lubricating bronze sliding bearings, steel rocker bearings, elastomeric bearings and pot bearings. Another special type of bearing seen on a number of structures is the pin and hanger bearing. Examples of the typical bearings are shown in Figures 3.3.1.1-1 to 3.3.1.1-5 and Figures 13.1.1 to 13.3.30 in FHWA BIRM Chapter 13.

3.3.1.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect all the bearings in accordance with BIRM Chapter 13.
- Illustrations of several bearing types and measurement forms are provided below for reference and use.
- Bearing areas must be cleaned, as necessary, or referred to Maintenance for cleaning, if excessive, to permit an adequate inspection of the bearings.
- A random sampling (approximately 25%) of the bearing anchor bolts will be tapped with a hammer to determine if they are intact and solidly anchored to the substructure. The frequency of sampling will be increased if defective bolts are found.

Documentation

- The condition of fixed bearings and elastomeric bearings may be described narratively on the inspection forms or on framing plans if included. Special or unusual problems like significant loss of bearing area or broken / cracked components will be sketched and photographed.

- The bearing conditions may be described directly in the SMS field. For bearings with a CS-4 due to Movement, Alignment or Loss of Bearing Area within the bearing, the above bearing measurement forms will be used to document the movement.
- Representative photographs will be included for bearings that appear to be frozen, are CS-4, or exhibit major deficiencies.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

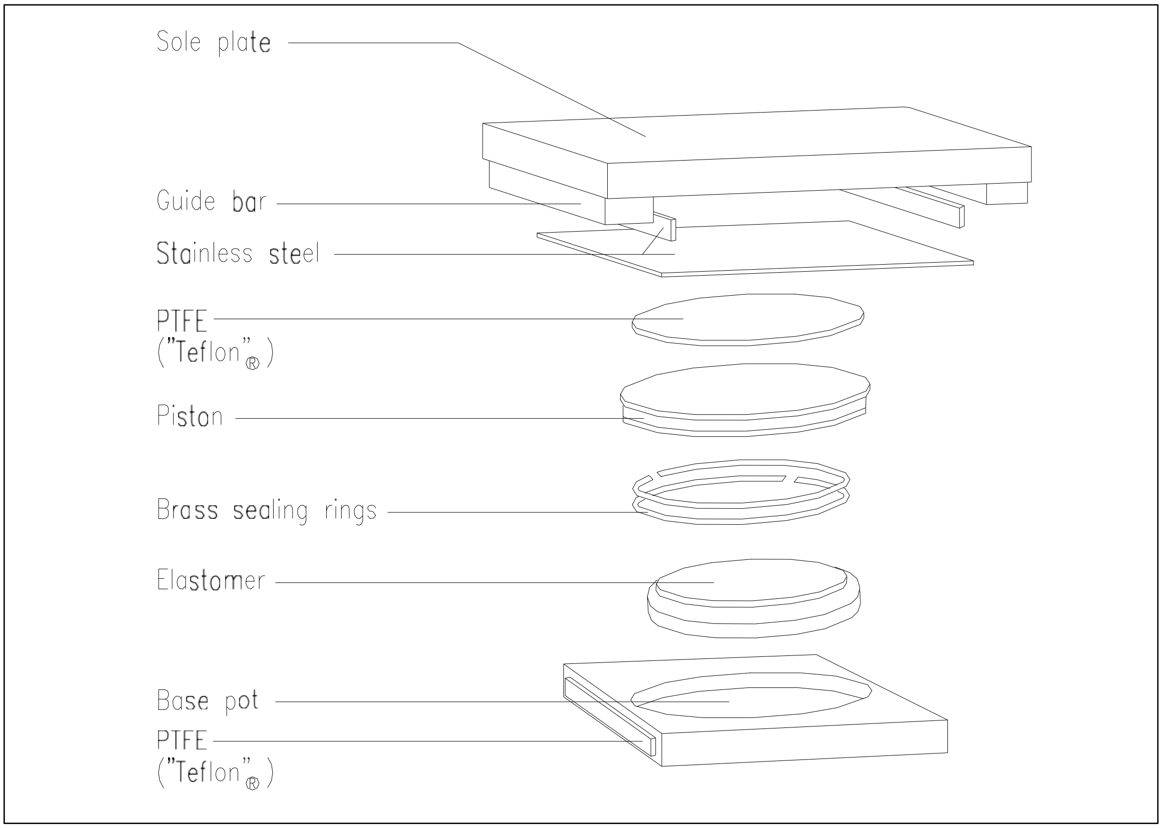


Figure 3.3.1-1 Typical Guided Pot Bearing Components

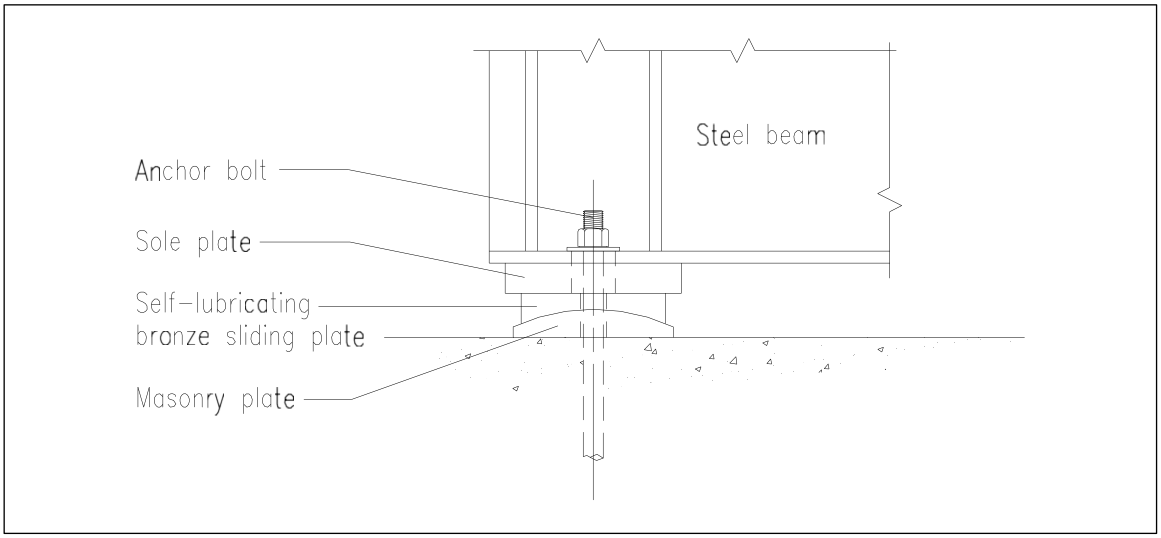


Figure 3.3.1-2 Typical Bronze Sliding Plate Bearing

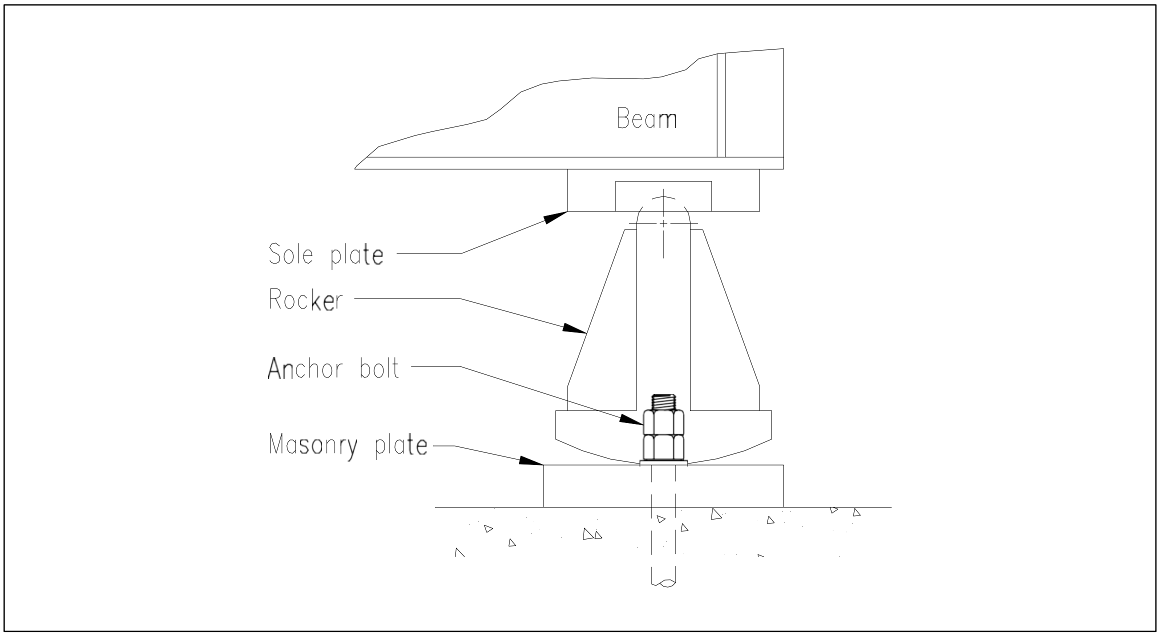


Figure 3.3.1-3 Typical Rocker Bearing

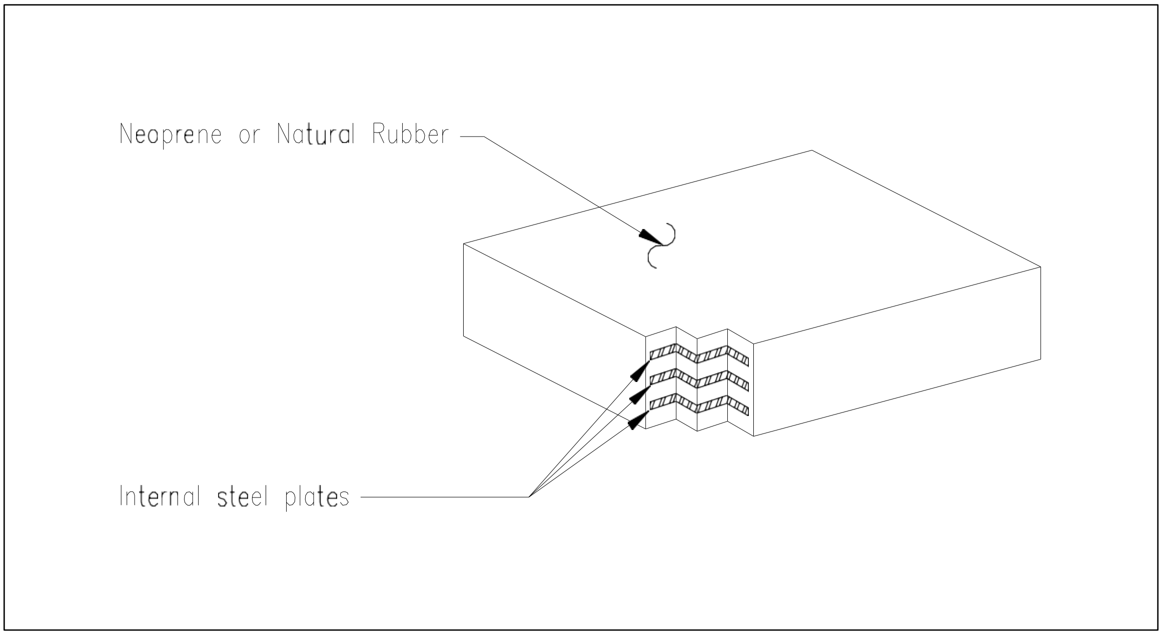


Figure 3.3.1-4 Typical Steel Reinforced Elastomeric Bearing

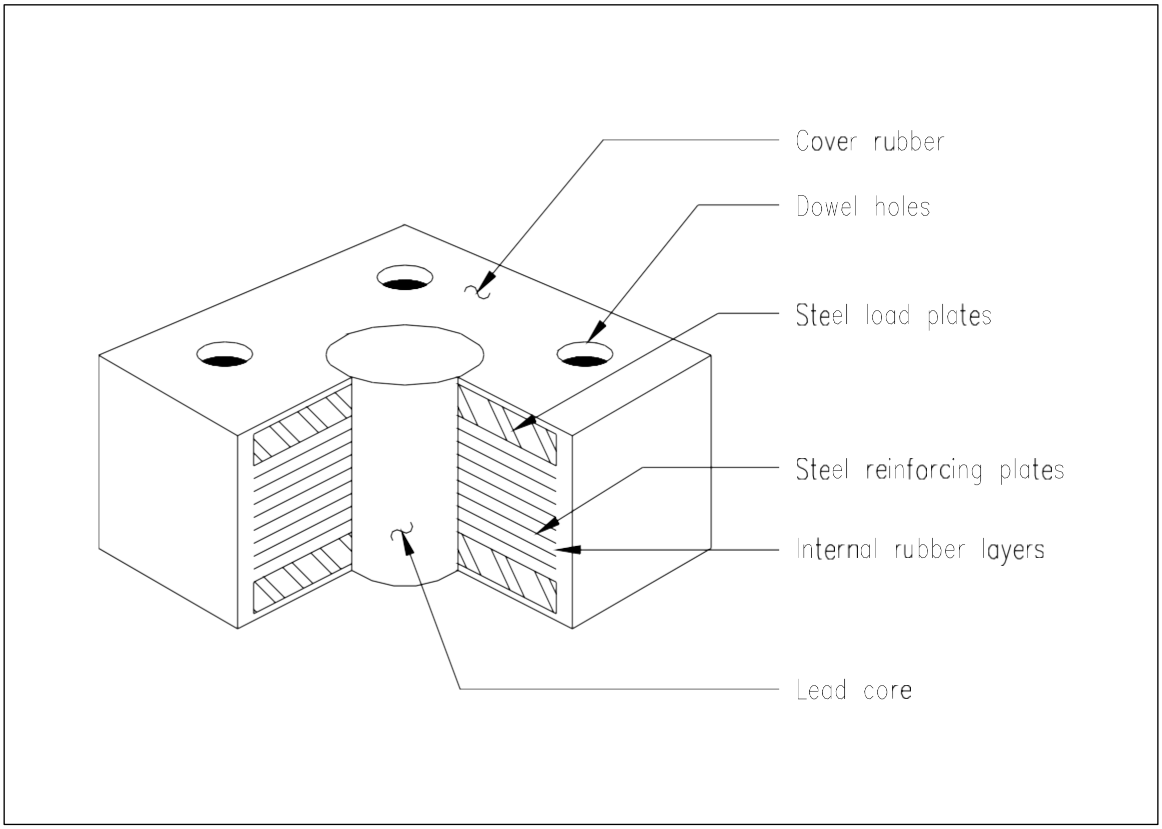
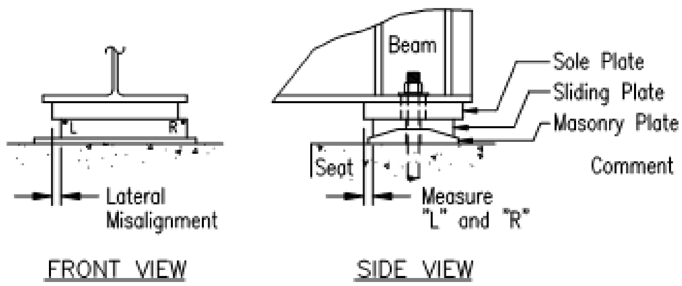


Figure 3.3.1-5 Dynamic Isolation Bearing for Seismic Protection

FIELD NOTES

BRIDGE NO.	DATE:
CREW:	SHEET

SLIDING BEARING MEASUREMENTS



Span No. = _____

Substructure Unit = ____________

Temperature = ____°F

Comment On:
- Presence of keepers or work done on bearings.
- Undermining of bearing. Attach sketch with dimensions.
- Cracking of plates or welds.
- Condition of anchor bolts.

Beam	Movement				Condition			Comments
	"L"	"R"	Mode Exp. or Contr.	Lateral Misalign.	Bearing Frozen?	Normal Mov't?	Rust ? H/M/L	

Figure 3.3.1-6 Sliding Bearing Measurement Form

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

ROCKER BEARING MEASUREMENTS

Span No. = ______

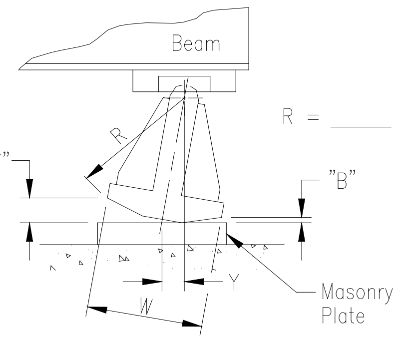
Substructure Unit = ______________________

Temperature = _____°F

$\theta = \sin^{-1}(F-B)/W$

$Y = R \tan \theta$

The "Front" of the bearing is the side facing the fixed bearing.



R = ______

W = ______

NOTE:

"F" & "B" should be measured at the left side corners of the rocker or on the side closest to to the front face of the substructure on skewed bridges.

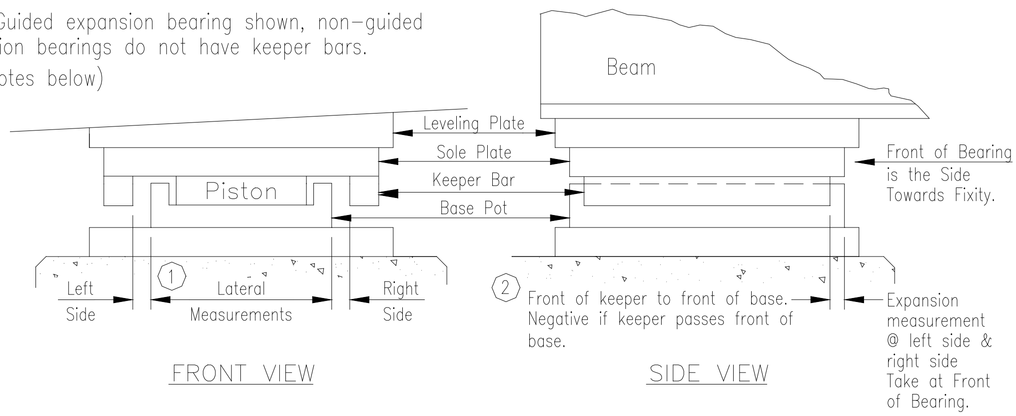
Beam	"F"	"B"	Y	Cont. or Exp.	Comments

Figure 3.3.1-7 Rocker Bearing Measurement Form

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

POT BEARING MEASUREMENTS

Note: Guided expansion bearing shown, non–guided expansion bearings do not have keeper bars.
(see notes below)



(1) –Left & Right are determined when facing the Front of the Bearing.
–For non–guided bearings, measure from side of sole plate to side of piston @ center line of piston.

(2) –For non–guided bearings, measure expansion from front of sole plate to front of piston @ center line of bearing.

Span No. & Substructure Unit = ______________________ Temperature = ____°F

Beam	Expansion			Lateral		Comments
	Exp. Measurement		Side of Brg.	Left	Right	
	L	R	(N,S,E,W)			

Figure 3.3.1-8 Pot Bearing Measurement Form

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage areas may be caused by vehicle impact, earthquake, or extreme weather events. This is not an exhaustive list of the causes of damage.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation will include, but not be limited to:

- Documentation in the inspection report of the condition of any bearing element that has been damaged. Photographs of the damaged bearings are required and sketches or measurement forms are encouraged if description alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.1.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- When taken, expansion bearing measurements will be compared to those in the last inspection report to determine if there is a reasonable change in measurement based on the difference in temperatures at the time the bearings were measured.
- Comparison of bearing measurements will determine if there is lack of movement or a progressive movement taking place.

3.3.1.3 Maintenance Considerations

- Bearings must be relatively clean to function properly. Accumulated debris on a bridge seat, that tends to interfere with a bearing's movement and hold moisture around the bearing, will be removed by the inspector when possible; otherwise it will be included in a work item and debris removed by Maintenance.
- Normally, frozen bearings will develop irregularities, along their movement surfaces, that cause mechanical binding and prevent normal movement. Simply cleaning these bearings does not usually remove or correct the irregularities that cause the binding and, therefore, is not normally effective unless the deterioration is minor.
- On bridge spans under 100’, the amount of thermal movement is less than on longer spans and may be accommodated in the superstructure. If there are no signs of distress, the replacement of frozen bearings may not be justified.
- On bridges over 100’ or where a large number of bearings appear to be frozen, replacement of the bearings with suitable type bearings will be requested.

Figure 3.3.1-9 Over Extended Rocker Bearing.

- Note: Front of Rocker in Contact with Underside of Sole Plate.

Figure 3.3.1-10 Bronze Sliding Plate Bearing with a Gap Between the Sole Plate and the Sliding Plate.

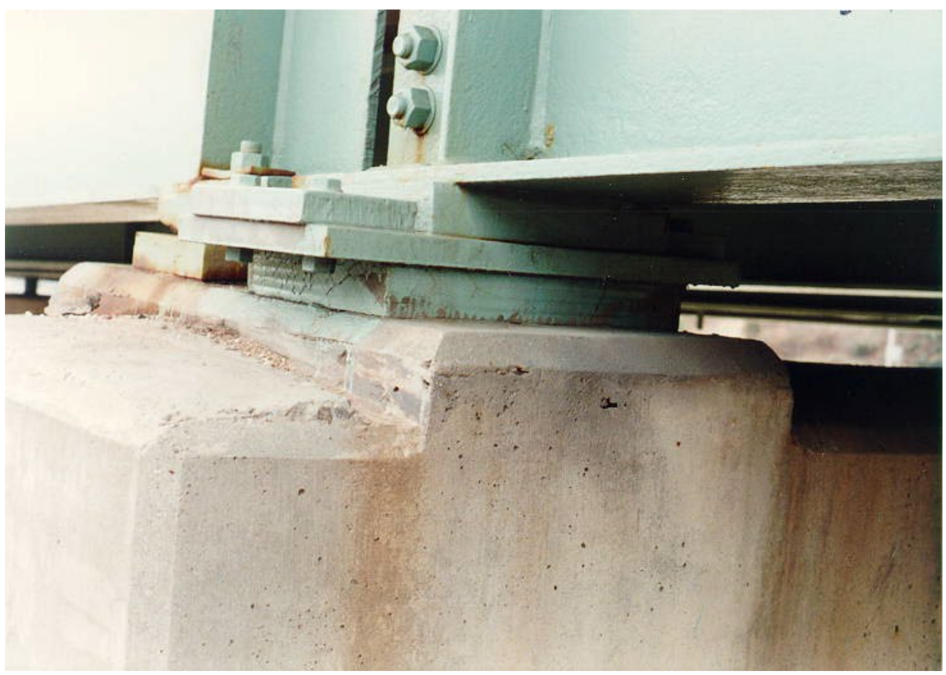


Figure 3.3.1-11 Retrofit Detail. Elastomeric Bearing Installed to Replace Bronze Sliding Plate Bearing.

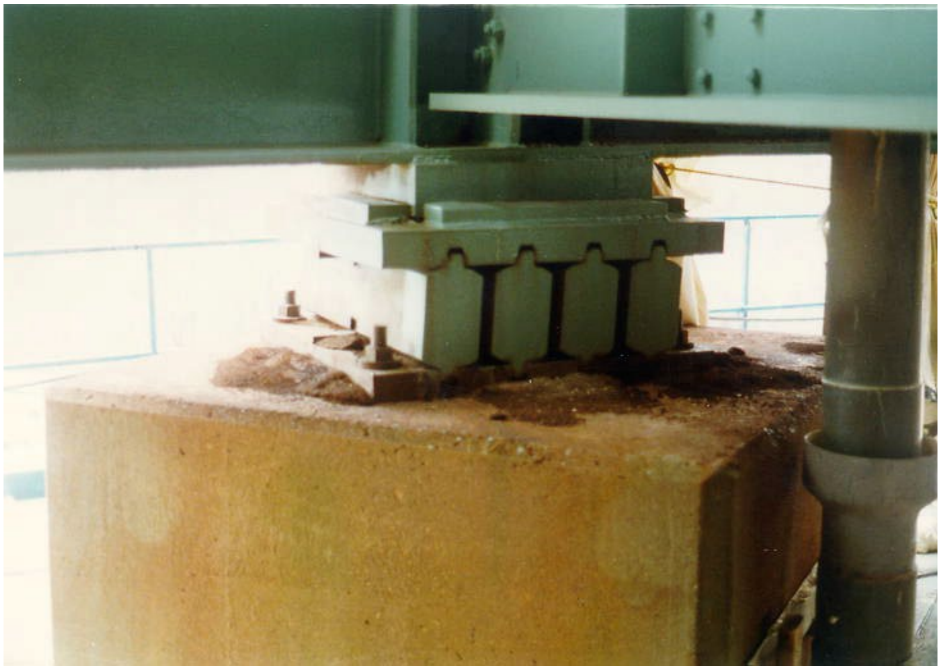


Figure 3.3.1-12 Nested Rocker Bearing Used for Very Large Spans.

Figure 3.3.1-13 Elastomeric Bearing. Note the Non-parallel Bearing Surfaces Causing Bulging and Cracking at the Rear of the Elastomeric Bearing Pad.

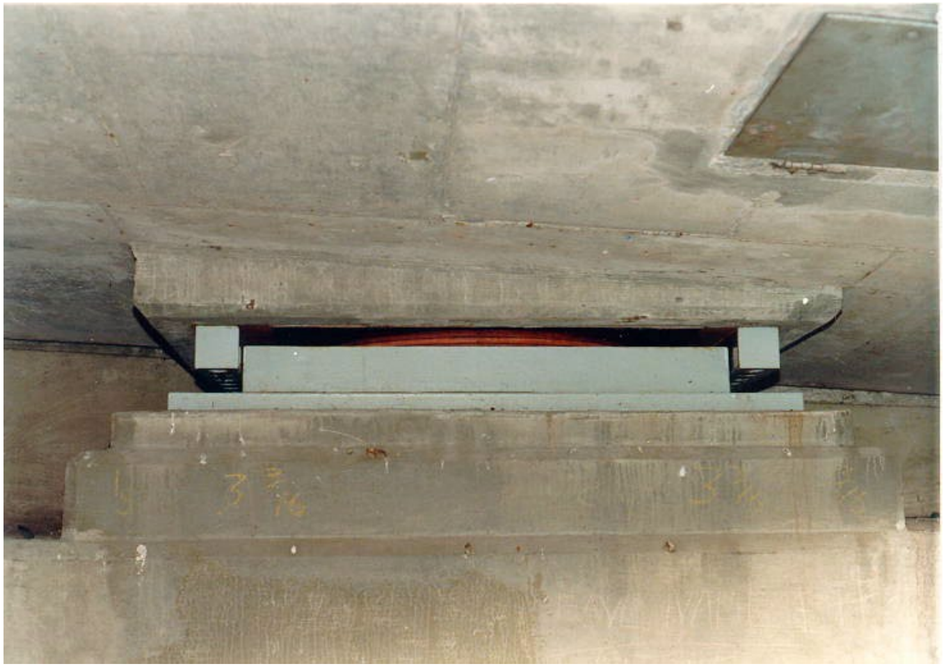


Figure 3.3.1-14 Pot Bearing with Side Guide Bars

Figure 3.3.1-15 Center Guided Pot Bearing

3.3.2 Pin and Hanger Assemblies

Reference: BIRM Section 10.1.10, 10.2, 10.3, and 10.4.11

3.3.2.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the pin and hanger assemblies in accordance with BIRM Sections 10.1.10, 10.2, 10.3, and 10.4.11.
- As stated in Section 2.6.8 of this manual, consultants are to be contracted to perform pin and hanger inspections which are required every 48 months.
- All pin and hanger assemblies will be treated as fracture critical, regardless of whether the girders they support are redundant. All pin and hangers will be inspected in accordance with the guidelines established in this section and in Chapter 7 for Fracture Critical Member Inspection.

Special Note:

- *Pin and hanger assemblies are put in bridges to permit thermal expansion and rotation of the bridge superstructure. If only rotation of the joint is desired, one pin is used to form a hinge in the beam. Where longitudinal expansion is also required, a system consisting of two pins with a hanger between them is used.*
- *Hangers are typically designed for pure tension forces. However, hangers may experience both tension and bending. Bending may result from corrosion binding the hanger and preventing rotation. Out-of-plane bending (perpendicular to the wide face) in the hanger bar may result from misalignment or skewed geometry due to transverse forces imparted by impacted rust, improper erection, etc.*
- *Pins are normally designed for shear and bearing on the full thickness of the hanger. In pins that have "shoulders" (changes in pin diameter at the threads), the pin can be subjected to excessive bearing stress if the hanger shifts off the pin shoulder and onto the threaded area. Pins can also see very high torsional forces if corrosion inhibits or prevents their ability to rotate freely.*

- Pin and hanger assemblies will be inspected "hands-on" using adequate lighting to detect corrosion, impacted rust, section loss, hairline cracks (external), impact or collision damage, or other deterioration. This will be done in conjunction with the inspection of the superstructure elements.

- Measurements are only required for pin and hanger assemblies that satisfy any of the following: Visual misalignment is observed, or they are part of a 48-month Pin and Hanger inspection. Complete the inspection forms shown in Figures 3.3.2-1 or 3.3.2-2, as they apply.

- Inspect the webs and flanges of the connected beams at all pin and hanger assemblies for proper alignment. This may be checked with a straight edge or plumb bob. Misalignment may indicate lateral movement caused by impacted rust.

- Inspect pin and hanger components for evidence that deck drainage is entering the assembly.

- Inspect the backside of hangers to the extent possible utilizing lights and inspection mirrors for impacted rust. It may be helpful to probe with a wire or slender steel ruler.
- Visually inspect the pin to the extent that it is visible and tap the pin with a hammer to check for significant looseness of the pin, nut and/or retainer cap. Measure the amount of any negative thread noted on each pin nut (the amount that the pin is recessed into the nut). Check the retainer cap to see if it is bent or deformed in any way. Verify that the face of the cap is flat with a straight edge. Verify that the nuts that hold retainer caps in place are tight and that a cotter pin or tack weld between the pin and nut are present and not bent or broken.
- Inspect components for signs of rotation that may be evidenced by cracked and/or worn paint between the hanger and web plates of the connected members. Differential movement between the hanger and web plates will also be noted during live load passage.
- When defects or deteriorations are found in a particular location on a pin and hanger assembly, all other pin and hanger assemblies will be inspected for the presence of similar defects.

Special Note:

- *If differential movement around the pin and hangers is excessive or if there is notable vertical movement with live load passage, the pins or pin holes may be excessively worn.*

- Inspect all rotating components for signs of movement and wear at the interface with other components. This may be evidenced by the presence of red or orange abrasion dust ("bleeding" rust).
- Inspect the hangers closely for signs of fatigue cracking. The critical areas most likely to develop cracks are outlined below and shown in Figure 3.3.2-3:
  - at welds used to connect hanger plates.
  - at welds used to connect web doubler plates.
  - in the base metal at the ends of hangers adjacent to pin holes.
  - in the base metal at the juncture between heads and shanks of eyebars.

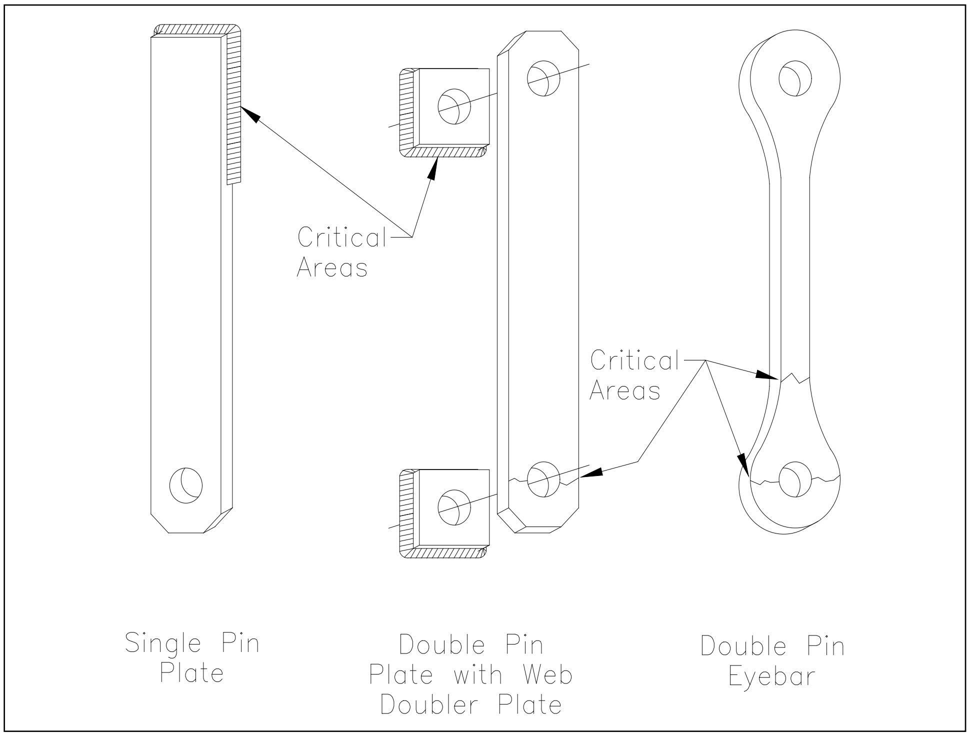


Figure 3.3.2-3 Fatigue Cracks in Pin and Hanger Assemblies

- All suspected cracks will undergo Nondestructive Testing (NDT) to attempt to confirm the existence and extent of the crack. All confirmed fatigue cracks will immediately be reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 2.2.16.2.
- Inspect retrofit systems, such as supplemental hangers, saddles or "catcher's mitts", for missing components, corrosion, section loss, cracks, and other deterioration. These "back-up" systems are normally designed to catch and support the beam in the event of a hanger failure. Measure the gap between the beams and the retrofit detail. Note if the gap appears too large (excessive impact loads would be applied at failure) or too small (joint movement is restrained). Compare measured gap values with design values. If a neoprene bearing pad is included in the assembly to lessen impact, evaluate the condition and integrity of the pad. Evaluate the ability of the retrofit to function in its design capacity.

Special Note:

Disassembly of Pin and Hanger assemblies for inspection:

- *No portion of any pin and hanger assembly should ever be disassembled by bridge inspection personnel. Partial or total disassembly of a pin and hanger joint should be undertaken only by approved personnel after proper engineering design is performed with auxiliary support supplied.*
- *Removal of the retainer nuts or caps should not be attempted unless an alternate means of retaining the hanger on the pin is in place.*
- *Hangers and pins are generally difficult to remove even after the retaining assemblies are taken off. This is not always true, however, and a pin that is subjected to high torsional stresses due to impacted rust can rotate or fail suddenly if the nut is loosened. Hangers that are subjected to bending stress due to impacted rust may slip off the "shoulder" or pin itself once the nut is loosened.*
- *Partial or full disassembly of pin and hanger assemblies should never be undertaken until all live load is removed from the structure. Live load should remain off the structure until reassembly is complete.*

Nondestructive Testing:

- *Ultrasonic testing is currently the best means available for checking pins in place for internal flaws. However, the presence of "dead spaces" within the pin (locations where sound waves cannot reach due to the geometry of the pin surface relative to the transducer) may skew test results.*
- *Only trained, certified technicians, knowledgeable in the theory and limitations of ultrasonic testing should perform and evaluate the test results.*

○

- Inspect seated beam assemblies and spliced beam type retrofit details using the inspection guidelines established in Sections 3.3.1 Bearings, 3.3.8 Steel Multi-Girders or 3.3.9 Steel Girder and Floorbeam Systems.

Documentation

- The pin and hanger measurement forms shown in Figures 3.3.2-1 & 3.3.2-2 will be completed for hangers and hinges, where required.
- Document the presence of all loose, missing or cracked components or cracked welds on the pin and hanger assemblies. Mark these locations on the bridge in the vicinity of the assembly with a permanent marker or lumber crayon in such a manner that subsequent inspections may find the locations easily.
- Document all steel losses by noting the area and depth of the loss as well as its relative location on the pin and hanger assembly. Whenever possible, calipers or other measuring devices will be used to measure the remaining section where deteriorations are noted instead of estimating loss.
- Document whether evidence of rotation within the pin and hanger assembly was observed.
- Document the location and amount of any impacted rust found and whether rotation of the hanger assembly is affected.

- Specific care will be given to documenting the current condition of all previously noted deteriorations so the rate of deterioration can be established. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed will be included in the inspection report.
- Note the existence of all leakage or drainage onto the pin and hangers.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Fracture Critical Inspections

- "Hands-on" inspection of all fracture critical members on the bridge with the use of visual inspection methods where the inspector is about 24" from the surface. In some cases, supplemental non-destructive inspections may be necessary.
- Use additional light and magnification to evaluate the member if necessary.
- Per the NBIS, Fracture Critical Inspections are to be performed at regular intervals, not exceeding 24 months.
    - However, certain fracture critical members may require an inspection frequency less than 24 months.
- The Inspection procedure will contain sketches and drawings where needed and fatigue sensitive details will be indicated for fracture critical members.
- Record the type, size, and location of any defect.
- If defect is a crack, determine the length and depth (non-destructive testing may be required). Also measure and record the crack width.
- Identify any additional information that may help determine the age and severity of the defect.
- All exposed surfaces of all pin and hanger details and all exposed primary member surfaces within 3 ft of pin and hanger details will receive a 100% close-up, "hands-on" visual inspection during each inspection. This will be done regardless of redundancy.

Damage Inspections

- Inspection methods will vary depending on the type and severity of damage. Damage caused by impact with vehicular traffic will be inspected for signs of misalignment, cracking and loose connections.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will include, but not be limited to thorough documentation of the condition of any Pin and Hanger element that has been damaged. Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

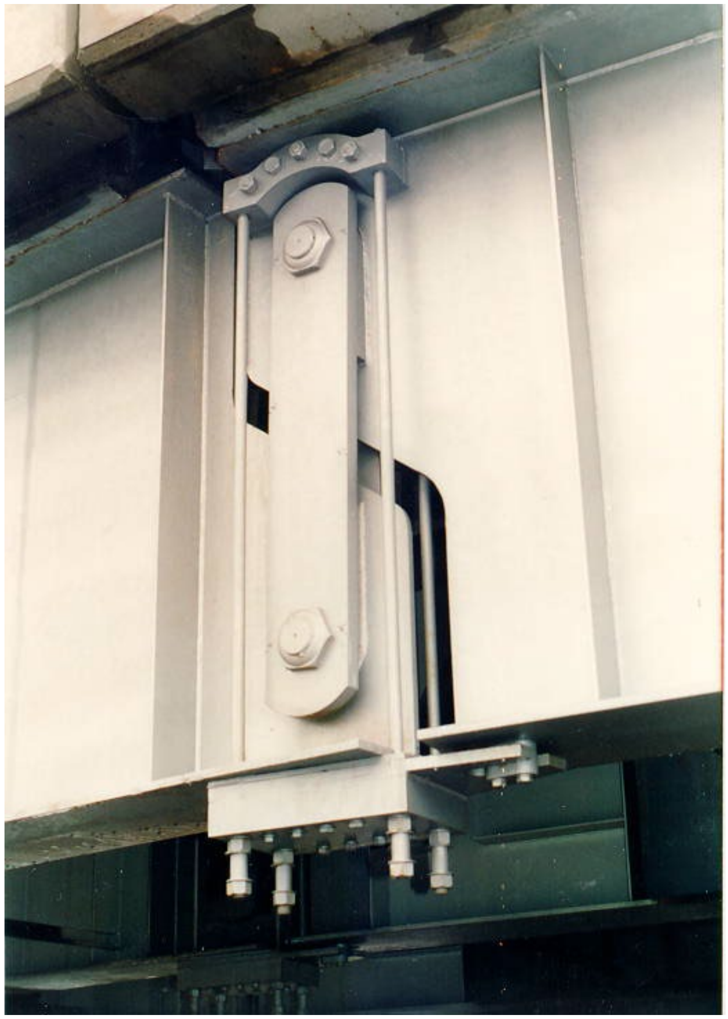


Figure 3.3.2-4 Expansion Hanger with Sling Backup System Installed.

Documentation

- All documentation required for routine inspections will be included in the detailed documentation plus the results of all ultrasonic testing performed.
- Documentation will clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph, that documents the overall condition of the pin and hanger assemblies as well as detail photographs that support the condition rating, will be provided. All fatigue cracks noted will be photographed.

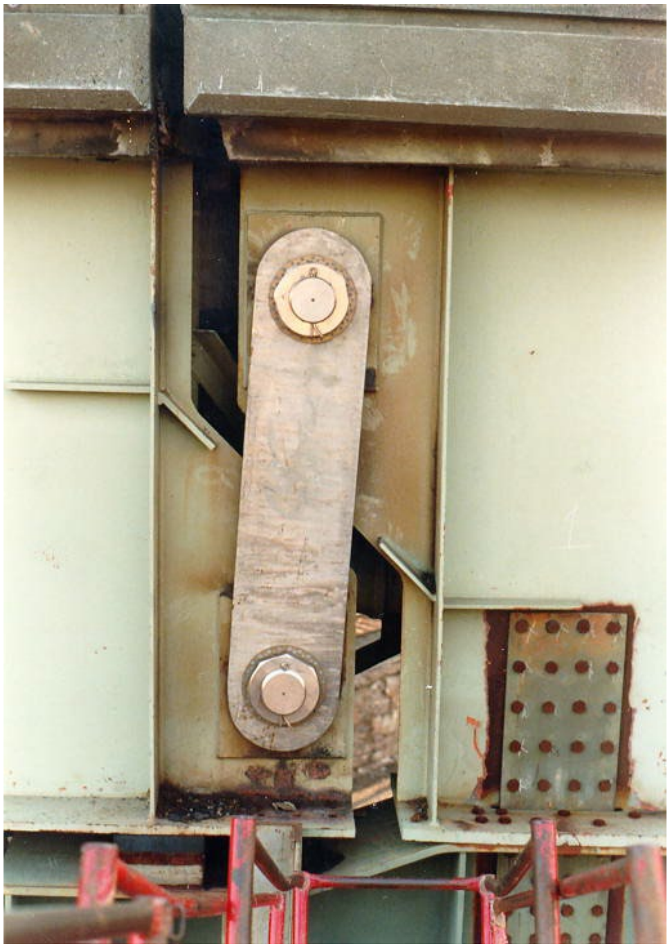


Figure 3.3.2-5 New Stainless-Steel Pin and Hanger with "Catchers Mitt" Retrofit Support Beam Installed.

3.3.2.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- The inspection reviewer will determine if fatigue problems have been noted on the pin and hanger assemblies and whether patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing past and present inspection reports.

3.3.2.3 Maintenance Considerations

- Remove debris and impacted rust to the extent possible without disassembly. Paint or spot paint the pin and hanger assemblies as required to cover exposed steel.
- Ensure that retainer cap nuts are tight and that anti-loosening devices such as cotter pin, tack welds, double nuts, etc., are in place and functioning as designed.
- Perform maintenance on the drainage system to prevent leakage onto the pin and hanger assemblies.

- If load has been transferred to the backup system, the performance of the backup system will be reviewed and returning the load to the primary system will be considered.

PIN & HANGER DATA SHEET

Measurements Taken By: ______ Date: ______

Bridge No.: ______ ______ Town: ______

Hanger Location: ______ Effective span for Movement: ______ (ft) Page: ______ of ______

Beam No.	V (in)	J (in)	T_r (in)	B_r (in)	T_ℓ (in)	B_ℓ (in)	Out to Out (in)	Secondary System Type	Gap[1] (Y/N)	Nut Restraint System	Temp	Comments
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Notes:

1) For Pin & Hanger assemblies with a redundant support system, indicate if there is a gap between the redundant system (bearing) and the bottom flange of the suspended girder.
2) All measurements are taken in reference to log direction.
   - **V** : Vertical misalignment of girders @ left edge of girder's bottom flange.
   - **J** : Joint opening between webs, measured just above the bottom flange fillet, on the left face of the girder's web.
   - **Out to Out :** The out-to-out of hangers taken at the leading edge, based on log direction.
3) Use a permanent marker to indicate locations of field measurements.

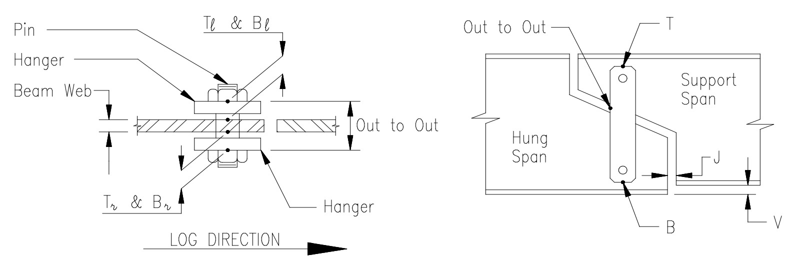


Figure 3.3.2-1 Expansion Hanger Measurement Form

HINGE DATA SHEET

Bridge No.: ______ ______ Town: ______ Measurements Taken By: ______ Date: ______

Date: ______

Hinge Located: ______ Effective span for Movement: ______ (ft) Page: ______ of ______

Beam No.	V (in)	J (in)	R (in)	L (in)	Secondary System Type	Gap[1] (Y/N)	Nut Restraint System	**Comments**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

<u>Notes:</u>

1) For Hinge assemblies with a redundant support system, indicate if there is a gap between the redundant system (bearing) and the bottom flange of the suspended girder.
2) All measurements are taken in reference to log direction.
   - **V** : Vertical misalignment of girders @ left edge of girder's bottom flange.
   - **J** : Joint opening between webs, measured just above the bottom flange fillet, on the left face of the girder's web.
3) Use a permanent marker to indicate locations of field measurements.

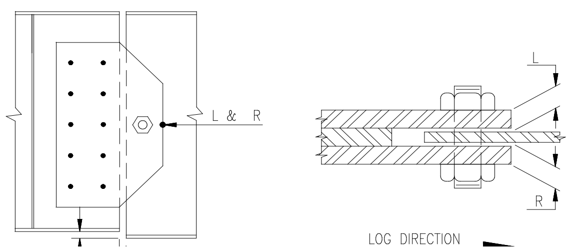


Figure 3.3.2-2 – Hinge (Fixed Hanger) Measurement Form

3.3.3 Reinforced Concrete Slabs

Reference: BIRM Sections 9.1.2, 9.2, 9.3 and 9.4

This section describes the inspection requirements for reinforced concrete slab superstructures. The requirements for concrete decks are discussed in Section 3.1.2. A concrete slab superstructure is a slab that is supported directly by the substructure. This type of superstructure is also known as an "Integral Deck" superstructure because the superstructure is also the riding surface or "deck."

3.3.3.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the slab in accordance with BIRM Section 9.1.2.
- The underside of the slab will be viewed from a distance close enough and with adequate lighting to detect cracks 0.012” wide.
- All areas of suspected delamination and at least 25% of those areas on the bottom of the slab showing cracking, scaling, wetness or staining will be tapped with a hammer or metal rod to determine soundness. For top of slab, reference Concrete Decks Section 3.2.2 requirements.

Documentation

- The size and location of cracks, spalls, delaminations, etc., will be noted. Where these cannot be described narratively, a sketch of the slab underside will be made that shows the size, location and orientation of deficiencies found. Cracks with rust staining will be documented as such since they may be indicative of leakage through the slab and deterioration of the reinforcing steel. Spalls that expose reinforcing steel will be specifically noted and include any deterioration or section loss on the exposed steel.
- Specific care will be paid to document increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection (up or down), a photograph or explanation of why the rating has changed will be included.
- Notes will be made describing the current condition of any previously discovered item that was being monitored.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage caused from vehicle live loads, such as spalling and damaged reinforcement, may require only a visual examination at one location.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Included, but not limited to, in the inspection report will be thorough documentation of the condition of any slab element that has been damaged. Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.

- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.3.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- The sudden or progressive appearance of flexure or shear cracks may indicate the need for a new structural evaluation and/or posting of the bridge structure for a weight restriction.
- Low condition ratings, which are caused by extensive widespread deterioration, could be reason to request supplemental testing to better determine the condition of the slab and whether rehabilitation or replacement is warranted.

3.3.3.3 Maintenance Considerations

- Due to the difficulty inherent with overhead concrete patching and the non-structural nature of the bottom surface concrete in typical simple span slabs, repair of spalled areas on the undersides of slabs is not normally necessary, except in slab bearing areas. At most locations, loose or hollow concrete will be removed, and the spalled area cleaned and coated with an appropriate material that will protect exposed reinforcing steel and prevent further deterioration.
- For the top of slab, reference Concrete Deck Section3.2.2 for maintenance considerations.
- Waterproofing methods can be the best way to prevent or slow the deterioration of reinforced concrete members. Care must be taken in the application of waterproofing systems to ensure that they are not applied in such a way as to prevent existing moisture in the slab from exiting.

Figure 3.3.3-1 - Typical Concrete Slab Bridge

Important Note for upcoming Sections 3.3.4, 3.3.7 and 3.3.8: *For manual sections 3.3.4, 3.3.7 and 3.3.8, a different format is being applied for use and feedback from inspectors, prior to applying to all of sections 3.2 through 3.4 for Deck, Superstructure and Substructure. This procedure is described below:*

There are general inspection procedural requirements which apply to all types of bridges and elements for biennial/routine inspections. General procedural requirements which apply to all Damage Inspections, Follow-up Inspections, Report Review and Maintenance Considerations are also covered below. In addition to procedural requirements, there are other inspection procedures that may be performed at the discretion of the inspector, referred to as "Inspector Judgment" procedures.

In the above noted sections, procedures are bulletized using either an "**R**" indicating **"Required"** or an "**I.J.**" indicating item is to be followed based on the **"Inspector's Judgement"**, as they may apply in some situations, but not others. Inspector Judgment procedures may not be used if their use results in a significant increase in the level of effort for little gain or if such procedures cause inspecting, documenting or reporting beyond what is necessary.

The process for using these sections:

1. Follow the General procedures below.
2. Follow the procedures for the type of inspection you are performing (i.e., Damage, Follow-up, etc..) below.
3. Follow the procedures for the type of materials and bridge components you are inspecting (i.e., concrete superstructures, timber substructures, etc.) below.
4. Follow procedures in the specific Section(s) which apply to the type of bridge you are inspecting (i.e., Section 3.3.4 Concrete Reinforced T-Beams, Section 3.4.3 Timber Substructures, etc.).

General Inspection Procedures:

- Inspection methods must be sufficient to determine and document the type, quantity, location, and extent of defects listed in the MBEI condition state tables and MDT's ADE tables in Chapter 4. Field notes must be sufficient to be able to differentiate and divide the defect quantities among the four condition states for every element.
- Inspection methods will consist of a progression, starting with visual, followed by physical for areas with visual defects requiring hands-on access to properly condition code (i.e. hammering suspect delamination or measuring section loss to steel). Advanced inspection methods may be required to properly condition code certain defects (i.e., using UT to confirm extent of fatigue cracks).
- If the NBI condition rating has changed from the previous inspection due to increased quantity, size or severity of deterioration, the inspection report will include photographs and/or documentation to justify why the rating has changed.
- Defects that may directly affect a structure's load rating will be documented with enough accuracy to be used to update the load rating without the need for a separate field visit. Defects will include the defect dimensions, as well as a location from a fixed point on the bridge. Where these defects cannot be described using text, a sketch of the framing plan will be made that shows the size, location and orientation of deficiencies found.
- Critical Findings will be documented and reported in accordance with section 2.14 of this manual.

- Relevant sections of the FHWA BIRM will provide “best-practice” information will be used to guide inspection and documentation.

Damage Inspection Procedures:

Inspection

- Coordinate the damage inspection between the inspector, bridge owner, and any other relevant agencies to determine the extent of damage and planned inspection methods.
- Inspection methods will vary depending on the type and severity of damage. Timber deck elements that have been damaged by fire may require a widespread visual and physical examination including the removal of charred surfaces, sounding, and probing. Damage caused from vehicle live loads, such as spalling and damaged reinforcement, may only require a visual examination at one location.

Documentation

- Include thorough documentation of the condition of any primary element that has been damaged. Photographs of the damaged areas are required.
- Sketches are required only when text cannot convey the nature and extent of the damage.

Follow-up Inspection Procedures:

Inspection & Documentation

- Inspection and documentation methods will be the same as the methods that were used or intended to be used when the inspection was first performed or intended to be performed.

Report Review Procedures:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures in Sections 2.9, 2.14 and Appendix 2B.
- Low condition ratings that are caused by extensive or widespread deterioration are possible reasons to suggest supplemental testing to better determine the condition of the element and whether rehabilitation or replacement is warranted.
- Suggest load rating updates due to conditions found at the structure (timber decay, section loss to steel members, structural cracking in concrete members, etc.).

Maintenance Consideration Procedures

- Follow guidance in Section 2.14.6 for documentation/generation of Repair Suggestions. In addition, specific example or repair suggests are given in each section of this chapter for the various bridge materials/components. Repair Suggestions will be input into SMS in the Work Candidates tab. Note that this tab has numerous input fields with dropdown menus to assist the inspector that must be filled out.
- Clean debris such as sand, spider webs, bird nests which obscure and inhibit proper inspection of element surfaces. A Repair Suggestion may be required if debris removal is extensive, time consuming, or hazardous.

Procedures for Concrete Superstructures: Initial / Inventory Inspections and Routine Inspection

Inspection

- Look at bearing areas for spalling and crushing due to friction from thermal movement and high bearing pressure.
- Look at areas near the supports for the presence of diagonal (shear) cracks. These will occur on the side of the stem or web and project up from the supports toward midspan.
- Look at tension zones for flexure cracks (which are due to overload in bending) and would be perpendicular to the member. Also look to deteriorated concrete (delaminations, spalls, and cracks with efflorescence, etc.), which could cause or be evidence of debonding of the tension reinforcement.
- Look at areas exposed to drainage for concrete spalling and scaling. This may be particularly evident along the curbline, at curb drains, scuppers or other thru-deck drains, and at the ends of beams where drainage seeps through deck joints.
- Look for repaired areas to determine if repair materials are in place and functioning as designed.
- Hammer-tap patched areas to determine if the patch is sound and adhering to the base material.

Documentation

- Document the size and location of defects including cracks, spalls, delaminations, etc.

Procedures for Steel Superstructures: Initial / Inventory Inspections and Routine Inspection

- The entire superstructure will be inspected with emphasis on areas of maximum moment (midspan for simple span beams and the area over the piers for continuous beams), ends of cover plates (or other locations of abrupt change in member cross section), bearing areas, connection plates and diaphragm connections.

- Sight along the flanges of beams for evidence of compression flange buckling or dead load deflection ("negative camber").
- Bolts and rivets will be visually inspected for tightness and section loss. Broken paint or bleeding rust around a bolt or rivet may indicate a loose or broken fastener.
- All visually suspected cracks on primary members will be inspected hands=on.
- The extent of identified cracks in primary members will be recommended for advanced Nondestructive Testing (NDT) to confirm their existence and to determine the extent of crack.
- All pin and hanger details will be inspected in accordance with Section 3.3.2.
- Laminated rust will be removed from high stress areas (flanges at midspans for simple spans and over supports for continuous spans and also webs near supports) to measure section losses.
- Girder/beam webs will be checked for signs of web crippling (out-of-plane bending) or beam tipping at all support locations.
- Twenty-five percent (25%) of all cover plate ends will be inspected "hands on" during each routine inspection. It will be clearly indicated in the inspection report, which beam cover plates were inspected "hands on." A different 25% will be inspected on each subsequent inspection. This provides for a "hands on" inspection of all the cover plate ends every four routine inspection cycles.
- Suspect fasteners will be tapped with a hammer to confirm their integrity.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected for similar defects.
- Welded repairs, diaphragm or utility connections, and any miscellaneous welds in the tension zones of beams will be inspected closely for fatigue cracks or other defects.

Some Pointers to Remember
About Weld Inspection

- *Visual inspection tells most. However, locations of ends of cracks may be erroneous as sub-surface crack propagation may be more extensive than surface propagation.*
- *Magnetic-particle inspection is outstanding for detecting surface or near-surface cracks and is used to advantage on heavy weldments and assemblies.*
- *Dye-penetrant is easy to use in detecting surface cracks. Its indicators are readily interpreted.*
- *Ultrasonic inspection is excellent for detecting subsurface discontinuities but requires expert interpretation and certification.*

Documentation

- Document the extent and severity of all rusting. Significant loss, whether from past or current rusting will be noted in sufficient detail for a load rating analysis to be performed. Engineering judgement is required in the field to determine the significance of areas with loss, but as a guideline specific notes are required when:

    a) Greater than 15% of the flange area is lost in areas of high moment.

    b) Greater than 30% of the web area is lost in areas of high shear.

    Less significant losses (typically <1/8”) will be noted, but exact measurements are not required.

- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the beam measured from a fixed point (i.e. 12” H x 12” W x 1/8” deep loss on girder web at the bottom flange, beginning 3’ from the west bearing on girder G1).
- Document locations and lengths of all cracks found on primary members. Mark these locations on the bridge with permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, document whether the crack has propagated past the arresting hole.
- Whenever possible, where deterioration is noted, calipers, D-Meter or other measuring devices will be used to measure the remaining section instead of estimating the loss. Notes will clearly indicate whether an "estimated loss" or measured remaining thickness is being given.
- Document locations and condition of all welded repairs or connections and other miscellaneous welds in the tension zones of the beams, if they were not detailed on the construction plans or noted in previous inspections.
- Document repaired locations and the details of the repairs (size, location, connection, etc.).
- Document in the field notes, the locations of loose bolts/rivets.

3.3.4 Reinforced Concrete T-Beams

Reference: BIRM Sections 9.1.3, 9.2, 9.3, and 9.4

This type of superstructure is also known as an "Integral Deck" superstructure because the top flange/slab portion of the superstructure is also the riding surface or "deck."

3.3.4.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the superstructure in accordance with BIRM Sections 9.1.3, 9.2, 9.3, and 9.4.
- Sound with a hammer or metal rod all areas of suspected delamination and at least 25% of those areas showing cracking, scaling, wetness, staining or other deterioration to determine soundness and/or extent of deterioration.

Figure 3.3.4-1 Concrete T-Beams with Large Spalls Exposing the Bottom Layer of Reinforcing Steel

3.3.4.2 Maintenance Considerations

- Due to the difficulty inherent with overhead concrete patching, and the non-structural nature of bottom surface concrete in typical simple span T-beams, repair of minor spalled areas on the bottom of the T-beam stem or top flange is normally not necessary. At most locations, loose or hollow concrete, which does not extend beyond the depth of the bottom layer of reinforcement, will be removed and the spalled areas cleaned and coated with an approved material that will protect any exposed reinforcing steel and prevent further deterioration. However, if the spall is deeper than the bottom layer of reinforcing steel, patching operations should be conducted.
- Waterproofing methods can be the best way to prevent or slow the deterioration of reinforced concrete members. However, care must be taken in the application of waterproofing systems to ensure they are not applied in such a way as to prevent existing moisture in the T-beams from exiting.

3.3.5 Concrete Rigid Frames and Closed Spandrel Arches

Reference: BIRM Sections 9.1.6, 9.1.7, 9.2, 9.3 and 9.4

3.3.5.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the concrete rigid frame or closed spandrel arch in accordance with BIRM Sections 9.1.6, 9.1.7, 9.2, 9.3 and 9.4.
- The entire superstructure will be inspected from a distance close enough and with adequate lighting to detect cracks 0.012" wide, as well as scaling, spalling, exposed reinforcing (with or without corrosion loss), delamination, impact damage or other defects.
- Suspect areas will be inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Inspect the area of the arch ring/skew back interface for deterioration.
- Inspect the arch or frame intrados (underside surface) for longitudinal cracks that may indicate differential vertical movement across the transverse section. Look for transverse tension cracks near the crown that may indicate an overload/overstress condition.
- Inspect the arch ring/spandrel wall interface for cracks and spalls that may indicate deflection of the wall or differential movement of the arch ring.
- Inspect the spandrel walls for bulging, tilting, or other signs of deterioration and signs of fill material exfiltration.
- Inspect the top of the roadway for signs of cracking parallel to the centerline of the arch, pavement pull-away from curb lines or for depressed pavement. Depressions or signs that the pavement has been patched may indicate loss of fill material or rotation of the spandrel walls.

Special Note:

- *In closed spandrel arch structures that are earth filled, the spandrel walls are primary members. They act as retaining walls and serve to resist the lateral earth pressures that develop in the fill material during transfer of dead and live loads to the arch ring. Cracks and spalls, which are large enough to allow exfiltration of fill material, reduce the effective transfer of load and can cause voids to develop below the roadway pavement. They should be sealed to prevent further exfiltration and monitored for recurrence.*
- *Because asphalt pavements and/or fill material are porous, water can easily penetrate to the inside surfaces of arch rings, spandrel walls and frame legs. If weepholes are ineffective and water is retained, unintended water pressure and/or deterioration may take place on the inside face long before water seepage, staining, or other signs of deterioration are noticeable on the outside face. Once cracks or spalls penetrate to the outside surface, water can accelerate exfiltration of fill material.*

- Check all areas exposed to drainage for concrete spalling and scaling. This may be particularly evident below the roadway curbline, and around scuppers and weepholes.
- Check that scuppers are not clogged, and that surface water drains away properly so that it does not saturate the fill material and/or penetrate to the structural concrete.
- Check weepholes to see if they appear clear to permit proper drainage of the backfill.

- Check for shear cracks that initiate at the intersection of the frame leg and intrados (underside surface) and propagate upward into the frame slab toward midspan or downward into the leg.
- Check the tension zones in frames for flexure cracks, cracks with rust stains or efflorescence, exposed or corroded tensile reinforcement, or deteriorated concrete that could cause debonding of the tension reinforcement.
- Check the frame legs for horizontal cracks that could indicate excessive backfill pressure, and for loss of section due to spalling or scaling that would increase the compressive stresses. Check for exposed reinforcement.
- Investigate areas that have been damaged due to impact for concrete damage (compression zones) and reinforcement damage (tensile zones).
- Inspect repaired areas to determine if repair materials are in place and functioning as designed. Hammer-tap patched areas to determine if the patch is sound and adhering to the base material.
- Look for spalling, scaling or delaminated concrete that is located above roadway travel lanes and could cause problems if it were to become loose and drop to the roadway below.

Documentation

- Document deficiencies and deteriorations observed. Dimensions will include the length, width, height, depth of loss, orientation, and location relative to a fixed point.
- Elevation and plan drawings may be provided to show the layout of the arch ring, frame, spandrel walls and foundation, along with all noted deteriorations. If required, additional sectional views and detail drawings will be provided as necessary to adequately describe the extent of deficiencies noted. Sketches will be provided if significant deterioration is found.
- Notes will be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If a condition rating has changed from the previous inspection due to increased quantity or size of deterioration, or if the deterioration has been repaired, photographs, documentation, and an explanation of why the condition rating has changed will accompany the report.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

3.3.5.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- Transverse cracking in the arch ring may indicate possible differential deflection of the arch ring and can seriously affect the ability of the arch ring to carry load. If these cracks are noted, further investigation as to the cause and effects will be considered.
- Rigid frames rely on the integrity of the moment connection between the slab and leg to transfer dead and live load moments to the footings. Cracking, spalling, exposed rebar, or other deterioration noted in this area, particularly in the tension area, will be monitored closely and further investigation as to the cause and effects will be considered.

3.3.5.3 Maintenance Considerations

- Spalls noted during the inspection should be patched utilizing approved materials and details. If exposed reinforcing bars are present, they should be cleaned of all rust and coated with an approved protective coating prior to patching operations. Consideration should be given to replacing severely corroded sections of reinforcing bars and/or utilizing wire mesh to reinforce the patch.
- Weepholes and scuppers should be cleaned as needed to insure proper drainage.
- Debris buildup on the roadway should be removed as needed to allow water runoff to drain effectively.
- Potholes and/or spalls in the roadway surface should be patched utilizing approved materials and procedures to prevent increased impact stresses and further deterioration.

Figure 3.3.5-1 A Closed Spandrel Reinforced Concrete Arch Bridge

Figure 3.3.5-2 Single-span Rectangular Concrete Rigid Frame Bridge

3.3.6 Open Spandrel Concrete Arches

Reference: BIRM Section 9.1.6, 9.2, 9.3 and 9.4

NOTE: The inspection criteria described in this section conservatively assumes that transverse floorbeams act integrally with the spandrel columns to form a rigid frame system. Also, it is assumed that any spandrel beams spanning longitudinally between the spandrel columns create a rigid frame configuration and will be inspected as such. Floorbeams supported on top of the longitudinal spandrel beams will be inspected as a continuous beam with cantilevered ends.

3.3.6.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the open spandrel concrete arches in accordance with BIRM Section 9.1.6, 9.2, 9.3 and 9.4.
- All superstructure elements will be inspected on all sides and surfaces from a distance close enough and with adequate lighting to detect cracks 0.012” wide, as well as scaling, spalling, exposed reinforcing (with or without corrosion loss), delamination, impact damage or other defects.
- All suspect areas will be inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Inspect the arch rib/spandrel column interface for horizontal cracks that may indicate excessive bending in the column due to overloads or differential arch rib deflection.
- Inspect the spandrel column/floorbeam interface for diagonal (shear) cracks that begin at the interface corner and propagate upward over the column. These may indicate differential arch rib deflection.
- Inspect the tension zones of floorbeams and spandrel beams for deteriorated concrete that could cause debonding of the tensile reinforcement.
- Inspect the area near the floorbeam and spandrel beam supports for the presence of shear cracks. These cracks will appear on the sides of the beams and project upward toward the beams midspan.
- Tension areas of floorbeams and spandrel beams will be inspected for the presence of flexure cracks. These cracks will appear at the bottom of the floorbeam near midspan. In the case of continuous spandrel beams or cantilevered floorbeams, these cracks may also appear at the top of the beams at the supports.
- When arch ribs are connected with struts, check the arches near the strut connection for diagonal cracks due to torsional shear caused by differential arch rib deflections.
- Inspect the arch ribs for cracks. Longitudinal cracks along the centerline of the rib or transverse cracks may indicate an overstress condition.
- Inspect the arch ribs for any section loss due to spalling that will increase the compressive stresses at the area of loss. Maximum compressive stresses in the arch ribs occur at the connection to the substructure.

- Inspect the spandrel columns for buckling due to eccentric loading. If a column is discovered to be buckled, the arch rib adjacent to the column will be inspected for torsional distortion.
- Examine all floorbeams and spandrel beams at bearing areas for spalling or crushing due to high bearing pressure.
- Examine all cracks for rust stains. This indicates possible rusting of the steel reinforcement that is not visible.
- Check areas exposed to water drainage for concrete spalling, delamination, and scaling. This may be particularly evident along the curblines, at scuppers, and at deck joints.
- Investigate areas that have been damaged due to collision for concrete damage (compressive zones) and reinforcement damage (tension zones).
- Inspect repaired areas to determine if repair materials are in place and functioning as designed. Hammer-tap patched areas to determine if the patch is sound and adhering to the base material.
- Inspect the arch superstructure elements above the floorbeams/bent caps using the procedures outlined in other sections of this manual as applicable.

Documentation

- Document deficiencies and deteriorations observed. Dimensions will include the length, width, height, depth of loss, orientation, and location relative to a fixed point.
- A framing plan of the deck system and an elevation of the arch rib should be provided as needed to show the layout of the superstructure. All notable deteriorations will be located on these sheets. Section views and detail drawings will be provided as necessary to adequately describe the extent of deficiencies noted. Also note that very detailed descriptions and locations of deteriorations are required to avoid confusion as to the exact location
- Notes will be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If a condition rating has changed from the previous inspection due to increased quantity or size of deterioration, or if the deterioration has been repaired, photographs, documentation, and an explanation of why the condition rating has changed will accompany the report.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage caused from vehicle live loads, such as spalling and damaged reinforcement, may require only a visual examination at one location.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will include, but not be limited to, thorough documentation of the condition of any Arch element that has been damaged. Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.

- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.6.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- The sudden or progressive appearance of cracks in the tension zones of any arch superstructure members or at any of the interfaces described in this section may indicate the need for a new load analysis and/or weight restriction on the structure.
- Because of the nature of open spandrel arches, with multiple elevation views of individual arch ribs, columns, spandrel beams and floorbeams, it is easy to inadequately document the location of defects. Therefore, the inspection report reviewer will review the field notes to ensure that correct nomenclature is used, and that section and detail sketches are correctly drawn and adequately described.
- It is very unlikely the spandrel columns and arch ribs of the arch superstructure will act in pure compression (as theory would describe) due to eccentric loading of the spandrel columns. Therefore, tensile stresses may develop in the columns and torsional stresses may develop in the arch rib below the column. The reviewer will review the inspection report and field notes for documentation of columns (particularly long columns), that appear to have flexure cracks, and ribs that have torsional cracks. If these cracks are noted, additional investigation as to the cause and effect is warranted.
- Review the inspection report and field notes for evidence of cracking caused by differential deflection of the arch ribs. These cracks are most common at the column/arch rib interface, the column/floorbeam/spandrel beam connection and arch strut/arch rib interface. Signs of arch rib differential deflection will be closely monitored and may warrant further investigation as to the long-term effects on the structure.
- Section loss due to spalls in compression members will cause higher compressive stresses in the member at the location of loss. Review the inspection report and field notes for locations of excessive section loss that may warrant further investigation.

Figure 3.3.6-1 Open Spandrel Concrete Arch Bridge.

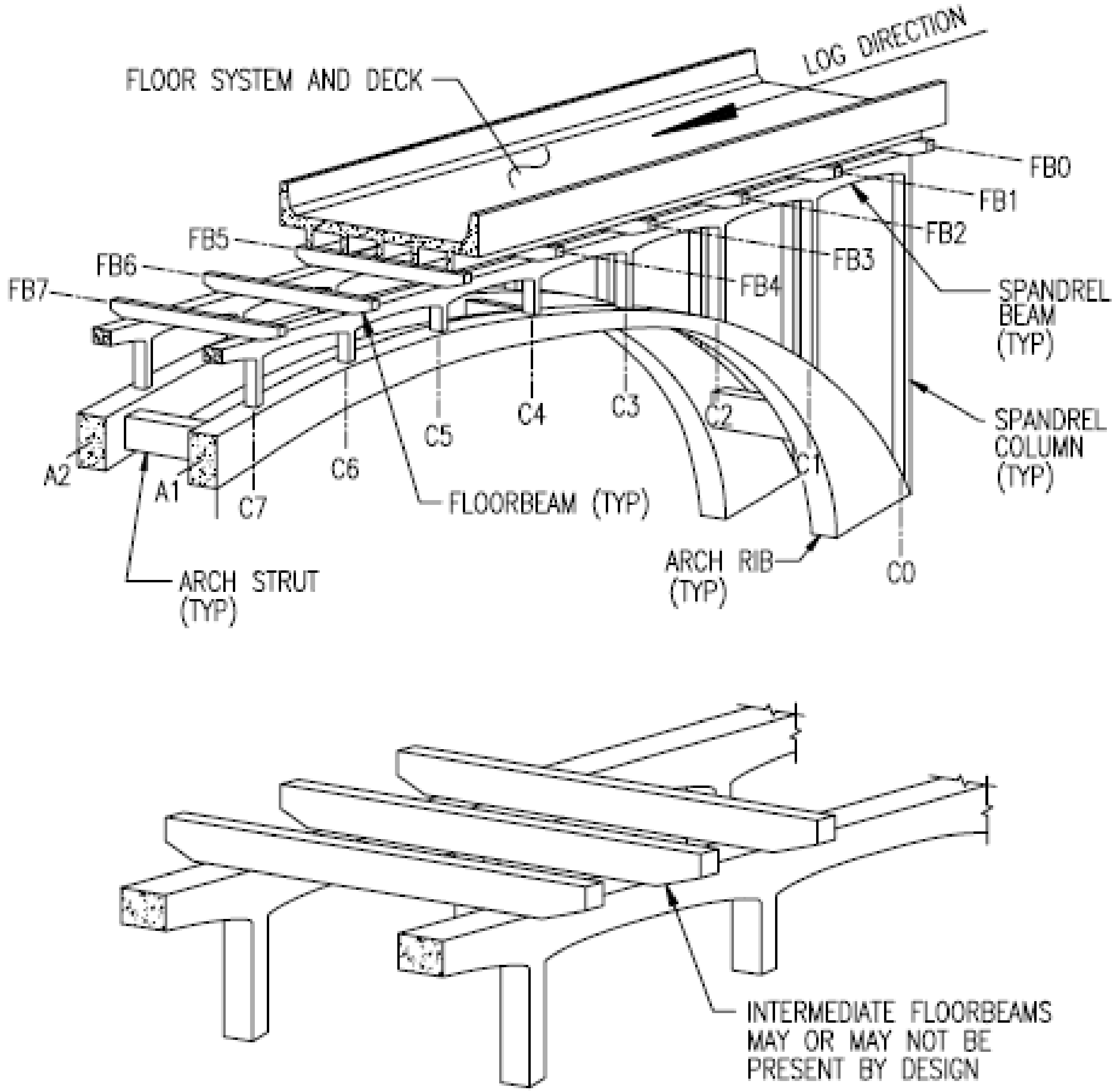


Figure 3.3.6-2 Open Spandrel Concrete Arch Bridge Components.

3.3.6.3 Maintenance Considerations

- Spalls noted during the inspection should be patched utilizing approved materials and details. If exposed reinforcing bars are present, they should be cleaned of all rust and coated with an approved protective coating prior to patching operations. Consideration should be given to replacing severely corroded sections of reinforcing bars and/or utilizing wire mesh to reinforce the patch.
- Scuppers and deck joints should be cleaned as needed to insure proper drainage.
- Debris buildup on the roadway should be removed as needed to allow runoff to drain effectively.

- Potholes and/or spalls in the roadway surface should be patched utilizing approved materials and procedures to prevent increased impact stresses and further deterioration.
- Certain structural cracks may be repaired using chemical repair techniques. Engineering judgement and discussion are required for specific applications.

3.3.7 Prestressed and Post Tensioned Concrete Superstructures

Reference: BIRM Sections 9.1.8 through 9.1.11, 9.2, 9.3 and 9.4

See "***Important Note for upcoming Sections 3.3.4, 3.3.7 and 3.3.8":*** located just before Section 3.3.4 for General, Damage and Follow-up inspection procedures and Report Review, Maintenance Considerations and Concrete Superstructure procedures prior to applying the below specific prestressed and post-tensioned inspection procedures.

3.3.7.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the superstructure in accordance with BIRM Sections 9.1.8 through 9.1.11, 9.2, 9.3 and 9.4.
- The interiors of box beams/girders will be inspected whenever they are accessible. Documentation/monitoring of deterioration/cracking will be done primarily from the interior of the boxes. Inspection of the interiors of box beams requires additional safety precautions. Refer to the section on inspection of steel box girders for comments on safety.

Documentation

- Flexure and shear cracks larger than 0.004" will be measured and accurately located.
- Nonstructural cracks need not be measured, but their general size, length, direction, location, and quantity will be documented in the inspection report.

3.3.8 Steel Multi-Girders

References: BIRM Section 10.1.2, 10.1.3, 10.2, 10.3 and 10.4
MDT Hands on Inspection of Steel Members

See "***Important Note for upcoming Sections 3.3.4, 3.3.7 and 3.3.8":*** located just before Section 3.3.4 for General, Damage and Follow-up inspection procedures and Report Review, Maintenance Considerations and Steel Superstructure procedures prior to applying the below specific steel multi-girder inspection procedures.

3.3.8.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the superstructure in accordance with BIRM Section 10.1.2, 10.1.3, 10.2, 10.3 and 10.4.

3.3.8.2 Report Review

- The appearance of new or sudden propagation of existing cracks may warrant a new load rating or fatigue analysis, and/or posting of the bridge structure for a weight restriction.

3.3.8.3 Maintenance Considerations

- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found on primary members will be immediately reported and corrective action will be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of severe rusting should be cleaned and coated to prevent further deterioration.

Figure 3.3.8-1 – Typical Rolled Multi-Stringer Superstructure with Ends of Partial Length Welded Cover Plates Visible.

3.3.8.4 Steps to Follow When Fatigue Cracks are Observed

Fatigue cracks are most detrimental to the safety and performance of a structure or component when they are orientated in a direction perpendicular to the applied stress. If a crack is detected, the following steps are recommended:

In the field:

1. A sketch and photographs will be prepared so that the crack location, size, and orientation can be evaluated.
2. Determine the locations of the ends of the crack visually. The crack tip will, in general, extend beyond the crack in the paint film and beyond any oxide indication.
3. Examine any other identical details on the bridge. Additional fatigue cracks are likely to occur at any time in similar details at the same relative location within the detail. Those details attached to members located under the most heavily traveled truck lanes will be examined first in multiple girder bridges.
4. When examining other similar details, look carefully for breaks in the paint and the formation of oxide dust at the location where the first crack originated.
5. If a suspect area is located in a detail found in many areas throughout the bridge, a more detailed examination of all such details will be carried out, such as performing magnetic particle

testing, having the paint removed in the area and applying dye penetrant or a visual examination with a 10X power magnifier.

6. If the inspector feels that a crack in a steel member is a critical finding, or if the inspector is uncertain whether a crack is a critical finding, refer to Section 2.14.7 for guidance.

In the office:

1. Evaluate the significance of the crack on the load-carrying capacity of the bridge, considering the crack size, known material characteristics, and temperature. Steel is much more brittle during periods of extreme low temperature, and brittle fracture is more likely to occur in cold weather than during warm weather.
2. If the crack is moving perpendicular to the stress field in the member, it is desirable to arrange to have holes drilled, at the crack ends, immediately. The edge of the holes should be placed at the presumed end of the crack. After holes are drilled, it is desirable to check the hole to ensure that the crack tip has been removed and does not pass through the hole. This is generally a temporary retrofit pending development of a permanent repair.
3. Determine if special nondestructive tests are desirable at other locations (i.e., dye penetrant, mag-particle, ultrasonic testing or a more thorough visual examination).
4. Review results of examination of other locations on the bridge. Determine if a pattern develops related to truck traffic lanes and geometry of the structure.
5. Determine if the crack or cracks have developed from normal fabrication conditions or as result of an unusual flaw.

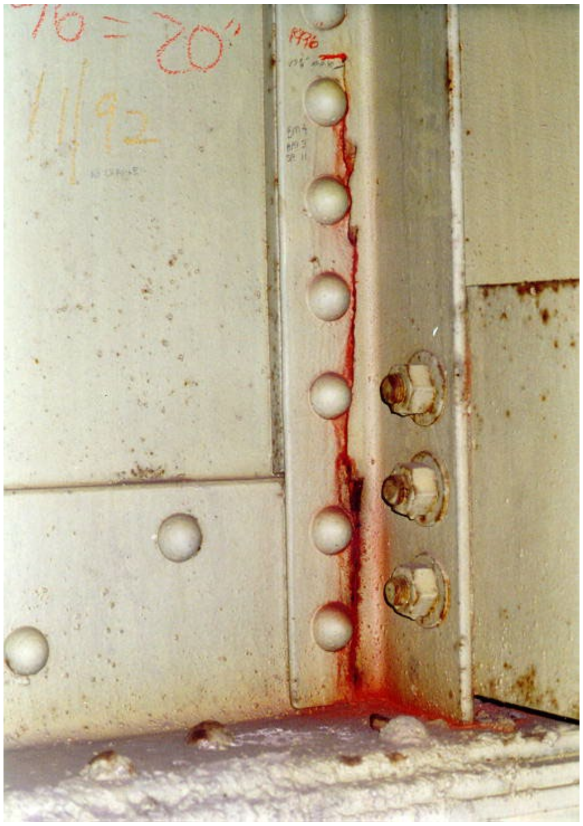


Figure 3.3.8-2 Fatigue Crack in a Diaphragm Connection Angle on a Girder.

Figure 3.3.8-3 Fatigue Crack Through the Bottom Flange of a Rolled Stringer at the End of a Partial Length Welded Cover Plate. A Stop Hole Has Been Drilled in the Web and Splice Plates Have Been Bolted to the Bottom Flange

3.3.9 Steel Girders and Floorbeam Systems

References: BIRM Sections 10.1.5, 10.2, 10.3, and 10.4
MDT Hands on Inspection of Steel Members

3.3.9.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the superstructure in accordance with BIRM Sections 10.1.5, 10.2, 10.3, and 10.4.
- Note that for this type of superstructure, these inspections will typically be performed in conjunction with Fracture Critical Inspections. As such, refer to each structure's Fracture Critical Inspection Plan for inspection procedures, methods, proximity, etc, for the inspection of the various superstructure members. Inspection procedures below are general, but applicable to most members. Also refer to the Fracture Critical Inspection Requirements below for items specific to fracture critical members.
- Suspect areas will be inspected "hands-on" to determine the type and extent of deterioration or deficiency. Use additional light and magnification to evaluate the member if necessary.
- Compression flanges will be inspected for flange buckling due to overloads.

- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and will be inspected closely.
- Webs will be inspected for signs of web crippling (out-of-plane bending) at all support locations. Where visual observation indicates the possibility of distortion in the web, the web will be checked with a plumb bob.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds in the tension zone of the non-fracture critical members will be inspected "hands-on" for fatigue cracks or other defects.
- All suspected cracks will undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of the crack.
- Bolts and rivets will be visually checked for tightness and section loss. Broken paint or bleeding rust around the bolt or rivet may indicate a loose or broken fastener. Suspect fasteners will be tapped with a hammer to confirm their integrity.
- Check the non-fracture critical connections for fatigue cracks due to out-of-plane bending.
- Lateral bracing gusset plate connections in tension zones of non-fracture critical members will be inspected for fatigue cracks due to out-of-plane bending.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected "hands-on" for the presence of similar defects.

Documentation

- Bullets below are for the documentation of all non-Fracture Critical Elements. See Fracture Critical Inspections below for FCM documentation guidance.
- Document the extent and severity of all rusting. Significant loss, whether from past or current rusting, will be noted in sufficient detail for a load rating analysis to be performed. Engineering judgement is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:

  a) Greater than 15% (typically 1/8”) of the flange thickness is lost in areas of high moment.

  b) Greater than 30% (typically 1/8”) of the web thickness is lost in areas of high shear.

  c) Less significant losses (typically <1/8”) will be noted, but exact measurements are not normally required.

- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the steel member, measured from a fixed point (i.e., *12” H x 12” W x 1/8” deep loss on the base of the girder G1, beginning 3’ from the west bearing on the north face of at abutment 2.*) Whenever possible, where deterioration is noted, calipers, D-meters, or other measuring devices will be used to measure the remaining section instead of estimating the loss. Notes will clearly indicate whether an "estimated loss" or measured remaining thickness is being given.
- Note locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the steel members.

- Determine the approximate percentage of bolts/rivets with section losses in the head/bolt and document extent of loss (i.e. *20% of rivets exhibit 10% head loss or all rivets at deck joints exhibit 50% head loss*).
- Document, in the field notes, locations of loose bolts/rivets found and mark locations on the bridge with a permanent marker or lumber crayon along with the date found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with permanent marker or lumber crayon. Note the date found and the extent of the crack in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection will also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether the crack has propagated past the arresting hole.
- Specific care will be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed will be included in the inspection report.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Fracture Critical Inspections

Inspection

- Per the NBIS, Fracture Critical Inspections are to be performed at regular intervals, not exceeding 24 months. However, certain fracture critical members may require an inspection frequency less than 24 months.
- Refer to each bridge's Fracture Critical Inspection Plan for inspection procedures, methods, proximity, etc, for the inspection of the various superstructure members.
- Inspection procedures note above for Initial / Inventory & Routine Inspections, noted above, generally apply.
- If a crack is found in a FCM, NDT will be performed as necessary to find the limits of the cracking and MDT will then be notified immediately from the field. See Section 7.3.3 for additional guidance for what to do when a crack is found.

Documentation

- Document the type, size, and location of all defects along the FCM's on the Fracture Critical Sketches from the Fracture Critical Inspection plan. See Initial / Inventory Inspection bullets above for an example of a defect note with a location call-out. Document the locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the FCM's on the Fracture Critical Sketches.
- The Fracture Critical Inspection Plan and associated Fracture Critical Sketches will be uploaded to the SMS Multimedia Tab.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damaged areas caused from vehicle live loads, will be inspected for tears, distortions, or cracks. Supports, adjacent areas and welds in the vicinity will be inspected for signs of overstress or damage.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Thoroughly document the condition of all damaged members. Any damage along fracture critical members will be noted on the Fracture Critical Sketches.
- Photographs of the damaged areas are required.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.9.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- The inspection reviewer will determine if fatigue problems have been noted and whether patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer will ensure that procedures for reporting critical deficiencies have been initiated, if warranted. Rate of deterioration progression will be determined by comparing present to past inspection reports.
- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note will be placed in the report stating that fatigue problems are evident and that they will be monitored closely.

3.3.9.3 Maintenance Considerations

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a qualified engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation possibly resulting in member failure. Therefore, all cracks found will be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.
- Areas of severe rusting should be cleaned and coated to prevent further deterioration.

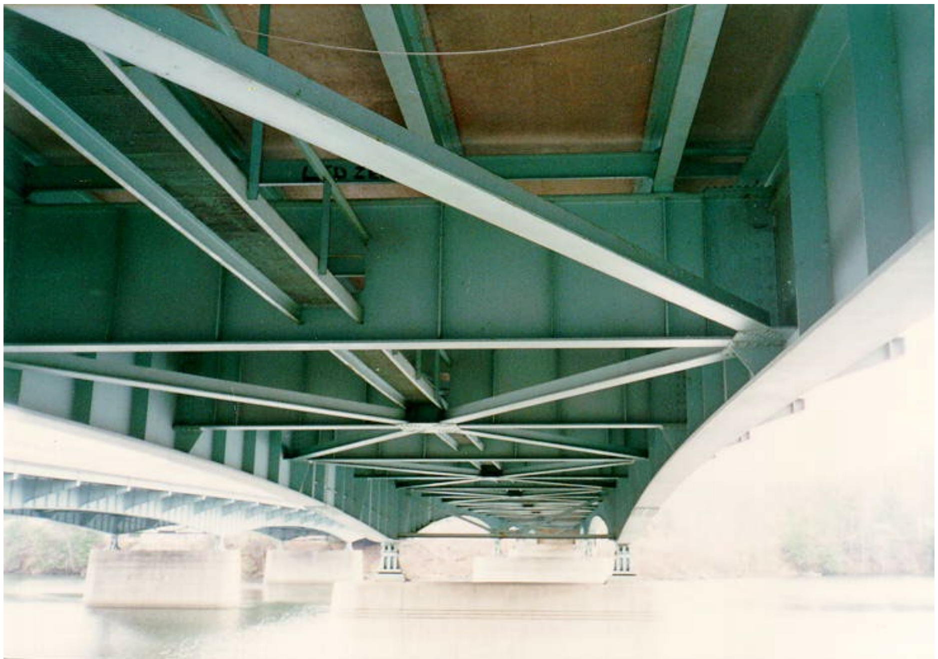


Figure 3.3.9-1 Typical Framing on a Girder-Floorbeam-Stringer Superstructure.

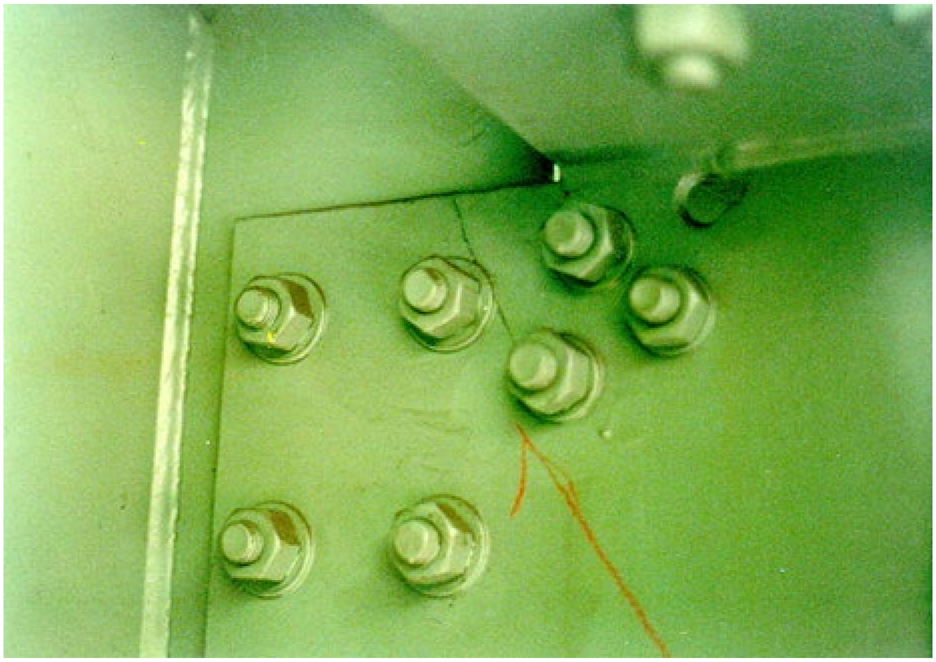


Figure 3.3.9 Fatigue Cracks in the Web of a Floorbeam at the Top Flange Cope. Stopper holes have been drilled and bolts installed in the holes.

3.3.10 Steel Box Girders

References: BIRM Sections 10.1.4, 10.2, 10.3 and 10.4
MDT Hands on Inspection of Steel Members

3.3.10.1 Inspection and Documentation Requirements

Safety Precautions: Inspection of the interiors of box beams requires additional safety precautions:

- Adequate lighting is required along with backup flashlights for emergency use.
- Air quality will be checked before entering the box girder in conformance with Confined Space procedures.
- It is important that at least one (1) crew member remain outside of the box to be able to obtain emergency help if necessary. This person will monitor the inspection progress from the hatch entrance and will not enter the box until help is sent for, and then only if it is safe to do so.
- Many boxes contain dust and pigeon debris. Dust masks will be worn if this material is present during the inspection. If the amount of debris is too great for safe inspection or obscures your vision of the areas to be inspected, then arrangements will be made for Maintenance to clean the box.

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the steel box girders in accordance with BIRM Chapter 10.
- Steel members that are not fracture critical are required to receive a hands-on inspection for their first and second inspections after construction. After the first two inspections, hands-on access may be reduced. Refer to MDT Hands on Inspection of Steel Manual for the inspection frequency table, after which these elements will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, and the defect type/severity.
- Bullets below are for the inspection of all non-Fracture Critical Elements and/or box girder bridges with at least three steel box girders. See Fracture Critical Inspections below for FCM inspection guidance (bridges with only one or two box girders).
- Particular attention will be given to all connections along the box girder, both internal and external.
- The interiors of the box girders will be inspected full length, with sufficient light and visibility to detect hairline cracks greater than1/2" in length in any portion of the box.
- All drain holes in the box beam will be checked to ensure they are clear of debris. All drainpipes that pass through the box girder will be checked to ensure that they are not leaking into the box girder.

Documentation

- Bullets below are for the inspection of all non-Fracture Critical Elements and/or box girder bridges with at least three steel box girders. See Fracture Critical Inspections below for FCM inspection guidance (bridges with only one or two box girders).
- Note any deficiencies or deterioration found. These may be described in narrative form, however, where defects cannot be simply described, sketches will be prepared. Significant deficiencies, such as impact damage, section loss, fatigue cracks, etc., will be located on a framing plan, either sketched or copied from the plans.

- If cracks are detected, at least one sketch and photo will be made of each type found. Other similar cracks can be noted in narrative form. The ends of cracks will be marked for monitoring.
- Note the extent and severity of any rusting. Significant loss, whether from past or current rusting, will be noted in sufficient detail for a load rating analysis to be performed. Engineering judgement is required in the field to determine the significance of areas with loss, but as a guide, specific notes are required when:

    a) Greater than 15% (typically 1/8") of the flange thickness is lost in areas of high moment.

    b) Greater than 30% (typically 1/8") of the web thickness is lost in areas of high shear.

    c) Less significant losses (typically < 1/8") will be noted, but exact measurements are not normally required.

- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the beam measured from a fixed point (i.e. *12" H x 12" W x 1/8" deep loss on girder web at the bottom flange, beginning 3' from the west bearing on girder G1*). Whenever possible, where deterioration is noted, calipers, D-meters or other measuring devices will be used to measure the remaining section instead of estimating the loss. Notes will clearly indicate whether an "estimated loss" or measured remaining thickness is being given.
- Care will be given to documenting increased quantity or size of previously noted deteriorations that have changed since the last inspection. If the condition rating has changed since the last inspection (up or down), a photograph or explanation of why the rating was changed will be included.
- Notes will be made describing the current condition of any item previously discovered and noted for monitoring.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Fracture Critical Inspections

Inspection

- This applies to box girder bridges comprised of one or two box girders.
- Fracture Critical Inspections will be performed per the procedures described in the bridge's custom Fracture Critical Inspection Plan. See Appendix 7A for template.
- Perform "Hands-on" inspection of all fracture critical members on the bridge with the use of visual inspection methods where the inspector is about 24" from the surface. In some cases, supplemental non-destructive inspections may be necessary.
- See Initial / Inventory Inspection guidance above and apply those inspection procedures to FCM's, except that inspection will be hands-on. Use additional light and magnification to evaluate the member if necessary.
- Per the NBIS, Fracture Critical Inspections are to be performed at regular intervals, not exceeding 24 months. However, certain fracture critical members may require an inspection frequency less than 24 months.
- If a crack is found in an FCM, NDT will be performed as necessary to find the limits of the cracking and MDT will then be notified immediately from the field. See Section 7.3.3 for additional guidance for what to do when a crack is found.

Documentation.

- Document the type, size, and location of all defects along the FCM's on the Fracture Critical Sketches from the Fracture Critical Inspection plan. See Initial / Inventory Inspection bullets above for an example of a defect note with a location call-out.
- Document the locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the FCM's on the Fracture Critical Sketches.
- The Fracture Critical Inspection Plan and associated Fracture Critical Sketches will be uploaded to the SMS Multimedia Tab.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage caused by a vehicle collision with a steel box girder, such as gouging or distortion, may require a more involved inspection than damage inflicted by alternate means.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Thoroughly document the condition of all damaged members. Any damage along fracture critical members will be noted on the Fracture Critical Sketches.
- Photographs of the damaged areas are required.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.10.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- Sudden or progressive geometric displacements, loss of greater than 15% of the flange thickness in areas of maximum moment, or loss of greater than 30% of the web thickness in bearing areas may indicate the need for a new load rating analysis and/or posting of the structure for a weight restriction.

3.3.10.3 Maintenance Considerations

- To prevent the intrusion of pigeons and other birds, all hatches should normally be kept closed. All openings large enough to permit the entry of birds should be covered with wire mesh.
- Drain holes should be kept clear to prevent the buildup of water in the boxes. The cause of any leakage into the box girders should be investigated and corrected.
- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a qualified engineer.

- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found will be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.
- Areas of severe rusting should be cleaned and coated to prevent further deterioration.

Figure 3.3.10-1 Curved Steel Box Girder Bridge.

Figure 3.3.10-2 Inside Steel Box Girder.

3.3.11 Trusses and Metal Arch Bridges

References: BIRM Sections 10.1.6, 10.1.7, 10.2, 10.3, and 10.4
MDT Hands on Inspection of Steel Members

3.3.11.1 Inspection and Documentation Requirements

General Inspection:

- General inspection requirements of Trusses and Metal Arches are shown below. Following general inspection procedures below for all the different bridge elements, there are inspection access proximity requirements for Inventory Inspections (non-Fracture Critical), as well as Fracture Critical inspections.
- Note that for these types of superstructure, these inspections will typically be performed in conjunction with Fracture Critical Inspections. As such, refer to each structure's Fracture Critical Inspection Plan for inspection procedures, methods, proximity, etc, for the inspection of the various superstructure members. Inspection procedures below are general, but applicable to most members. Also refer to the Fracture Critical Inspection Requirements below for items specific to fracture critical members.
- Inspect the trusses and metal arches in accordance with BIRM Sections 10.1.6, 10.1.7, 10.2, 10.3, and 10.4.
- All superstructure elements will be accessed from all sides to inspect for corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Emphasis will be placed on truss member connections, areas of maximum moment, maximum shear, maximum axial load, locations of fatigue sensitive details, bearing areas and floor system connections.
- Suspect areas will be inspected hands-on to determine the type and extent of deterioration or deficiency.
- Bolts and rivets will be visually checked for tightness and section loss. Broken paint or bleeding rust around the fastener may indicate a loose or broken fastener. Suspect fasteners will be tapped with a hammer to confirm their integrity.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected hands-on for similar defects.
- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and will be monitored closely.
- All suspected cracks will undergo NDT to confirm their existence and determine the extent of the crack. Mark any cracks on the bridge with a permanent marker or lumber crayon.

Floor System Inspection:

- Girders, floorbeams and stringers that comprise the floor system of trusses, deck arches and through arches will be inspected in accordance with the guidelines outlined in Section 3.3.9 Steel Girder and Floorbeams.

Pin Inspection:

- Pin and hanger details will be inspected in accordance with Section 3.3.2 of this manual.
- Inspect all panel point pins for corrosion, impacted rust and signs of scoring and wear (abrasion dust). Ultrasonic testing will be performed in accordance with Chapter 7 of this manual.
- Inspect spacer plates, nuts, retaining caps, cotter pins and keys for proper positioning, alignment, and installation. Check that pin nuts are fully threaded onto the pins.

- Inspect all pins for signs of rotation. Abrasion dust around the nut or spacer plates is an indicator that rotation occurs. Cracked paint around pin nuts may indicate rotation or may indicate the nut is loose. If this condition is noted, the nut should be tapped with a hammer to determine tightness.

Truss and Metal Arch Tension Member Inspections:

- This section will cover all truss tension members, as well as axially loaded members that are in a constant state of tension in braced ribbed and spandrel braced deck and through arches.
- Members that undergo force reversal will also be inspected as tension members.
- Inspect all tension members for signs of corrosion, section loss, wear, impacted rust, fatigue induced cracks, impact damage, signs of misalignment, debris build up, loose, missing, or deteriorated fasteners, and other deterioration.
- Check alignment of tension members. Buckling or bowing due to causes other than impact, may be indicative of permanent force reversal, and may be caused by settlement, tilting or other displacement of the substructure elements. If bowing or buckling is observed, a thorough investigation as to the causes and effects will be conducted.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds on tension members will be inspected "hands-on" for fatigue cracks or other defects. Particular attention will be placed on inspection of welds that are transverse to the direction of applied stress.
- Inspect counter members to see if they are laterally movable by hand. Counters are designed to be stressed during live load application only. Inability to move counters during dead load application only indicates that unanticipated loads are being applied to the member.
- Inspect counter eyebars within a panel for contact, abrasion dust or wear between the eyebars at the cross over.
- Inspect eyebars for corrosion and cracks along their entire length. Particular attention will be paid to forged joints between rolled bars and their cast eye.
- Inspect threaded rod eyebars and turnbuckles for corrosion, impacted rust, tack welds and cracks. Inspect the threaded portion of the rod for signs that the turnbuckle is loosening.

Truss Compression Member and Metal Arch Rib Inspection:

- This section will cover all truss compression members as well as axially loaded members that are in a constant state of compression in braced ribbed deck and through arches.
- Inspect all compression members for signs of buckling, web crippling, corrosion, section loss, impacted rust, collision damage, wrinkles or waves in flanges, welds, misalignment, debris buildup, loose, missing, or deteriorated fasteners or other deterioration. Buckling, warping, wrinkling, etc., may indicate member overstress. Section loss, tears, misalignment, etc., may result in possible loss of load capacity. Both conditions warrant analysis to determine the effects on the structure.
- Inspect the condition of lacing bars, stay plates and batten plates. Note that the condition of these items will not normally be considered when assigning a condition rating to the compression member. However, if deterioration extends into the compression member base metal or if the alignment of compression member components is affected (impacted rust causing bent flanges, web plates, etc.), sound judgement will be used to determine if and to what extent the condition rating will be adjusted.

- Truss top chord members that are integral with the bridge deck or that support portions of the floor system between panel points, will be inspected as both axially loaded and bending members.
- Inspect all splice plates for loose, missing, or deteriorated fasteners, cracks, and impacted rust.

Gusset Plate Inspection:

- Inspect gusset plates closely for any signs of deterioration (corrosion, impacted rust, distortion, cracking, debris accumulation, etc.).
- Closely inspect the exterior lines of rivets/bolts at right angles to the applied stress.

Spandrel Member Inspection:

- Inspect the spandrel columns for signs of buckling, corrosion, impacted rust at connections, and loose, missing, or deteriorated fasteners.
- Inspect the spandrel columns for fatigue cracks at floorbeam connections.

Cable Hanger Inspection:

- In addition to the inspection requirements of this section, cable hangers will be inspected in accordance with the guidelines given for Truss and Metal Arch Tension Members, and in Chapter 7 for Fracture Critical Members.
- Inspect the cable hangers for corrosion, broken or misaligned wire strands, collision damage, welded attachments, and proper alignment.
- Note locations where superstructure steel, utility supports, or other members are in hard contact with the cable hangers and note the extent of any abrasion caused by this contact.
- Inspect the cable hanger connection details to the truss and floor system or tie girder for fatigue induced cracks, loose, missing, or broken fasteners, misalignment, debris buildup, corrosion, and other deterioration.

Secondary Member Inspection

- Inspect the top chord bracing, bottom chord bracing, floor system lateral bracing, sway bracing and knee braces for cracks, corrosion, impacted rust, loose, missing or deteriorated fasteners, proper alignment, debris buildup, impact damage and other deterioration.

Initial/Inventory Inspection (Non-Fracture Critical Members)

- Steel members that are not fracture critical are required to receive a hands-on inspection for their first and second inspections after construction. After the first two inspections, hands-on access may be reduced. Refer to MDT Hands on Inspection of Steel Manual for the inspection frequency table, after which these elements will be inspected, using the procedures noted above, from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, and the defect type/severity.

Initial/Inventory Documentation (Non-Fracture Critical Members)

- Document all steel losses by noting the area and depth of the loss as well as the relative location along the length of the member measured from a fixed point (i.e., 12” H x 12” W x 1/8” deep loss on the north elevation of the stringer 3 web, starting at the connection to floorbeam 4.

Whenever possible, where deterioration is noted, calipers, D-meters or other measuring devices will be used to measure the remaining section instead of estimating the loss. Notes will clearly indicate whether an "estimated loss" or measured remaining thickness is being given.

- Document the locations and condition of all welded repairs, connections, cover plate ends, utility connections and other miscellaneous welds on all steel members and in tension zones of members.
- Determine and document the approximate percentage of bolts/rivets with section loss in the head/bolt and document the extent of the loss (i.e. 20% of rivets exhibit 10% section loss).
- Document the locations of all loose bolts/rivets and mark locations on the bridge with a permanent marker or lumber crayon along with the date found.
- Document locations and lengths of all cracks found. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection will also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether the crack has propagated past the arresting hole.
- Specific care will be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed will be included in the inspection report.
- The results of all NDT performed will be included in the inspection report.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with section 2.14 of this manual.

Fracture Critical Inspections

Inspection

- Fracture Critical Inspections will be performed per the procedures described in the bridge's custom Fracture Critical Inspection Plan. See Appendix 7A for template.
- Perform "Hands-on" inspection of all fracture critical members on the bridge with the use of visual inspection methods where the inspector is about 24" from the surface. In some cases, supplemental non-destructive inspections may be necessary.
- See General Inspection guidance above and apply those inspection procedures to FCM's, except that inspection will be hands-on. Use additional light and magnification to evaluate the member if necessary.
- Per the NBIS, Fracture Critical Inspections are to be performed at regular intervals, not exceeding 24 months. However, certain fracture critical members may require an inspection frequency less than 24 months.
- If a crack is found in a FCM, NDT will be performed as necessary to find the limits of the cracking and MDT will then be notified immediately from the field. See Section 7.3.3 for additional guidance for what to do when a crack is found.

Documentation

- Document the type, size, and location of all defects along the FCM's on the Fracture Critical Sketches from the Fracture Critical Inspection plan. See Initial / Inventory Inspection bullets above for an example of a defect note with a location call-out.
- Document the locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the FCM's on the Fracture Critical Sketches.
- The Fracture Critical Inspection Plan and associated Fracture Critical Sketches will be uploaded to the SMS Multimedia Tab.

Damage Inspections
Inspection

- Inspection methods will vary depending on the type and severity of damage. Damaged areas caused from vehicle live loads, will be inspected for tears, distortions, or cracks. Supports, adjacent areas and welds in the vicinity will be inspected for signs of overstress or damage.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Thoroughly document the condition of all damaged members. Any damage along fracture critical members will be noted on the Fracture Critical Sketches.
- Photographs of the damaged areas are required.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.11.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- The inspection reviewer will determine if fatigue problems have been noted and whether patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer will ensure that procedures for reporting critical deficiencies have been initiated. Rate of deterioration progression will be determined by comparing present to past inspection reports.
- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note will be placed in the report stating that fatigue problems are evident and that they will be monitored closely.

3.3.11.3 Maintenance Considerations

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a qualified engineer.

- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found will be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.
- Areas of severe rusting should be cleaned and coated to prevent further deterioration.

Figure 3.3.11-1 Historic Steel Through Truss Bridge.

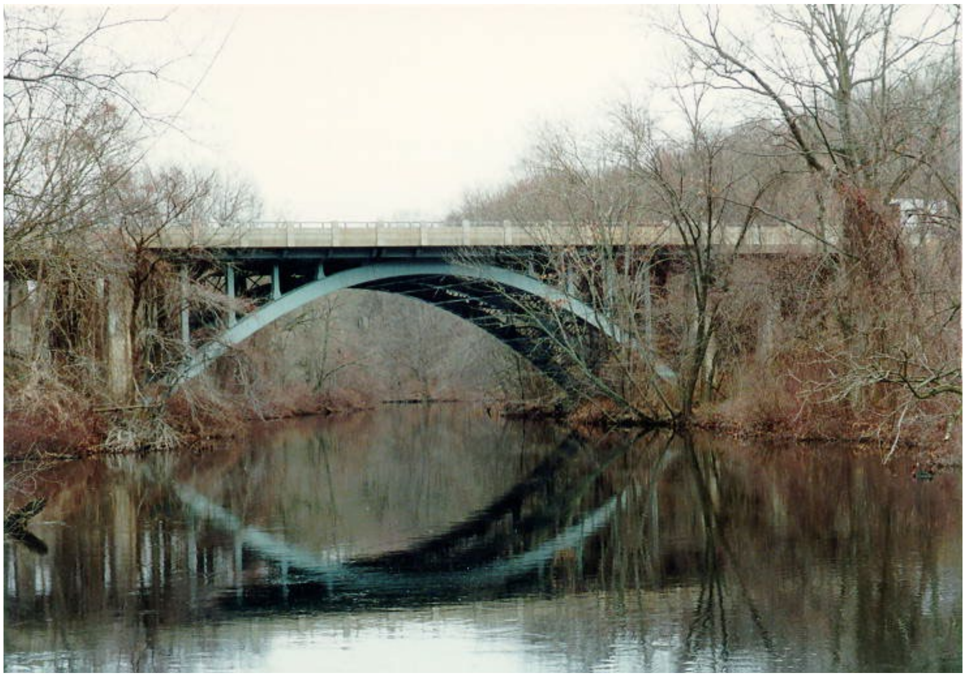


Figure 3.3.11-2 Steel Deck Arch Bridge.

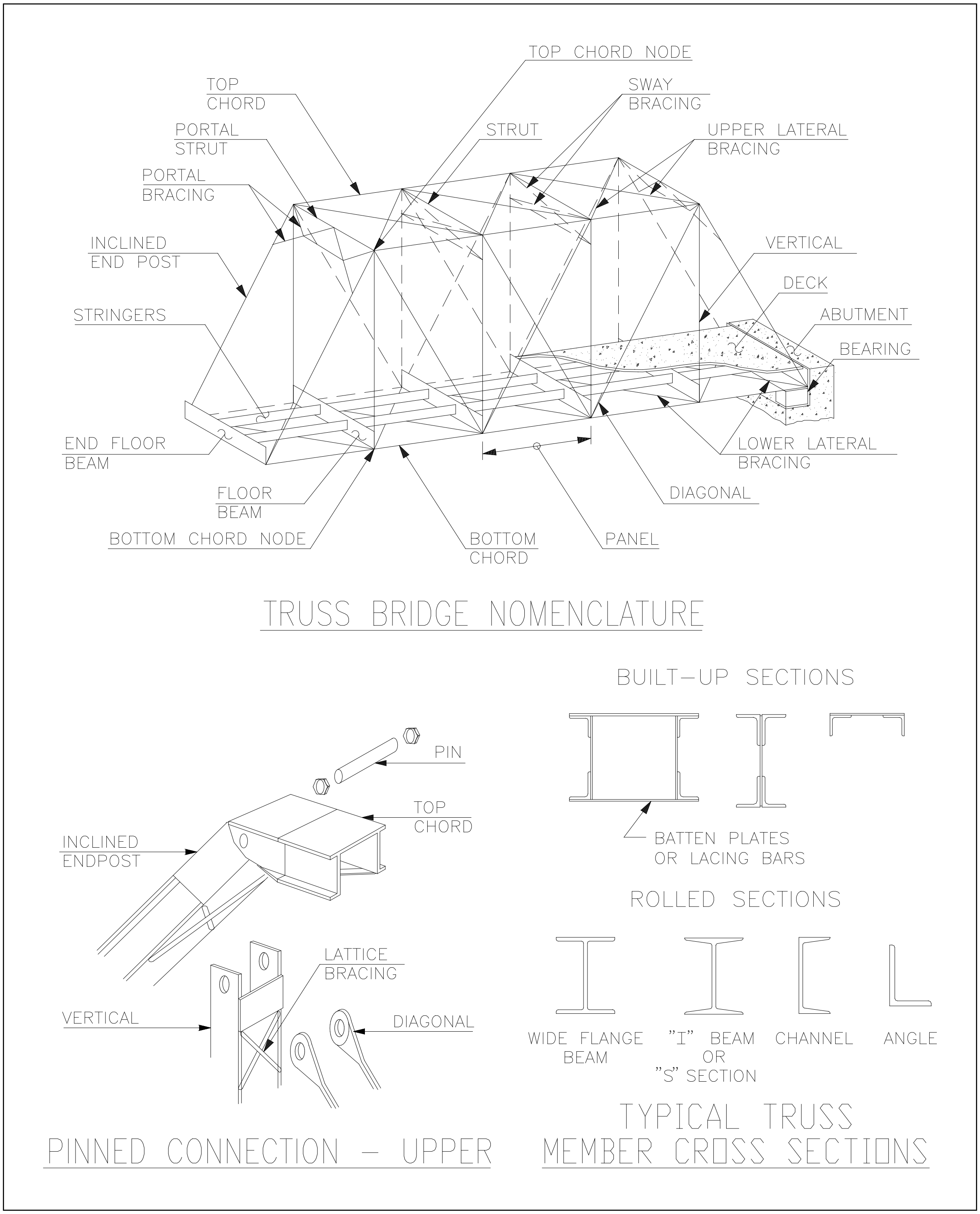


Figure 3.3.11-3 Truss Bridge Nomenclature and Details.

3.3.12 Timber Superstructures

Reference: BIRM Chapter 11, USDA Forest Service Publication "Timber Bridges: Design, Construction, Inspection and Maintenance"

3.3.12.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the timber superstructure in accordance with BIRM Chapter 11.
- The entire superstructure will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Inspect timber members for signs of crushing at bearing areas and at stringer/floorbeam connections. Look for signs of overstress in areas of maximum bending stress, such as cracks extending from the bottom surface of simply supported areas near midspan. Cracks are also commonly seen extending from knots in tension zones.
- Inspect for decay (discoloration, soft spots) and parasite damage at ends of members where dirt, debris, and moisture tend to accumulate and at the superstructure/deck interface. Deteriorated areas may also occur at locations of field constructed connections where the paint or preservative system has been damaged or disrupted. Areas that have evidence of serious deterioration, decay or infestation will be considered for possible further investigation by Non-Destructive Testing (NDT) and Destructive Testing (DT) methods (such as Resistivity Drilling or Increment Boring).
- Hammer tap or probe with a sharp object 25% of all surface areas showing no apparent deterioration to determine soundness of member. *Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in the internal cavities.*
- For localized fire damage, Inspect the fire-damaged areas, removing the charring to reveal the remaining section and expose undamaged wood for defects hidden by charring. Note that if the fire damage is not localized and/or new, a Damage Inspection may be required, and the inspector will consult MDT if uncertain.
- Check for horizontal shear cracks/splits in solid sawn members and delamination between laminas in glue-laminated members. Horizontal shear cracks/splits and delaminations at mid-height of the member are more critical than those nearer the top or bottom surface. Horizontal cracks will cause the member to act as two smaller members, independent of each other, in the vicinity of the crack or delamination.
- Secondary members may be timber or steel members. For timber, check for deterioration, proper fit, cracked or split members and corroded, loose, or missing fasteners. For steel members, check for section loss, loose or missing fasteners, and bowing or buckling of the member.
- Timber members are best connected with seated, bearing type connections. Check bolted, framed, or nailed connections for member deterioration or connection failure.
- Areas on the underside of the deck that are below repaired, or deteriorated areas of the wearing surface or overlay will be inspected "hands-on" to evaluate the condition of the repair or limits of deterioration.
- Check primary members for excessive deflection, sagging and bounce as well as for proper alignment.

- Evaluate the condition and effectiveness of the roof and siding of covered bridges as well as the protective coating (paint or pressure treatment).

Documentation

- Document all deterioration such as debris build-up, fungus growth, parasite infestation, fire damage, impact or collision damage, weathering and warping, splitting, cracking, checking, chemical damage, isolated fire damage, and signs of overstress. All deteriorations noted will include the size and relative location on the member. Where possible, measurements will be taken to determine the remaining effective section of the member.
- Document any horizontal shear cracks, splits, or delaminations in bending members. Note whether the cracks, splits, or delaminations pass entirely or partially through the member and measure the depth of the crack, if possible. Also dimension the height of the member halves above and below the crack, as well as the member base and the amount that the crack has opened.
- A simple framing plan will be provided showing locations of deteriorations and other noted problems. Member elevations and sections will be provided as required to adequately document the deterioration or other problems found.
- Care will be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed since the last inspection, a photograph and explanation of why the rating has changed will accompany the inspection report.
- Notes will be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with Section 2.14 of this manual.

Damage Inspections
Inspection

- Inspection methods will vary depending on the type and severity of damage. For example, the inspection performed in response to a vehicular collision with a timber superstructure might differ from that performed following a fire beneath a timber structure.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Thoroughly document the condition of any superstructure element that has been damaged.
- Photographs of the damaged areas are required, and sketches are required if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closure

3.3.12.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.

- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- Review all field notes to determine if further non-destructive testing and/or destructive testing is warranted.

3.3.12.3 Maintenance Considerations

- The most common type of preventive maintenance for wood structures is to deny the timber food source to any fungi or parasites. This is done through application of preservative treatment, paint, or other protective coatings.
- Pressure treatments typically do not penetrate through the entire cross-section of the member. Therefore, as with non-treated members, interior deterioration due to parasite infestation may still occur despite the solid appearance of the exterior.
- Loose connections may occur due to timber shrinkage, cracking, checking, decay, or crushing around the connector. These connectors may need to be tightened or replaced with larger connectors over time.
- Clean debris to avoid moisture accumulation.
- Cut vegetation from around wet areas and areas prone to debris buildup to better allow air circulation for drying action.

Figure 3.3.12-1 Elevation View of a Solid Sawn Timber Bridge.

Figure 3.3.12-2 Underside View of a Solid Sawn Multi-Beam Timber Bridge.

3.3.13 Stone Masonry Arches

Reference: BIRM Sections 11.2.4 and 11.5.2

3.3.13.1 Inspection and Documentation Requirements

Note: Stone masonry arches may have concrete, stone or other type of construction for the spandrel portion of the arch structure. Spandrels that are comprised of stone masonry will be inspected in accordance with this section. Spandrels constructed of concrete will be inspected according to the guidelines outlined in Section 3.3.5, Concrete Rigid Frames and Closed Spandrel Arches.

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the superstructure in accordance with BIRM Sections 11.2.4 and 11.5
- The entire stone masonry arch superstructure will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity. All problem areas observed will be subsequently inspected "hands-on" to determine the extent of the deterioration.
- Inspect the arch stones for signs of possible failure from any of the following failure modes:
    1. Crushing of stones (See the special note below).
    2. Sliding of one arch stone on another.
    3. Rotation of an arch stone, or series of arch stones, about an edge of a joint creating an opening at the joint.
- Probe areas where joint mortar is missing to determine the average depth of loss and the location of maximum loss.

- Stones adjacent to joints with missing mortar will be inspected for displacement, tilting, cracking, heaving, spalling, and crushing due to the freeze thaw effects of penetrating water and the effects of non-uniform bearing pressure.
- Check stones that have experienced cracking to determine whether the pieces are still in tight contact with the adjacent stones and still providing adequate stability to the arch.
- Where visible, inspect the footing areas for signs of displacement due to the horizontal forces induced by the arching action in the structure.
- Where visible, inspect the extrados area to see if a waterproof membrane is in place and functioning.
- Inspect the arch spandrel walls for distress (large shear cracks initiating from the arch stones) or deterioration (spalls, map cracking, delamination, loss of joint mortar, etc.)
- Check to see if the arch and spandrel walls are plumb. Visually sight along the walls and thru the arch barrel to try to detect bulges or deformations.
- Inspect the roadway for signs of cracking parallel to the center line of the arch as well as sagging and depressions. Also, look for signs that fill or asphalt has been used to level the roadway. This may indicate loss of backfill material.

Documentation

- Document all deficiencies and deteriorations observed. Dimensions will include the length, width, height, depth of loss, orientation, and location relative to a fixed, identifiable point.
- When deficiencies cannot be easily described or if the condition rating is a "4" or less, elevation drawings as well as topside and underside plan drawings will be provided to show the layout of the stone masonry joints and noted deterioration. Sectional views and detail drawings will be provided, as required, to adequately describe the extent of noted deficiencies.
- Note areas of water leakage (infiltration and exfiltration).
- Notes will be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If the condition rating has changed from the previous inspection due to increased quantity or size of deterioration or if the deterioration has been repaired, photographs, documentation, and an explanation of why the condition rating has changed will accompany the inspection report.
- Significant changes in condition state or discovery of critical findings will be documented and reported in accordance with Section 2.14 of this manual.

Underwater Inspections
For portions requiring underwater inspection:

Inspection

- Inspect in accordance with BIRM Chapter 16.2
- The same defects will be inspected for as noted above under “Initial / Inventory Inspections and Routine Inspections”.
- All elements in, or adjacent to, waterways will be checked for the presence of scour and undermining, especially at the interface of the base with earth. Scour will be checked by probing around the entire base of every element exposed to potential scour.
- Debris build-up or aggradation within or near the arch will be noted.

Documentation

- The same defects will be documented as noted above under "Initial / Inventory Inspections and Routine Inspections".
- An aggregate of the above water and below water condition will be considered when evaluating the overall condition rating for the arch.
- Photographs will be taken of any defect causing a condition rating of "4" or less.
- Photographs and/or explanations will also be provided when conditions warrant changing a rating number from a previous inspection (either up or down). Additional consideration will be added to include photographs of, but not limited to, inadequate waterways, ice jams or flows, debris, channel and structure alignment, and riprap conditions.
- Scour will be de documented with an elevation sketch, when required, showing locations of scour with reference to a fixed point on the affected structure.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage. Damage caused from vehicle live loads, such as spalling and missing stones and mortar, may require only a visual examination at one location.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- Thoroughly document the condition of any Masonry element that has been damaged.
- Photographs of the damaged areas are required, and sketches are required if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.3.13.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity, and severity of the deteriorations found support the numerical condition rating given. The reviewer will compare the present inspection report to past reports.
- Crushing or spalling of the arch ring stones may be an indication the stone is being overstressed and is deteriorating. This may be caused by an increased loading condition or a shifting of the neutral axis within the stone. Any arch ring stone crushing warrants monitoring and consideration of more detailed analysis to determine any adverse effects on the integrity of the arch.
- Low condition ratings caused by extensive or widespread deterioration will be reasons to request supplemental testing or analysis to better determine the condition and stability of the stone masonry arch and whether rehabilitation or replacement is warranted.
- The sudden or progressive appearance of cracks or movements in the arch stones may indicate the need for a new load analysis and/or weight restriction of the bridge.

3.3.13.3 Maintenance Considerations

- Arches originally constructed without mortar between the stones ("dry laid") do not need to be pointed. Arches originally constructed with mortared joints, however, should normally have missing or deteriorated mortar repaired.
- The object of joint mortar, when incorporated into the design, is to furnish a cushion for adjacent stones that helps to distribute the pressure uniformly, relieve the stone of transverse stresses and relieve stresses from concentrated crushing pressures to which the projecting points are subjected when in contact with other stones. Therefore, loss of joint mortar can increase the stresses in the stone to the point where crushing or cracking may occur. Lost joint mortar should be replaced.
- Cracks in stones, cracks in joint mortar and openings in joints provide access to water seepage that can further deteriorate the stone or joint through freeze/thaw action or allow exfiltration of fill material. Consider all cracks and joint openings for injection or other repair depending on their location and proximity to the arch ring. Engineering judgement is required prior to conducting repair work to determine the extent and criticality of the problem, effects on public safety and cost/benefit ratio of the repair.

Figure 3.3.13-1 Stone Masonry Arch and Spandrel Wall

3.4 Substructure Inspection

3.4.1 Concrete Substructures

Reference: BIRM Chapter 14

3.4.1.1 Inspection Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the substructure in accordance with BIRM Sections 14.4-14.6.
- The entire substructure will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Substructure elements will be carefully observed for delaminations, spalls, exposed reinforcing, patches, efflorescence, rust staining, cracking, abrasion/wear, settlement, scour (if appliable) and damage from the ground on all sides. Binoculars are acceptable where appropriate (non-critical areas). Areas of noticeable advanced deterioration will be accessed for hands-on inspection.
- A visual inspection is required for all bearing seat areas and the front faces of abutments and piers in the vicinity of bearings. If cracks, delaminations, scale or spalls are observed that potentially reduce the bearing area of any bearing, hands-on access will be required to accurately document dimensions (height, length, width, depth, etc.) of the observed deterioration.
- A visual inspection is required of the faces of pier caps in areas of high tension or shear stresses. If cracks, delaminations, spalls or other indications of overstressing are observed, hands-on access will be required to accurately document dimensions of the observed deterioration.
- Areas of cracks, scale, wetness, efflorescence or rust stains will be sounded with a hammer to determine the integrity of the concrete. Surrounding areas of scale and spalls will be sounded with a hammer to determine, if any; additional limits of delaminated or deteriorate concrete.
- Any exposed reinforcing will be cleaned of corrosion, if any. If section loss has initiated, the remaining diameter will be measured by calipers, or an estimated percentage of section loss will be noted. Weep holes will be inspected for clogs or blockages.
- Concrete protective coatings (oil-based, latex, epoxy, urethanes, etc.) will be inspected for bubbling/cracking/peeling and overall effectiveness.
- Where differential foundation movement (tipping or settlement) of an element is suspected, plumb bob/digital level measurements and joint opening or misalignment measurements will be taken. The location where measurements were taken will be clearly marked (with chisel and paint spot) so that measurements can be made in a similar manner at the same location during follow-up inspections (See Figure 3.4.1-1).
- Exposed concrete footings will be measured to show extent of exposure or undermining.
- Submerged surfaces of substructure elements will be inspected with waders if the water level is less than 2 ft deep, the water is clear enough for visual inspection, and stream flow velocities allow for safe inspection. See Underwater Inspection Chapter 9.
- All substructure elements in, or adjacent to, waterways will be checked for the presence of scour and undermining. Scour will be checked by probing around the entire base of every

element exposed to potential scour. Areas that cannot be accessed with available equipment will be referred for underwater inspection.

- ***Special Note**: After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to a limited degree.*

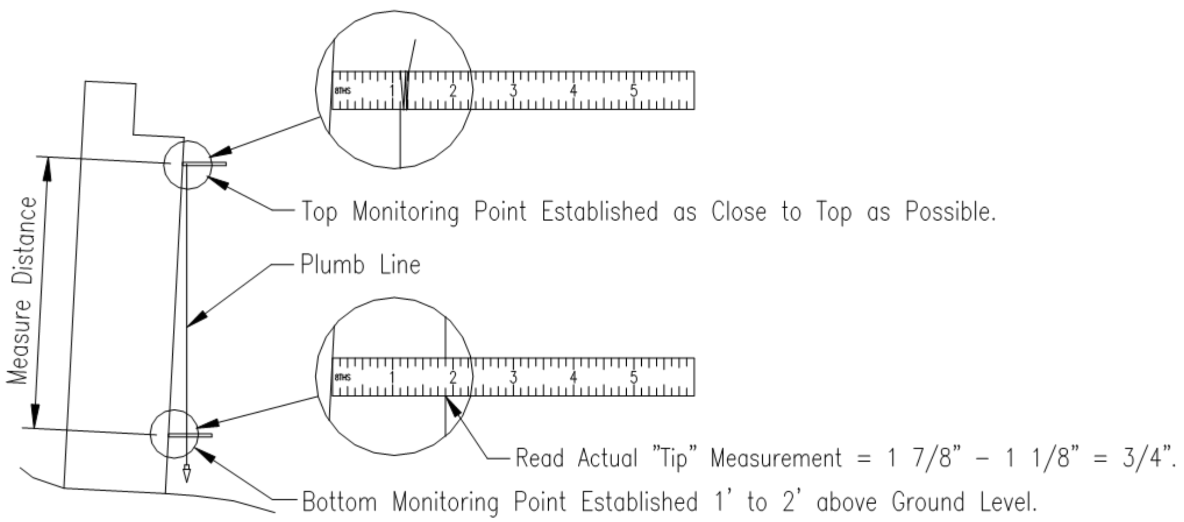


Figure 3.4.1-1 Recommended Method for Measuring Substructure Tipping Using a Plumb Line. ("Hold-Off" Method illustrated for use where face of substructure interferes with free movement of plumb bob)

Documentation

- Field notes must be sufficient to be able to differentiate and divide the defect quantities among the four condition states for every element.
- A narrative description of defects found will be adequate when it is possible to fully describe them. Defects in condition states CS-3 and CS-4 will be described with location referencing a fixed, definable point and will include full defect dimensions (length, width, height, depth of loss, etc.).
- Sketches will be required if any of the following situations exist:
  - An individual substructure unit condition rating is "4" or less or a substructure has greater than 20% of its linear footage in condition state CS-3 or any CS-4.
  - There is 10% loss of bearing area or more due to spalls or scaling (or potential loss).
  - Scour resulting in undermining.
  - The defects found cannot be simply described as to size, orientation, and location.
  - Structural cracks (tension or shear cracks) are found in a pier cap.
- Cracks in reinforced concrete greater than 0.012 inch will be noted.
- Cracks in prestressed concrete greater than 0.004 inch will be noted.
- Concrete protective coatings will be documented for areas of peeling/bubbling/cracking and overall effectiveness.

- If stream scour condition exists that could influence the substructure at some time in the future, a reference will be made to conditions described under Channel & Channel Protection.
- Photographs will be taken of any defect causing a condition rating of "4" or less, and or condition state of CS-3 or CS-4.
- Photographs and/or explanations will also be provided when conditions warrant changing a condition rating or condition state from a previous inspection (either up or down).

Underwater/Probe and Wade Inspections

Inspection

- Inspect the substructure in accordance with BIRM Chapter 14, Sections 14.4-14.6.
- All substructure elements in, or adjacent to, waterways will be checked for the presence of scour and undermining. Scour will be checked by probing around the entire base of every element exposed to potential scour.
- Vertical, horizontal, transverse and/or longitudinal cracks will be measured for length and width. Cracking may be indications of settlement and/or scour.
- Look for abrasion typically at or below the water line, note any exposure of reinforcing and section remaining.
- Debris build-up or aggradation along substructure will be noted.

Documentation

- An aggregate of the above water and below water condition will be considered when evaluating the overall condition rating for Item 60 – Substructure.
- Photographs will be taken of any defect causing a condition rating of "4" or less, and or condition state of CS-3 or CS-4.
- Photographs and/or explanations will also be provided when conditions warrant changing a rating number from a previous inspection (either up or down). Additional consideration will be added to include photographs of, but not limited to, inadequate waterways, ice jams or flows, debris, channel and structure alignment, and riprap conditions.
- Scour will be de documented with an elevation sketch when footings are exposed, showing locations of scour with reference to a fixed point on the affected substructure.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage:
    - Concrete substructure elements damaged by environmental factors (i.e. Earthquakes, flooding etc.) require widespread visual and physical examination for cracks, spalls, delaminations, settlement, and scour.
    - Concrete substructure elements damaged by impact damage requires concentrated visual and physical examination of the damaged element for cracks, spalls, delaminations, alignment, and scour.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will have thorough documentation, including height, length, width, depth, etc. of the condition of any concrete substructure element that has been damaged.
- Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.

3.4.1.2 Report Review

- Findings will be reviewed in accordance with the established Quality Control and Quality Assurance procedures.
- The inspection report reviewer will determine if the pattern, quantity or severity of the deteriorations found support the numerical condition ratings and condition states.
- Verify that critical defects (evidence of movement, presence of scour, structural cracks etc.) have been measured for comparison with previous measurements or that adequate monitoring points have been established. Progression of these defects may be cause for a lower condition rating and condition states and/or the need for stabilization work.
- Bridges with large or ongoing settlement/movement problems will be referred to the Soils and Foundations section for their review.
- Scour problems, other than simple run-off erosion, will be referred to the Hydraulics section for their review.

3.4.1.3 Maintenance Considerations

- Concrete deterioration is most commonly the result of a leaking deck joint or defective drainage system. The cause of the deterioration (joint or drainage) will always be repaired before, or in addition to, any recommended concrete repairs.
- Certain structural cracks may be repaired using chemical repair techniques. Engineering judgement and discussion with the Supervising Engineer are required for specific applications.
- Waterproofing methods can be the best way to prevent or slow the deterioration of reinforced concrete members. Care must be taken in the application of waterproofing systems to ensure that they are not applied in such a way as to prevent entrapped moisture in the concrete from exiting.
- A determination by an Engineer as to what is a structural repair and what is a "cosmetic" or non-essential repair, may help to limit repair quantities to a manageable level. Typically, spalls on massive concrete elements like abutments and solid shaft piers may not need repair if structural reinforcing steel is not exposed and aesthetics are not a concern.
- Repair of scour problems, other than simple run-off erosion, will not be proposed without discussion with the Hydraulics section.
- Addressing movement of substructure elements is normally beyond the scope of maintenance repairs and will require individual attention.
- When removing deteriorated concrete for repair of pier columns, generally the reinforcing steel will not be exposed for more than 6 ft. on one face at a time.

Figure 3.4.1-2 Tall Concrete Pier with Decorative Stone Masonry Facing

3.4.2 Masonry Substructures

Reference: BIRM Chapter 14

3.4.2.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the substructure in accordance with BIRM Section 7.5.6 and Sections 14.4-14.6.
- The entire stone masonry substructure will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Problem areas with potential for CS-4 rating will be inspected hands-on to determine the extent of the deterioration or deficiency.
- Visually inspect the substructure elements for tilting, settlement, rotation, or other movement. If any of the following are noted, further investigation may be warranted:
    - Check to see if the substructure elements are plumb (Note: check to see if the design calls for a battered or sloped face).

- Look to see whether or not the horizontal mortar joints appear parallel with the surface of the water if applicable.
- Look for abutment weepholes, if present, to see if they are clogged. A build-up of water behind the abutments can generate hydrostatic pressures that can cause lateral movement.
- Visually inspect abutments for signs of hydrostatic piping. This is caused when perforated drain pipes or weepholes become clogged, forcing water to seep through the embankment material, under the abutment footing, and discharge through the fill in front, possibly bringing with it sizable amounts of backfill material. Look for deep ruts in the fill in front of the abutment with possible exposure of the footing. The roadway or the approach slab may also show settlement.
- Visually sight along the faces of the substructure elements to try to detect displacement, tilting, settlement or other deformation.
- Look at the masonry stones for vertical splits through several courses of stone in the same general area.
- Evaluate the following items from the bearing, approach and joint inspections that may indirectly indicate substructure movement:

- Gaps between the bearings and the pedestals.
- Positioning of the bearing elements on the pedestals, i.e. longitudinal or transverse misalignment, lack of full contact in the bearing area between the sole plate, bent or broken anchor bolts.
- Vertical misalignment between the approach roadway slab and bridge deck. However, pavement expansion and approach fill expansion could conceivably cause vertical movement in the approach slab.
- Gaps between the superstructure elements and abutment backwalls that are significantly greater or less than the design value or that expected for the ambient temperature.
- If the superstructure end is in contact with the backwall, it may indicate that an abutment is moving.

o ***Special Note***: *If movement of a substructure element occurs, the effects of that movement on bearings, joints, etc., may be visible at adjacent substructure elements, not at the element where the movement occurred. For example, over rotation of rocker bearings at a pier may be caused by movement of an adjacent abutment or pier with fixed bearings.*

- Probe areas where joint mortar is missing to determine the average depth of loss and the location of maximum loss.
- Stones with missing mortar below deck joints will be inspected for displacement, tilting, splitting, heaving, spalling, and crushing due to the freeze thaw effects of penetrating water.
- Check stones that have experienced splitting to determine whether or not the pieces are still in tight contact with the adjacent stones and still providing adequate stability to the substructure element.
- Look for signs of possible failure from crushing. Particular attention will be paid in the vicinity of bearings.

- All substructure elements, in or adjacent to waterways, will be checked for the presence of scour and undermining. Scour will be checked by wading and probing around the entire base of every element exposed to potential scour.
- Submerged surfaces of substructure elements will be inspected with waders if the water level is less than 2 ft deep, the water is clear enough for visual inspection, and stream flow velocities allow for safe inspection. Areas that cannot be accessed with available equipment will be referred for underwater inspection

  - ***<u>Special Note</u>**: After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to a limited degree.*

Documentation

- Field notes must be sufficient to be able to differentiate and divide the defect quantities among the four condition states for every element.
- A narrative description of defects found will be adequate when it is possible to fully describe them. Defects in condition states CS-3 and CS-4 will be described with location referencing a fixed, definable point and will include full defect dimensions (length, width, height, depth of loss, etc.).
- When deficiencies cannot be easily described, the condition rating is a "4" or less, or more than 20% of the substructure is in condition state CS-3 or CS-4, elevation drawings will be provided of the substructure elements to show deteriorations noted. Sectional views and detailed drawings will be provided, if necessary, to adequately describe the extent of noted deficiencies.
- Document areas of water staining and deterioration due to water leakage from deck joints.
- Document all scour as well as areas of exposed footings and undermining of the substructure elements. Depths of scour holes will be measured utilizing probing rods, survey rods, sonic equipment or other measuring device and the presence of any backfilled sediment will be noted.
- Document any impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.
- Document any signs of crushing or splitting of the stones in the area of bearings.
- Notes will be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If the condition rating has changed from the previous inspection due to increased movement or quantity or size of deterioration or if a deteriorated area has been repaired, photographs, documentation and an explanation of why the condition rating has changed will accompany the inspection report.
- Photographs will be taken of any defect causing a condition rating of "4" or less, and or condition state of CS-3 or CS-4.

Underwater/ Probe and Wade Inspections

Inspection

- Inspect the substructure in accordance with BIRM Chapter 14, Section 14.4-6.

- All substructure elements in, or adjacent to, waterways will be checked for the presence of scour and undermining. Scour will be checked by probing around the entire base of every element exposed to potential scour.
- Split stones, spalls and masonry displacement defect dimensions will be measured. Defects may be indications of settlement and/or scour.
- Look for abrasion typically at or below the water line, note any exposure of reinforcing and section remaining.
- Debris build-up or aggradation along substructure will be noted.

Documentation

- An aggregate of the above water and below water condition will be considered when evaluating the overall condition rating for Item 60 – Substructure.
- Photographs will be taken of any defect causing a condition rating of "4" or less, and or condition state of CS-3 or CS-4.
- Photographs and/or explanations will also be provided when conditions warrant changing a rating number from a previous inspection (either up or down). Additional consideration will be added to include photographs of, but not limited to, inadequate waterways, ice jams or flows, debris, Channel and Structure alignment, and riprap conditions.
- Scour will be de documented with cross sections when footings are exposed or undermined, showing locations of scour with reference to a fixed point on the affected substructure. An elevation sketch may also be necessary to describe scour conditions.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage:
    - Masonry substructure elements damaged by environmental factors (i.e. earthquakes, flooding etc.) require widespread visual and physical examination for splits, spalls, displacement, settlement, and scour.
    - Masonry substructure elements damaged by impact require concentrated visual and physical examination of the damaged element for splits, spalls, displacement, and alignment.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will have thorough documentation, including height, length, width, depth, etc. of the condition of any masonry substructure element that has been damaged.
- Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.
- Document any impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- Review the inspection field notes for signs of tilting, displacement, settlement or rotation of any substructure elements. The reviewer will also check for signs of contraction and local scour around substructure elements. If either of these conditions are noted for the first time, or if additional movement or scour is noted from the previous inspection, or if movement or scour is having serious adverse effects on the stability of the substructure element, the reviewer will make recommendations to correct the observed deficiencies.
- Review the inspection field notes for signs of crushing of the substructure stones particularly in the area of bearings that may indicate the stone is being over stressed. If crushing is noted for the first time or if additional crushing is noted from the previous inspection, the reviewer will investigate the need for a revised load rating or make recommendations to correct the observed deficiencies.
- Low condition ratings or condition states that are caused by extensive or widespread deterioration should be reasons to request supplemental testing or analysis to better determine the condition and stability of the substructure element and whether rehabilitation or replacement is warranted.
- The inspection reviewer will determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of cracks or movements in the substructure stones may indicate the need for a new load analysis and/or weight restriction of the bridge structure.

3.4.2.2 Maintenance Considerations

- The purpose of joint mortar, when incorporated into the design, is to furnish a cushion for the stones that helps to distribute the pressure uniformly across the stone surface. It also relieves the stone of transverse stresses and concentrated crushing pressures to which the projecting points are subjected when in contact with other stones. Therefore, loss of joint mortar can increase the stresses in the stone to the point where crushing or splitting may occur. Lost joint mortar will be replaced with an approved material utilizing approved procedures.
- Stone masonry set without mortar (dry laid) does not need to have joints mortared as a maintenance repair. In some cases, to do so may make the situation worse. For example, by preventing water from draining through an abutment, a build-up of hydrostatic pressure behind the abutment may cause tipping.
- Splits in stone, joint mortar breakdown and openings in joints provide access to water seepage that can further deteriorate the stone or mortar joint through freeze/thaw action. Splits and open joints will be considered for sealing, injection or other repair depending on their location and severity. Only splits that are allowing water to enter will be sealed. Splits or mortar breakdown that is allowing water from behind the abutment to exit will not be sealed unless it is determined that this is causing a larger problem. Engineering judgement and discussion is required prior to conducting repair work in order to determine the extent and criticality of the problem, effects on public safety and cost/benefit ratio of the repair.
- Settlement or tipping of substructure elements may be caused by erosion of the foundation material caused by scour. If the waterway at the bridge site has a history of scour problems,

consideration will be given to the design and construction of waterway protection devices such as rip rap, gabions, cofferdams, check dams, etc., to reduce the adverse effects of scour. However, if the bridge is a movable bridge or if a traffic intersection is located at one end of the bridge, movement of the substructure elements may occur due to the longitudinal forces induced by vehicles decelerating and stopping for bridge openings and traffic signals.

- If the substructure elements are regularly impacted by ice and debris, consideration will be given to the design and construction of protection devices to divert or absorb the impact forces. This will have a secondary benefit of moving waterway blockages and turbulence away from the substructure elements. However, this will also require a hydraulic analysis to be sure the hydraulic capacity of the structure is not reduced appreciably.
- All substructure impact protection devices (guardrail, fender system, ice breaker, etc.) will be routinely checked to ensure that adequate protection is maintained. All damaged protection devices will be repaired in a timely manner to maintain the integrity of the system.

Figure 3.4.2-1 Tall Stone Masonry Bridge Abutment with Newer Concrete Wingwall Added.

3.4.3 Timber Substructures

References: BIRM Chapter 14
USDA Forest Service Publication "Timber Bridges: Design, Construction, Inspection and Maintenance”
MDT Timber Bridge Inspection Guide
MDT Timber Element Condition State Guide

3.4.3.1 Inspection Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the timber substructure elements in accordance with BIRM Section 7.4.7 and Sections 14.4-14.6 and the MDT Timber Bridge Inspection Guide.
- The entire substructure will be inspected from a distance that is appropriate to identify and evaluate defects consistently and accurately for weather conditions, light conditions, defect type and severity.
- Areas that appear to have advanced deterioration or signs of stress in critical areas during the visual inspection will be inspected hands-on to determine the type and extent of deterioration or deficiency.
- Check timber members for signs of crushing at timber pile/concrete footing interface (if exposed), pile/bent cap interface, or other bearing areas. Look for buckling, cracking, crushing and other signs of over stress along the length of axially loaded piles and in areas of maximum bending stress on pier bent caps.
- Check for signs of decay and parasite damage of timber piles in areas frequently exposed to wetting/drying cycles. Deterioration may also occur at locations of connections where the paint or preservative system has been damaged or disrupted. Areas that have evidence of serious deterioration, decay or infestation will be considered for further investigation by Nondestructive Testing or Destructive Testing methods (such as Incremental or Resistograph Boring).
- A representative sample of the timber surface area showing no surface deterioration will be hammer tapped or probed with an ice pick in an attempt to locate internal deterioration. If deterioration is found, additional probing will be performed. Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in the internal cavities.
- If timber piles on bridges have been repaired using steel or FRP jacket wraps filled with concrete or epoxy. The FRP jacket wraps will be inspected for cracking and deformations.
- Visually inspect the substructure elements for tilting, settlement, rotation or other movement.

  - ***Special Note****: If movement of a substructure element occurs, the effects of that movement on bearings, joints, etc., may be visible at adjacent substructure elements, not at the element where the movement occurred. For example, over rotation of rocker bearings at a pier may be caused by movement of an adjacent abutment or pier with fixed bearings.*

- Note all fire damaged areas and whether or not the damage is superficial (scorched) or if loss of effective section has occurred. Note the depth of char.
- Check for shear cracks parallel to the longitudinal axis of piles and pier caps. If there are any glue-laminated members (pier caps), look for shear cracks between the laminas. For bending members, horizontal shear cracks will cause the member to split and act as two smaller members, independent of each other. Therefore, horizontal cracks and delaminations at mid-height of the member are more critical than those nearer the top or bottom surface.
- Secondary bracing members may be constructed of timber or steel members. For timber, check for deterioration, proper fit, cracked or split members and corroded, loose or missing fasteners. For steel members, check for section loss, loose or missing fasteners and bowing or buckling of the member.
- Timber members are best connected with seated, bearing type connections. Check bolted, framed, or nailed connections for member deterioration or connection failure.
- Check bent caps for excessive deflection, sagging and vibration as well as for proper alignment.

- All substructure elements, in or adjacent to waterways, will be checked for the presence of scour and undermining. Scour will be checked by wading and probing around the entire base of every element for signs of contraction or local scour.
- Submerged surfaces of substructure elements will be inspected with waders if the water level is less than 2 ft deep, the water is clear enough for visual inspection, and stream flow velocities allow for safe inspection. Areas that cannot be accessed with available equipment will be referred for underwater inspection

Special Note: *After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to a limited degree*.

Documentation

- Field notes must be sufficient to be able to differentiate and divide the defect quantities among the four condition states for every element.
- A narrative description of defects found will be adequate when it is possible to fully describe them. Defects in condition states CS-3 and CS-4 will be described with location referencing a fixed, definable point and will include full defect dimensions (length, width, height, depth of loss, etc.).
- When deficiencies cannot be easily described, the condition rating is a "4" or less, or more than 20% of the substructure is in condition state CS-3 or CS-4, elevation drawings will be provided of the substructure elements to show the layout of the timber substructure and deterioration noted. Sectional views and detailed drawings will be provided, if necessary, to adequately describe the extent of noted deficiencies.
- Document deterioration such as debris build-up, fungus growth, parasite infestation, fire damage, weathering and warping, crushing, splitting, cracking, checking, chemical damage and signs of overstress. All deteriorations noted will include their size and relative location on the member. Where possible, measurements will be taken to determine the remaining effective section on the member.
- Document horizontal cracks, splits, or delaminations in bending members. Note whether or not the cracks, splits, or delaminations pass entirely or partially through the member and measure the depth of the crack, if possible. Dimension the height of the member halves above and below the crack, the member width and the amount the crack has opened.
- Document signs of substructure settlement, tilting or other misalignment and whether or not adverse effects on the superstructure elements were noted.
- Document areas of water staining and deterioration due to water leakage from deck joints.
- Document conditions of contraction and local scour. Depths of scour holes and the presence of backfilled sediment will be noted.
- Document impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.
- Particular care will be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed since the last inspection, a photograph and explanation of why the rating has changed will accompany the inspection report.

- Notes will be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "4" or condition states CS-3 or CS-4 will be photographed.
- Jacketed Timber Piles (steel or FRP) will be documented and quantified.

Underwater Inspections

Inspection

- Inspect the timber substructure in accordance with BIRM Section 7.4.7 and Sections 14.4-6.
- All substructure elements in, or adjacent to, waterways will be checked for the presence of scour and undermining. Scour will be checked by probing around the entire base of every element exposed to potential scour.
- Check for signs of decay and parasite damage of timber piles in areas frequently exposed to wetting/drying cycles. Deterioration may also occur at locations of connections where the paint or preservative system has been damaged or disrupted. Areas that have evidence of serious deterioration, decay or infestation will be considered for further investigation by Nondestructive Testing or Destructive Testing methods (such as Incremental or Resistograph Boring).
- Look for abrasion typically at or below the water line.
- Debris build-up or aggradation along substructure will be noted.

Documentation

- An aggregate of the above water and below water condition will be considered when evaluating the overall condition rating for Item 60 – Substructure.
- Photographs will be taken of any defect causing a condition rating of "4" or less, and or condition state of CS-3 or CS-4.
- Photographs and/or explanations will also be provided when conditions warrant changing a rating number from a previous inspection (either up or down). Additional consideration will be added to include photographs of, but not limited to, inadequate waterways, ice jams or flows, debris, Channel and Structure alignment, and riprap conditions.
- Scour will be de documented with an elevation sketch when footings are exposed or undermined, showing locations of scour with reference to a fixed point on the affected substructure.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage:
    - Timber substructure elements damaged by environmental factors (i.e. earthquakes, flooding etc.) require widespread visual and physical examination for splits, cracks, breaks, alignment, displacement, settlement, and scour. Connections will be inspected and will be in place and functioning as intended.
    - Note all fire damaged areas and whether or not the damage is superficial (scorched) or if loss of effective section has occurred. Note the depth of char.
    - Timber substructure elements damaged by impact damage requires concentrated visual and physical examination of the damaged element for splits, cracks, breaks, alignment, displacement, and settlement.

- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will have thorough documentation, including height, length, width, depth, etc. of the condition of any timber substructure element that has been damaged.
- Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- As stated in Section 2.6.5 of this manual, damage inspections are typically used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.
- Document any impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.

3.4.3.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer will determine if a pattern of deterioration or progressive deterioration is taking place. Progression will be determined by comparing past and present inspection reports.
- Review the inspection field notes for signs of tilting, settlement or scour, splitting, cracking or impact damage. Determine if conditions require additional analysis or immediate repair.
- Low condition ratings that are caused by extensive or widespread deterioration will be reasons to request supplemental nondestructive or destructive testing or analysis to better determine the condition and stability of the substructure element, and whether rehabilitation or replacement is warranted.

3.4.3.3 Maintenance Considerations

- The most common type of preventive maintenance for wood structures is the application of preservative treatment, paint or other protective coatings to protect the timber from fungus or parasites and the elements. Preservative treatment or paint will be applied as required to protect the timber elements. It will be noted that preservative treatments typically do not penetrate through the entire cross-section of the member. Therefore, as with non-treated or painted members, interior deterioration due to parasite infestation may still occur despite the solid appearance of the exterior.
- Loose connections may occur due to timber shrinkage, cracking, checking, decay or crushing around the connector or deterioration of the fastener itself. Loose fasteners will be tightened, and broken, missing or deteriorated fasteners (exhibiting greater than 20% section loss) will be replaced.
- Remove debris to avoid moisture accumulation.
- Cut vegetation from around wet areas and areas prone to debris buildup to allow better air circulation for drying action.
- If the substructure elements have been properly designed and show little deterioration, movement of substructure elements may likely be caused by scour. If substructure elements at

a particular bridge site have a history of, or high susceptibility to the effects of contraction and local scour, consideration will be given to the design and construction of waterway protection devices such as rip rap, gabions, cofferdams, check dams, etc., to reduce the adverse effects of scour.

- If the substructure elements are regularly impacted by ice and debris, consideration will be given to the design and construction of protection devices to divert or absorb the impact forces. This will have a secondary benefit of reducing waterway blockages and turbulence around the substructure elements.
- Substructure impact protection devices (guardrail, fenders, dolphins, ice breakers, etc.) will be routinely checked to ensure adequate protection is maintained. All damaged protection devices will be repaired to maintain the integrity of the system.

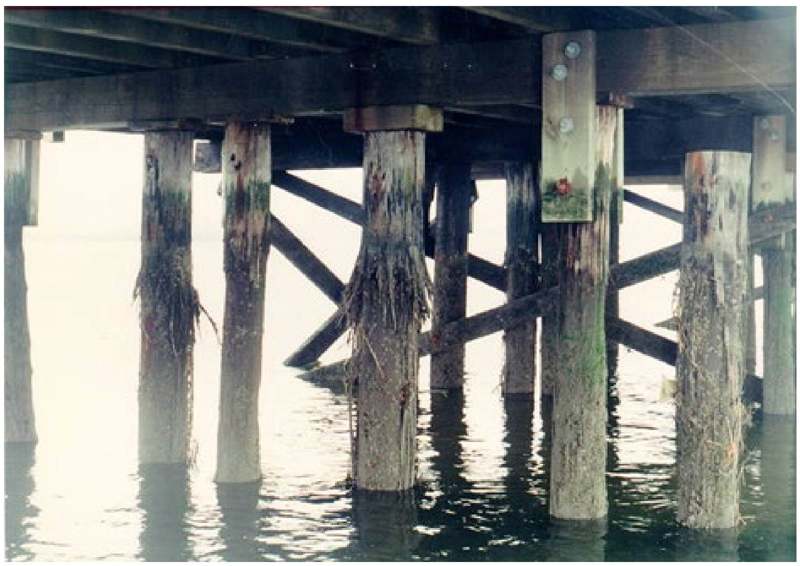


Figure 3.4.3-1 Timber Pile Bent exhibiting Freeze-Thaw Damage above the waterline. Also examples of shims, blocking and splices between the piles and pile cap

3.5 Waterway Inspection

3.5.1 Channel and Channel Protection

The purpose of this section is to describe inspection and documentation methods and procedures for assessing the stability and capacity of a channel under the bridge as well as the effectiveness of any channel or substructure protection provided. This resulting documentation will assist in coding ADE Item 900 – Scour and 901 – Scour Countermeasures as well as the following Federal coding items:

- Item 61 – Channel and Channel Protection
- Item 71 – Waterway Adequacy
- Item 111 – Pier or Abutment Protection and
- Item 113 – Scour Critical Bridges.

It will also provide information for Federal coding of Items 38, 39 and 40 (Navigation Control, Vertical and Horizontal Clearances) when the waterway is navigable.

Chapter 9 has supplemental information and requirements for Underwater Inspection and Probe and Wade Inspections, as well as channel terminology and types and causes of scour.

Scour Appraisals:

Each bridge in Montana over a waterway should have a coding for NBI Item 113 – Scour Critical Bridges. The Multimedia tab in the SMS Hydraulics folder will contain a scour analysis/appraisal, if one has been done. Typically scour appraisals have only been performed in the past when Item 113 was rated lower than 5.

If conditions found in the field do not appear to correlate with the sketches in the Federal Coding Guide for this item (i.e., if Item 113 is coded 8, but footings are exposed), then the inspector will suggest a re-evaluation of the existing scour appraisal or request an initial scour appraisal be performed, if none exists. The request will be in the form of note in the General Notes section of the bridge report in SMS. Any changes will be done by the Bridge Management Engineer.

Reference: BIRM Chapter 16.1

3.5.1.1 Inspection and Documentation Requirements

Initial / Inventory Inspections & Routine Inspections

Pre-Inspection review, preparation and planning are discussed in Section 2.11; however, for channels and waterways it is advisable to obtain as-builts (showing foundation details) and previous cycles of cross-section or bathymetric survey measurements and/or historic information on the channel shape and possible lateral migration. Aerial photos could also reveal this. If it is a navigable waterway (permit required), the plans will also show the minimum vertical and lateral clearances. Plans can also be used to help in calculating the hydraulic opening available.

Inspection

- Inspect the channel and all channel protection devices in accordance with BIRM section 16.1.
- All rip-rap, gabions, spurs, spur dikes and other types of channel and flood plain protection devices will be inspected for signs of joint separation, broken or deteriorated retention cages,

missing or displaced stones, cracked, spalled or deteriorated concrete, impact damage, erosion, loss or lack of vegetated cover, tilting, displacement and other deterioration.

- If the channel is navigable per NBI item 38, protection devices such as timber, rubber, concrete or steel fender systems, dolphins, protective islands, etc., will be inspected for defects or impact damage and evaluated as to their effectiveness in providing adequate impact protection to the bridge structure from marine vessels. Navigation guidance systems (signs, lights, etc.) will be inspected for deteriorated or broken devices.
- Visually evaluate the overall effectiveness of the channel protection devices at redirecting or absorbing the energy of the water flow by estimating the flow velocity (fast or slow) and observing the flow characteristics (calm, turbulent, swirling, above normal flow depths, etc.), upstream, downstream and through the hydraulic opening.
- Look at all rigid protection devices in the channel such as gabions and concrete walls, for signs of local or contraction scour. Inspect non-rigid protection devices such as riprap or earthen dikes, for local scour of the base material (look for sloughing of the construction material) or erosion of the construction material itself.
- Probe all areas of suspected scour to determine the limits of scour.

The problem of accurately determining maximum local scour and rate of change of local scour over time is one of the most difficult aspects of bridge inspection, yet it is one of the most important aspects of evaluating bridge safety. In order to effectively evaluate the scour potential of a structure, it is recommended to look back multiple inspection cycles for evidence of general and contraction scour and any lateral movement of the waterway so that a clearer picture of the extent and rate of scour development can be seen. This is essential to plan the proper maintenance efforts required to arrest current or potential scour damage.

Special Note: *After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to determine actual scour depth.*

- Look for irregularities in the surface slope of the protective devices (dips, depressions, sink holes, etc.), which can be a first indication of erosion or scour of the base material.
- Observe the channel for signs of general scour (degradation) and aggradation.
- Look at the banks of the channel for signs of erosion and sloughing of the bank material or vegetation.
- Site the main channel for misalignment with the bridge substructure elements. If misalignment is observed, estimate the degree of misalignment.
- Look in the channel for debris accumulation from ice, vegetation, etc., that constricts the water flow through the hydraulic opening. This accumulation may accelerate contraction or local scour, due to increased water flow velocity and development of water vortices.
- Look at the channel for signs of lateral movement since previous inspections.

Documentation

- Currently, there is no comment box for Item 61. Channel notes will be located in SMS as follows:

- Channel defects that do not affect the substructure will be documented in the General Notes section of SMS.
- Channel defects that directly affect the substructure, such as scour exposing a footing that should be covered by channel material, will be documented at ADE 900 – Scour. A quantity of (1) each will be used for every affected substructure unit.
- Scour Countermeasures and any associated defects will be noted at ADE 901 – Scour Countermeasures.

- Document defects found in the channel protection devices. A channel sketch showing the defects will be provided when the channel is rated 4 or less.
- Record the general flow characteristics of the channel (fast, slow, high, low, turbulent, etc.), at the time of inspection.
- Record the direction and distribution of the flow between piers and between piers and abutments. For example, which span has the main flow, is the flow impacting the substructure at an angle, is debris causing the flow velocity to increase along a substructure.
- Document all conditions of general, contraction and local scour as well as any signs of undermining of the protective device elements.
- Excessive scour conditions and any undermining conditions causing a safety concern requiring immediate action will be reported as a Critical Finding.
- Depths of all scour holes will be measured utilizing probing rods, survey rods, drop lines or sonic equipment and the presence of any backfilled sediment will be noted. Depths will be documented relative to the natural mudline (average channel bottom), not from the surface of the water.
- Document accumulation of any ice, debris, vegetation, etc., which constricts or disrupts the water flow through the hydraulic opening or around the protection devices.
- Document the presence of sediment buildup immediately downstream of the bridge structure that may indicate the presence of contraction scour.

Underwater (Dive) Inspections

Inspection

- Underwater (diver) inspections will only be required when portions of the substructure are in the waterway and cannot be inspected by wading year-round. If a bridge is not scheduled for an underwater inspection and requires an underwater inspection, do not change the underwater inspection requirements in SMS. Contact the underwater inspection term contract manager to have the bridge added to the underwater list.
- If the high-water conditions are temporary in nature, then it may be possible to perform a "Follow-up" Probe and Wade inspection, in lieu of requesting an Underwater Inspection.
- If the anniversary date for inspection is typically during times of seasonal high water, consider shifting the anniversary date for the inspection to a time of seasonally low water, if possible.
- Inspect the channel and channel protection in accordance with BIRM Section 16.2
- Inspect per the Underwater Inspection requirements in Chapter 9.

Documentation

- Document per the Underwater Inspection requirements in Chapter 9 and also per the above.

Damage Inspections

Inspection

- Inspect the channel and all channel protection devices in accordance with BIRM section 16.1.3.
- Inspection methods will vary depending on the type and severity of damage.
- Channel and channel protection elements damaged by environmental factors (i.e. earthquakes, flooding etc.) require widespread visual and physical inspection for defects such as undermining, settlement, debris blockages, scour and failure.
- The damage inspection will be coordinated between the Team Leader, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will have thorough documentation, including height, length, width, depth, etc. of the condition of any channel or channel protection element that has been damaged.
- Photographs of the damaged areas are required, and sketches are encouraged if text and photos cannot easily convey the scope of the damage.
- Damage inspections may be used in the decision-making process for implementing or lifting emergency load posting restrictions or bridge closures.
- Document any impact damage on the channel and channel protection elements due to ice, debris and marine or vehicular traffic.

3.5.1.2 Report Review

- Review the inspection findings in accordance with established quality control and quality assurance procedures.
- Cross reference the inspection report, inspection field notes, and photographs to ensure they are mutually supportive of their documentation.
- If excessive debris build-up or degradation of the channel is noted, check to see if any adverse effects due to scour were noted in the substructure section of the report.
- Review the inspection report for signs that a pattern of deterioration or progressive deterioration is occurring in the channel or with the channel protection devices. Progression will be determined by comparing present and past inspection reports.
- If the reviewer feels there is progressive scour that could impact the substructure, such as scour exposing a footing, and/or the inspector suggests an initial scour evaluation or reevaluation, then the reviewer will forward a request for this to the Bridge Maintenance Engineer, who will forward to MDT Hydraulics, if appropriate. See 3.5.1 above for examples.

3.5.1.3 Maintenance Considerations

- The inspector will only perform minor maintenance that will facilitate better access and/or allow better visual evaluation of an element, such as:
    - Removing small debris accumulation
- Limit work Candidates/repair suggestions to items that can generally be performed by in-house MDT Maintenance forces, such as:
    - Removing excessive aggradation to facilitate streamflow
    - Adding minor amounts of riprap to protect the substructure

Figure 3.5.1-1 Timber Fender System with Navigation Lights.

Figure 3.5.1-2 Sand Bar and Vegetation Growth in the Channel.

3.5.2 Waterway Adequacy

This section is intended to provide additional guidance based on field observations to properly code NBI Item 71 – Waterway Adequacy.

Reference: BIRM Chapter 16.1

3.5.2.1 Inspection Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection

- Inspect the waterway adequacy in accordance with BIRM section 16.1.
- Observe whether the lowest elevation of any component of the bridge superstructure is higher than the lowest point in the approach roadway. This gives indication that the approach

roadways will be topped by flood water before the bridge superstructure is subjected to lateral forces due to the flood water.

- Observe whether waterborne debris is hung up in the bridge superstructure or around bearings. This indicates that the maximum hydraulic opening has been exceeded or that past flooding has come close to exceeding the maximum hydraulic opening.
- Observe the location of any high-water mark. This may be indicated by displaced vegetation, deposited debris, water staining on the bridge elements, etc.
- Observe whether significant aggregation or degradation has occurred that effects the hydraulic opening of the structure.
- Observe whether the superstructure has moved laterally in the direction of flow on the bearing plates or pedestals. This may indicate displacement during past flood conditions.

Figure 3.5.2-1 Pier Settlement due to Undermining

Documentation

- Update/verify coding for NBI Item 71.

3.6 Culverts

Reference: BIRM Chapter 15

3.6.1 Inspection Requirements

Initial / Inventory Inspections & Routine Inspections

Inspection – Approach Roadway and Embankment

- Inspect Roadways and Embankments in accordance with BIRM Section 15.5.9
- Inspect the roadway for settlement due to culvert flattening, for evidence that the roadway has been patched or otherwise built-up, for cracks running parallel to the culvert centerline and for signs of erosion or failure of the side slope over the culvert. Look for signs of sink holes over the culvert that may be due to exfiltration of the fill material through joints in the culvert.
- Evaluate the approach shoulder profile-and safety features such as guardrails. **These observations will not affect the condition code of the culvert but** will be included in the inspection report.
- Inspect the approach embankments for any conditions that might affect negatively impact the culvert (heavy embankment erosion near barrel ends, trees growing along the embankment whose roots may damage the culvert, etc).

Inspection – Waterway

- Inspect the waterway in accordance with Section 3.5 and Chapter 9.
- Check for changes in stream/culvert horizontal or vertical alignment that might affect the hydraulic adequacy of the culvert or cause scour. Note whether or not the stream bed fluctuates between high and low flow volumes. For example, when looking at the previous report photos, has the amount of channel bed material along the bottom of the culvert changed (culvert bottom was bare previously but is now covered in 6" of bed material). If deposition or removal of stream bed material is apparent, consideration could be given to taking measurement(s) from the channel bed to culvert ceiling at repeatable points within the culvert barrel(s).
- Check for changes in the ground cover or land use that might change the volume of water the culvert must pass within the line of sight while looking upstream and downstream from the culvert inlet/outlet. If the channel bends in the vicinity of the bridge, check upstream/downstream from the bend(s).
- Check for any debris buildup or other obstructions in the waterway upstream and downstream from the culvert and any effects the obstruction is having on the hydraulic adequacy. Check the inlet and outlet for evidence of piping (water flowing under/around, instead of through the pipe).

Inspection – Culvert Barrel and End Treatments

- Inspect in accordance with BIRM Section 15.5
- General:
    - Check the culvert headwall, wingwalls, and end treatments for any material deficiencies/deterioration, undermining, scour, piping, tipping and settlement.
    - Check for any separation and/or misalignment of the culvert at junctions with the headwalls and/or aprons.

- In general terms, inspect the level of channel bed material inside of the culvert (i.e., is it consistent throughout the barrels, are there isolated heavy deposits, is there channel bed material along just one side of the barrel, etc.)

- Concrete:
  - Check the culvert barrel, cut-off wall, and end treatments for material deficiencies such as spalling, exposed rebar, cracking, scaling/abrasion, delaminations, efflorescence, etc.
  - Check for signs of distress/structural cracking (i.e., cracks along the centerline of the barrel roof).
  - Check the culvert barrel for vertical and lateral misalignment along the joints between adjacent precast sections. Also check these joints for differential opening (i.e., wider at the top than bottom).
  - Check for backfill material and/or water passing through the joints between adjacent precast sections.
  - Check any weep holes for functionality/clogging.

- Metal:
  - Check the culvert barrel and end treatments for corrosion and section loss. Section loss on the fill side of the pipe is difficult to detect unless there are visible perforations, so randomly tap the culvert surfaces with a hammer/rod to detect denting which may indicate section loss. Keep in mind that while aluminum doesn't rust, it can exhibit section loss due to the pH level of backfill material and runoff with fertilizer.
  - Intermittently tapping the culvert floor with a hammer or rod will also help detect voids below the pipe floor (possible indication piping or water flowing below the pipe).
  - Check the culvert barrel for deformation. Deformation may be flattening, peaking, creasing, tears or dents due to settlement, loads over time, construction, flood debris, or rocks below the culvert that have slowly deformed the floor. General gradual deformation like settlement may be difficult to quantify, so the inspector may have to quantify this using general terms (i.e. "minor settlement"). Other deformations can be more easily quantified by taking measurements at these locations and also at control points (areas with no visible deformation) between bolt lines, across the spring lines or from floor to ceiling if there is no debris to skew the measurements.
  - Check for cracking in the metal. This are more likely to be found along bolt lines for pipes constructed from several plates. Cracks are also seen at areas of heavy section loss.
  - Check for gaps/separation of the pipe culvert and headwalls. Also check for separations at pipe joints.

Inspection – Aprons, Energy Dissipaters, and Flumes

- Inspect in accordance with BIRM Section 15.5.
- Check the apron, which reduces erosion at the inlet and outlet (typically a concrete slab or rip-rap), for deterioration, missing stones, undermining of slab, movement of stones due to scour and deterioration of the joint between the apron slab and headwall. Deterioration of this allows leakage of water to the soil behind the headwall.

- Check the energy dissipaters, which reduce out flow velocity and downstream erosion (typically rip-rap or concrete basin), for missing stones, movement of stones, scour, undermining, deterioration of the basin and overall effectiveness of the dissipater.
- Check the flumes (typically concrete, bituminous material or rip-rap) for deterioration, erosion, debris and signs of water bypass.

Documentation

- Since there are typically no topside NBEs, BMEs or ADEs for culverts under fill, any significant topside deterioration notes will be placed in the General Notes section of SMS, especially if deteriorations necessitate the generation of a work item (i.e. shoulder erosion that makes guardrail unstable).
- Document culvert deficiencies. Widespread defects can be discussed using general terms (i.e. the culvert walls have surface rust throughout, +/-50% of surface area). Otherwise, defect dimensions will include length, width, height, depth of loss, orientation and location relative to a fixed, easily identifiable point.
- Deformation documentation will include repeatable monitoring measurements at the defect, as well as similar measurements taken at a control point where there is no deformation. This will give the scale of the deformation.
- Document the channel condition in accordance with Section 3.5 and Chapter 9.

Underwater (Dive) Inspections

Inspection

- Inspect the channel in accordance with MDT BIRM Section 3.5, MDT BIRM Chapter 9, and Federal BIRM Chapter 16.2
- Inspect areas of the culvert not accessible via wading, as noted in inspection procedures above for typical biennial inspections (not underwater).

Documentation

- Document the condition of underwater elements using the same procedures as noted in the documentation procedures above for typical biennial inspections (not underwater).
- Document the channel condition in accordance with Section 3.5 and Chapter 9.

Damage Inspections

Inspection

- Inspection methods will vary depending on the type and severity of damage:
    - Culvert elements damaged by environmental factors (i.e. earthquakes, flooding etc.) require widespread visual and physical inspection for defects including, but not limited to displacement, settlement, scour, piping, and debris blockages. Additional defects will be inspected for based on the culvert type.
    - Culvert elements damaged by impact require a concentrated visual and physical inspection based on the element type damaged.
- The damage inspection will be coordinated between the inspector, bridge owner, and any other relevant agencies to determine the scope of damage and planned inspection methods.

Documentation

- The inspection report will have thorough documentation, including height, length, width, depth, etc. of the condition of any element that has been damaged.
- Photographs of the damaged areas are required, and sketches are encouraged if text alone cannot easily convey the scope of the damage.
- Document any impact damage on elements due to ice, debris and marine or vehicular traffic.

3.6.2 Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer will determine if a pattern of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present and past inspection reports.
- Special attention will be given to field note documentation indicating changes in the culvert shape, the presence of scour, piping or other problem that may warrant further investigation.
- Culverts are usually designed to use the vertical and horizontal earth pressures to maintain their stability and increase their live load capacity. Therefore, any change in the "As-Built" condition of the soil surrounding the culvert (addition or removal) will be noted and possibly analyzed for effects on the stability and capacity of the culvert.
- Changes which increase or decrease the depth, velocity or flow direction of the waterway, will be assessed in terms of how they may affect the long-term waterway stability (i.e. lateral movement, aggradation, degradation, etc.) and hydraulic adequacy of the culvert.

3.6.3 Maintenance Considerations

- By the nature of their construction, culverts often constrict the flow of water in the waterway. This constriction increases the potential for waterway blockage with debris and sediment, and increases the probability of scour around the culvert especially if high outlet velocity or high inlet turbulence exist. Therefore, any blockages noted will be removed as soon as possible (during the inspection if possible).
- Culverts typically have steep approach embankments, as well as large, abrupt drop-offs at the culvert crossings. Headwalls and wingwalls may be exposed to traffic presenting collision hazards to passing vehicles. Routine maintenance will include safety considerations (i.e. guardrails) as well as structural and hydraulic considerations.
- The addition of cut-off walls will be considered where "piping" or seepage around the outside of the culvert structure is found or suspected.
- Severely deteriorated culverts may be reviewed for repair by relining the culvert barrel.
- Significant debris will be removed in the vicinity of the bridge and inside the barrels.

Figure 3.6.3-1 Cast-In-Place Concrete Culvert with Erosion at the Outlet.

3.7 Alternative Supplemental Inspection Methods

References: Society of Professional Rope Access Technicians (SPRAT)
International Rope Access Trade Association (IRATA)
Federal Aviation Administration (FAA) - Part 107 Code of Federal Regulations

3.7.1 Alternative Method Overview

When and where approved or directed by MDT, there are two Alternative Supplemental Inspection Methods available for performing bridge inspections. Climbing is the first method and is employed on portions of structures where traditional and typical methods of access, such as aerial lifts, under bridge inspection vehicles (UBIV), boats and ladders, are not practical. This method allows inspectors to access the bridge via climbing techniques in accordance with a certifying body for fall protection and/or two-rope systems. The second method is the use of Unmanned Aircraft Systems (UAS) and can be a useful tool for the inspection of many types of structures for close-up or special inspection of single elements. Use these two methods when traditional methods cannot obtain adequate visual, physical, or non-destructive evaluation access, as required per this Manual and/or the National Bridge Inspection Standards (NBIS). These techniques may also be used where they provide a more-cost effective or safer solution compared to traditional access methods, as long as the quality of the inspection is not compromised.

The following recommendations are not a fully comprehensive list for climbing, rope access, and UAS activities but serve as a basis of understanding to implement these techniques for bridge inspections. It is recommended frequent training occurs and updates to the regulations be checked for compliance within any program.

3.7.2 Climbing Access

Climbing access is an alternative method that an inspector may use to inspect a structure. Climbing access can be broken down into various levels.

- Level A climbing denotes climbing on structures using preinstalled fall arrest systems, such as handrails and safety cables in conjunction with hooks and connectors.
- Level B climbing is limited climbing where the front sternal connection on a Class 3 harness is used to limit the fall potential to the manufacturer's regulations. Pre-rigged rescue systems are recommended.
- Level C climbing includes technical rope access climbing using a two-rope system where advanced training is required.
- Level A and Level B climbing follow the Occupational Hazard and Safety Administration (OSHA) regulations, which is the regulatory body that oversees jobsite safety. Level C climbing typically follows guidelines by the Society of Professional Rope Access Technicians (SPRAT) or International Rope Access Trade Association (IRATA).
- SPRAT and IRATA are the two certifying bodies that currently exist in the United States at the time of this manual update. It is important to take note of what defines rope access.
    - From SPRAT's website "Rope access refers to a set of techniques where ropes and specialized hardware are used as the primary means of providing access and support to workers. Generally, a two-rope system is employed: the working rope supports the worker and the safety rope provides back-up fall protection."
    - From IRATA's Website "International's rope access system is a safe method of working at height where ropes and associated equipment are used to gain access to and from the work position, and to be supported there."

Note that there is often an overlap where Level A and Level B climbing are used in conjunction with Level C climbing, however the training and skills required for Level C extend far beyond the others. Additionally, the bodies that oversee each activity vary greatly. Inspectors are required to be familiar with the rules and regulations of each body and ensure adequate training is obtained prior to performing inspections.

While an inspector can easily use Level A and Level B climbing to gain access to difficult areas, advanced planning and training is still needed to determine how an inspector will self-rescue or be rescued by others in a timely fashion if they should fall. It is not a guarantee that a fire rescue department has the skills and training required to perform these types of rescues. Qualified rescue personnel may have an extended response time, especially in remote areas, and as a result can cause suspension trauma to the inspector.

Unless otherwise noted, follow typical inspection practices and procedures as outlined in this manual such as defect documentation, photography, quality control plan, data entry and reporting.

For simplicity, any use of the term "climbing" in this chapter will refer to all climbing levels unless noted otherwise.

Figure 3.7.2-1 Bridge Inspector Using Climbing Techniques (Level A Climbing)

Figure 3.7.2-2 Bridge Inspector Using Climbing Techniques (Level B Climbing)

Figure 3.7.2-3 Bridge Inspectors using Rope Access Techniques (Level C Climbing)

Evaluate climbing access for general feasibility. Climbing may be advantageous due to the ability to work without traffic lane closures and its versatility in accessing various bridge components. Overall site safety is pertinent to the success of a climbing inspection project. Due to the strenuous nature of climbing, good physical conditioning and recognition of any physical limitations is required of all climbing inspectors.

Proper and careful preparation are essential for a safe climbing inspection. The two primary areas of proper preparation are overall project organization and obtaining the correct inspection equipment.

3.7.2.1 Overall Project Organization

If one does not already exist, develop a detailed inspection plan prior to the inspection date that is unique to each inspection and minimizes climbing time. While this is not an exhaustive list and it is also recommended that Inspectors refer to their certifying body for additional guidance, a detailed inspection plan may include the following items:

- Consideration of inspection type requirements and how the inspection team will meet them. Inspection types include routine, inventory, fracture critical, damage, and special inspections.
- Organizing daily site meetings prior to commencing any work.
- Access and Rescue Plans:
    - Describes how the inspector will access each portion of the structure that needs to be inspected.
    - Describes potential rescue scenarios and evacuation protocols.
    - Discusses communication preferences in the event of a rescue or an evacuation. Communication styles may include radios, whistles, and visual hand signals. Radios are essential for clear communication when an inspector will be climbing away from the group to perform inspection duties. It is also important to establish designated hand

signals to communicate basic messages such as "I am OK" and "I need help". In the event of a radio failure or inability to make visual contact, inspectors will also carry a whistle. It is the responsibility of the inspecting team to associate meaning with number and sequence of whistle blasts. Universally, three whistle blasts are associated with MAYDAY, or "it is time to evacuate the bridge".

- Job Hazard Analysis:
  - Identifies potential hazards an inspector may face based on the environment and type of work being performed.
  - Establishes means and methods to eliminate or reduce hazards.
  - Should be discussed daily and signed by each inspector prior to commencement of work.
- Consideration of special permits, including confined space permits and railroad right-of-way.
- Traffic Control Plan:
  - Consider whether traffic control is necessary to complete the scheduled work. If needed, follow MDT guidance and the guidelines specified in The Manual for Uniform Traffic Control Devices (MUTCD) for all traffic control operations.
  - Level C climbers must mind their ropes while working over or near live traffic to maintain adequate clearance. Low or loose hanging ropes pose a severe threat to the climber if snagged by live traffic.
- Appropriate checklists:
  - Checklists may be helpful to prepare for and execute the inspection plan properly and efficiently.
  - Example checklists, such as the "Access Work Plan" developed by SPRAT, are available on their website under documentations. The Access Work Plan checklist is intended to ensure that the access work plan is in accordance with SPRAT's Safe Practices for Rope Access.

3.7.2.2 Inspection Equipment

Proper inspection equipment is essential to a safe climbing inspection. The equipment list outlined in Chapter 2 is not an exhaustive list. Expand the list as necessary to fit the inspection requirements of the specific bridge when using climbing access. The equipment lists below are also not exhaustive. Reference the certifying or regulatory body under which they are operating to build an appropriate climbing kit.

Basic Personal Protective Equipment (PPE) is required for all climbing inspections. Basic PPE may include the following:

- Helmet
  - Choose a helmet with chin strap that meets the requirements of the American National Standards Institute (ANSI) and specific to the type of work that is being performed. Ensure the helmets fit the inspector in all positions of work, including being inverted.
- Eye protection (safety glasses)

- Appropriate boots
    - While some projects require steel toe boots, it is typically recommended for Level C climbing that a lighter boot be worn as bulky and heavy boots make it challenging to climb and ascend rope. Wear comfortable boots with good traction, especially on steel surfaces.
- Hearing protection
- Tool Tie-offs
    - All tools need to be tied off or tethered when climbing.
    - Frequently check for updates to ANSI requirements such as 121-2018 which is the standard for dropped object prevention solutions for proper and rated tool tie offs.
- Whistle
- Headlamp

A typical kit for Level A climbing may include the following:

- Basic PPE items
- Full body harness and lanyard(s)
- Hooks and connectors

A typical kit for Level B climbing may include the following:

- Basic PPE items
- Class 3 full body harness
- Fall arrest and positioning lanyards
- Hooks and connectors
- Pre-rigged rescue system

A typical kit for Level C climbing may include the following items listed below. Refer to SPRAT and IRATA for detailed lists of recommended rope access gear.

- Basic PPE items
- Knee pads
- Ropes (main line and back-up line):
    - Use kernmantle ropes designed for life safety in rope access inspection. It is ultimately up to the user to select the proper rope that is rated for their desired system safety factor. Each certifying body outlines what the required factor of safety and minimum breaking strength (MBS) of the rope must meet to operate safely.
    - Static and dynamic ropes are the two most common types of kernmantle rope. Static rope is the preferred type of rope as it does not have as much stretch as a dynamic rope would, and most devices used in rope access require static rope. Dynamic ropes are often used when the potential for a fall is higher, the rope is designed to absorb and stretch, thus limiting the forces on the climber.
    - Select the appropriate length rope for the work being performed. This is especially important when preparing for rescue situations as to not delay the care of a fall victim.
- Anchors

- Climbers must ensure that the structure being anchored to is of adequate strength and meets the requirements of their certifying body.

- Class 3 full body harness
- Descender(s)
- Hand Ascender with foot-loop
- Chest Ascender
- Back-up device(s)
- Hooks and connectors
- Rescue equipment

Figure 3.7.2-4 Level C Climbing Kit Example

Care for and store climbing equipment in accordance with the manufacturers' recommendations. Always thoroughly inspect climbing equipment and log use per certifying body's recommendations and requirement of individual companies.

3.7.2.3 Weather

Consider weather conditions when planning for a safe climbing inspection and to maintain safety during a climbing inspection. Moderate temperatures with low wind speeds are desirable for a climbing inspection. Steel surfaces become very slippery when wet, and therefore a steel structure inspection may need to be postponed in the event of rain. Additionally, high winds increase the complexity of a climbing inspection due to the drag on a climber's ropes, the difficulty with positioning and concern over ropes swinging into traffic. Discuss evacuation procedures for severe weather in the project's safety documents.

3.7.2.4 Level C Climbing Certifications

As previously mentioned, there are two main certifying bodies, SPRAT and IRATA, for Level C climbing. Both use a series of certification levels that range from Level 1 to Level 3, with each level requiring more advanced proficiencies in rope access maneuvers, skills, and site supervision. In addition to a written and practical examination, each level requires approved hours of training and field time that prove efficiency in the skills related to the level that the technician is certified to. Time between levels range from 500 hours and 6 months (SPRAT) to 1000 hours and 12 months (IRATA) before advancing to the next level of certification. Ultimately, the level 3 technician is the highest ranking and qualified person on site and is required to oversee the entirety of the access portion of the inspection. Below are the homepage links to both SPRAT and IRATA. While SPRAT and IRATA are the two most common certifying bodies used in the United States, there may be others that exist or come about after this manual is produced.

- SPRAT (https://sprat.org/)
- IRATA (https://irata.org/)

3.7.2.5 Designating a Bridge for Climbing Inspection

The MDT Bridge Inspection Engineer, in coordination with the MDT Bridge Inspections will determine on a case-by-case basis when the use of Climbing access is required on individual bridges. Bridges are generally nominated to MDT Headquarters by District Bridge Inspection Coordinators for climbing inspection access. Factors that are considered in whether to used Climbing access includes, but is not limited to:

- Traffic volume
- Load capacity of the bridge (UBIV too heavy for bridge)
- Bridge type

3.7.3 Unmanned Aerial Systems (UAS)

In scenarios where MDT approves the use of UAS, this equipment may be used to supplement an inspection. Using UAS can significantly cut down on inspection time and therefore increase safety for inspectors. UAS can produce high quality images and videos along bridge elements that can be viewed and inspected for defects in real time and/or reviewed later. Defects noted during UAS inspections may require a "hands-on" follow-up inspection to confirm or determine the extent or severity of the defect using another access method.

Figure 3.7.1-1 A UAS pilot and a sensor operator fly a UAS to collect video on a cable.

3.7.3.1 UAS Safety

Overall site safety is important to the success of an inspection project utilizing UAS. Pilots must be certified and always fly their UAS safely and within the regulations set forth by the Federal Aviation Administration (FAA). It is the responsibility of the pilot to register their UAS, to know the current Part 107 rules, and where it is safe/legal to fly. An electronic copy of the Part 107 Code of Federal Regulations can be found here: https://www.ecfr.gov/cgi-bin/text-idx?SID=795f3720e106147f41212aef340f0d11&mc=true&node=pt14.2.107&rgn=div5

Pilots should refer regularly to the FAA for updated rules and regulations.

The weather is also an important consideration when flying UAS. Pilots must plan accordingly for weather in their area. Most manufacturers list a maximum wind speed for their UAS equipment that should not be exceeded. In windy conditions, even if below the maximum wind ratings, quality of the data collection is typically reduced, and this should be considered by the pilot. Sun angles while collecting photos/video of the structure will be a factor, and the pilot should be aware of camera settings and adjustments that accommodate optimal documentation of the element. Extreme heat and cold can affect battery life and pilot dexterity negatively, so proper cooling/warming measures should be in place for both the batteries and the pilot. Refer to the manufacturer's documentation of the specific UAS being used for operational limits in different weather conditions.

Pilots should assess the risks present with flying a UAS at each site before initiating flight. Risks can include heavy vehicular traffic, pedestrians, power lines, vegetation, line of sight constraints, frequent airspace incursions, etc. Safety and risk mitigation will be part of the site safety plan for each inspection. The pilot will only operate the UAS within their own personal comfort and skill range.

3.7.3.2 UAS Equipment

UAS equipment varies in cost, capabilities, and the quality of data it can collect. Consumer-grade airframes without mechanical zoom lenses can be used for inspection purposes, but depending on the sensor quality, the UAS may need to be 5-10 feet away from the structure to detect a small crack. Professional-grade airframes with enhanced sensor quality and/or zoom lenses can be used for inspections and typically flown at a greater offset distance and still detect a small crack. Quantification of element-level condition states can be performed during the post processing if a known scale (e.g. flange thickness) is observable in the visual data. UAS data collected will be reviewed in more detail after collection to verify the first-person view from the inspector that was done in real-time.

3.7.3.3 UAS Certifications and Pilot Registration

According to the FAA, pilots flying small UAS less than 55 pounds must fly according to the Code of Federal Regulations Part 107 rules. To become a FAA-Certified Remote Pilot, users must learn the rules and pass a knowledge test. The steps and rules are outlined by the FAA here: https://www.faa.gov/uas/commercial_operators/.

Montana is in the process of filling a position for UAS Program Manager and then will develop and implement a UAS policy/manual.

3.7.3.4 Designating a Bridge for UAS inspection

The MDT Bridge Inspection Engineer, in coordination with the MDT Bridge Inspections will determine on a case-by-case basis when the use of UAS is allowed or preferred on individual bridges, similar to the process used to determine when to use climbing assess on a bridge. Considerations include:

- Bridge Type
- Urgency of needed inspection vs the availability of other inspection methods or climbing access Consultants.
- Traffic volume
- Load capacity of the bridge (UBIV too heavy for bridge)

Other requirements for MDT UAS inspections:

- Coordinate any UAS inspections performed using MDT pilots with the MDT *UAS Program Manager* located in the MDT Construction Engineering Services Bureau.
- Requests by or requirements of consultants use of UAS for bridge inspection will be considered and determined by the Bridge Inspection Contract Manager in coordination with the MDT Bridge Inspection Engineer.
- Coordinate all flight requirements and restrictions for Consultant or MDT UAS inspection with the MDT *UAS Program Manager*.

The Montana Unmanned Aerial Systems Council provides recommendations and strategies for the State of Montana to determine the best way to centralize oversight and control UAS. It also provides a central resource for UAS regulations, requirements, and best practices. The council's webpage can be found here: https://www.mdt.mt.gov/pubinvolve/uas/.

The Montana Department of Transportation also hosts a forum for topics relating to UAS. The forum can be found here: https://www.mdt.mt.gov/mdt/uav-forum.shtml.

Chapter 3 Appendices

Appendix 3A
Roadway Clearance Templates

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For One Lane Roadway

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/

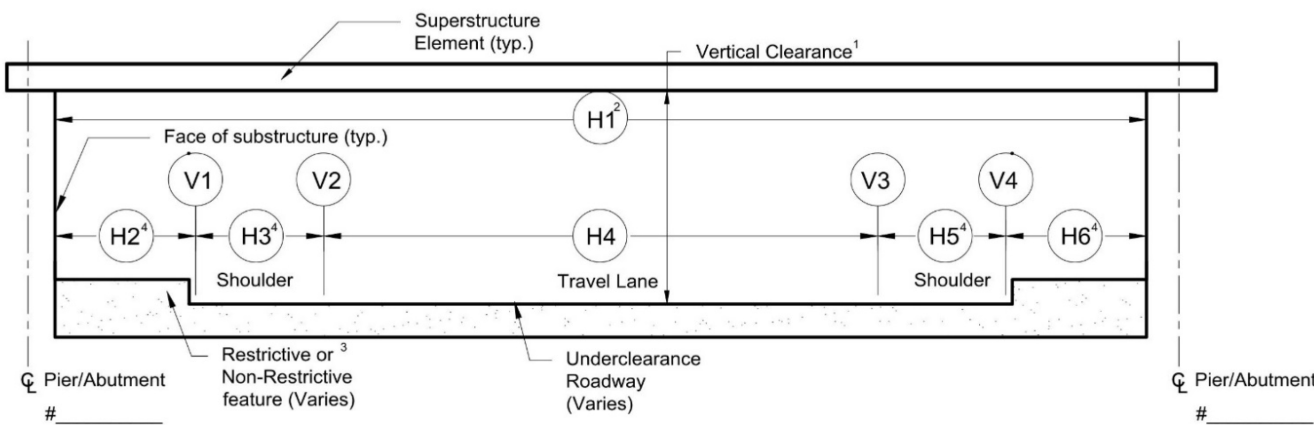
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the roadway. Measure starting at the edge of the roadway near the lowest designated substructure element at the following locations:
   a. At each curb line
   b. At each shoulder line
   c. At each travel lane line
2. If a curb or shoulder line does not exist for the roadway, assume 12' width of lanes.
3. For bridges intersecting a divided highway, use a separate sheet for each direction

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances from the lowest designated substructure at the following locations:
   a. Sidewalk or edge of roadway
   b. Shoulder
   c. Travel lane
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above			
	V1	V2	V3	V4

Elevation	Horizontal Clearances (XX.X') - at Locations Above					
	H1	H2	H3	H4	H5	H6

Notes:

1. Item 10: Code the greatest of the vertical clearances that a 10' wide truck could pass through for the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: Record and code the minimum vertical clearance for the roadway (travel lanes only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the roadway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the roadway.
3. Item 47: Underbridge roadways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.
4. Item 55B/56B: If this form is used for one way roadway. The minimum of the minimum lateral clearances should be recorded.

Additional Inspector Notes:

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For Two Lane Roadway

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/

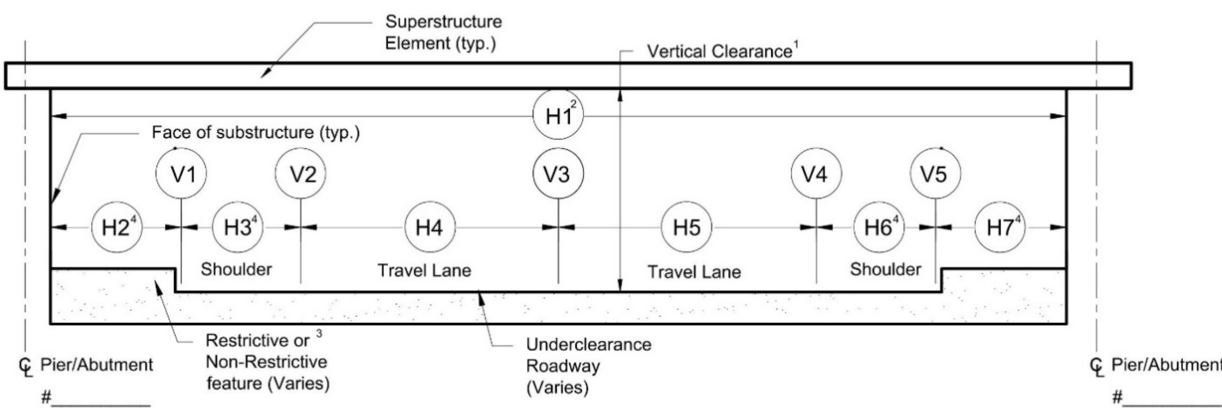
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the roadway. Measure starting at the edge of the roadway near the lowest designated substructure element at the following locations:
   a. At each curb line
   b. At each shoulder line
   c. At each travel lane line
2. If a curb or shoulder line does not exist for the roadway, assume 12' width of lanes.
3. For bridges intersecting a divided highway, use a separate sheet for each direction

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances from the lowest designated substructure at the following locations:
   a. Sidewalk or edge of roadway
   b. Shoulder
   c. Travel lane
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above				
	V1	V2	V3	V4	V5

Elevation	Horizontal Clearances (XX.X') - at Locations Above						
	H1	H2	H3	H4	H5	H6	H7

Notes:

1. Item 10: Code the greatest of the vertical clearances that a 10' wide truck could pass through for the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: Record and code the minimum vertical clearance for the roadway (travel lanes only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the roadway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the roadway.
3. Item 47: Underbridge roadways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.
4. Item 55B/56B: If this form is used for one way roadway. The minimum of the minimum lateral clearances should be recorded.

Additional Inspector Notes:

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For Three Lane Roadway

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/

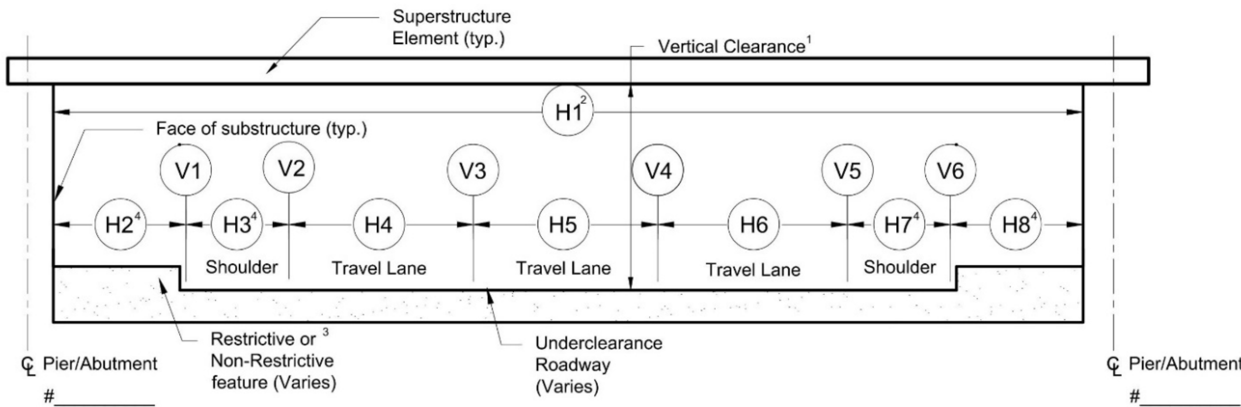
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the roadway. Measure starting at the edge of the roadway near the lowest designated substructure element at the following locations:
   a. At each curb line
   b. At each shoulder line
   c. At each travel lane line
2. If a curb or shoulder line does not exist for the roadway, assume 12' width of lanes.
3. For bridges intersecting a divided highway, use a separate sheet for each direction

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances from the lowest designated substructure at the following locations:
   a. Sidewalk or edge of roadway
   b. Shoulder
   c. Travel lane
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above					
	V1	V2	V3	V4	V5	V6

Elevation	Horizontal Clearances (XX.X') - at Locations Above							
	H1	H2	H3	H4	H5	H6	H7	H8

Notes:

1. Item 10: Code the greatest of the vertical clearances that a 10' wide truck could pass through for the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: Record and code the minimum vertical clearance for the roadway (travel lanes only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the roadway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the roadway.
3. Item 47: Underbridge roadways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.
4. Item 55B/56B: If this form is used for one way roadway. The minimum of the minimum lateral clearances should be recorded.

Additional Inspector Notes:

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For Four Lane Roadway

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/

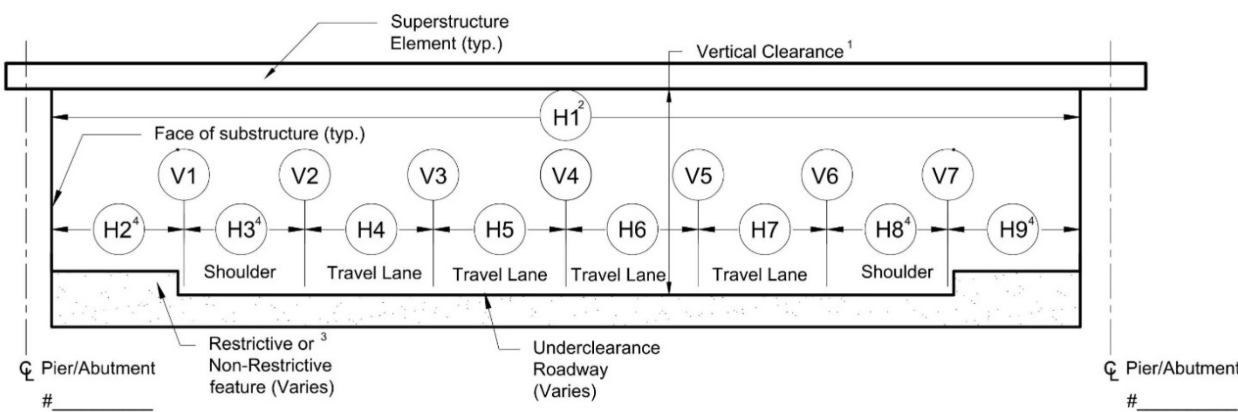
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the roadway. Measure starting at the edge of the roadway near the lowest designated substructure element at the following locations:
   a. At each curb line
   b. At each shoulder line
   c. At each travel lane line
2. If a curb or shoulder line does not exist for the roadway, assume 12' width of lanes.
3. For bridges intersecting a divided highway, use a separate sheet for each direction

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances from the lowest designated substructure at the following locations:
   a. Sidewalk or edge of roadway
   b. Shoulder
   c. Travel lane
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above						
	V1	V2	V3	V4	V5	V6	V7

Elevation	Horizontal Clearances (XX.X') - at Locations Above								
	H1	H2	H3	H4	H5	H6	H7	H8	H9

Notes:

1. Item 10: Code the greatest of the vertical clearances that a 10' wide truck could pass through for the inventory route identified in item 5, whether the route is "on" the structure or "under" the structure. Item 54B: Record and code the minimum vertical clearance for the roadway (travel lanes only). Signage or non-structural features with measured clearances lower than that measured to the controlling superstructure element should also be noted.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the roadway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the roadway.
3. Item 47: Underbridge roadways have varying restrictive (Non-Mountable curbs, slopes steeper than 3:1, Concrete barriers, etc.) and non-restrictive (Mountable curbs, sloped curb, Metal Beam Rails, unpaved areas etc.) features and layouts.
4. Item 55B/56B: If this form is used for one way roadway. The minimum of the minimum lateral clearances should be recorded.

Additional Inspector Notes:

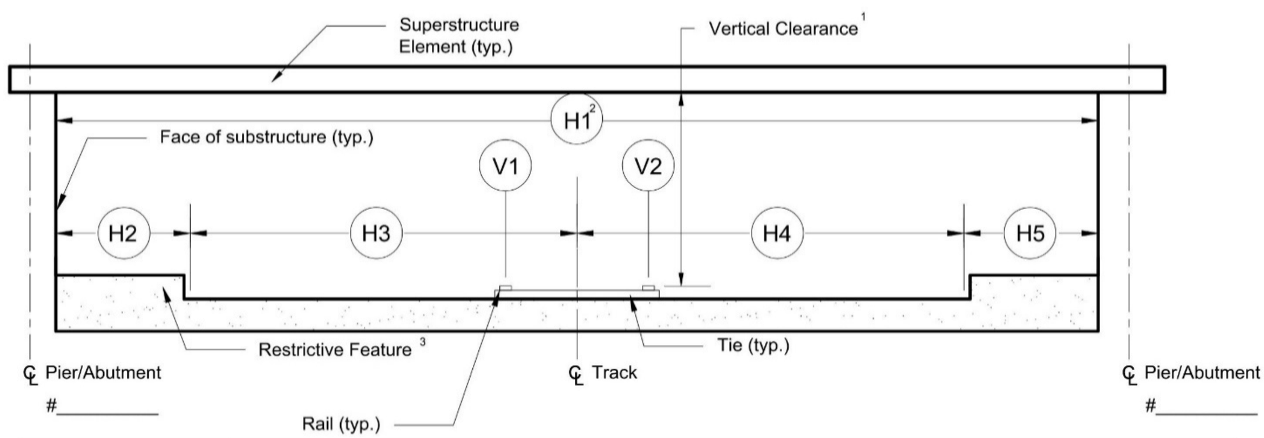
Appendix 3B
Railroad Clearance Templates

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For One Track Railroad

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 55B / 56B:	/ NA

Instructions:
Vertical Clearance Measurements:
1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the Track. Measure starting at the rail near the lowest designated substructure element.
2. For bridges intersecting a divided railway, use a separate sheet for each span.
3. Horizontal Minimum Clearances:
1. Measure and record horizontal minimum clearances between the limits shown below.
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above	
	V1	V2

Elevation	Horizontal Clearances (XX.X') - at Locations Above				
	H1	H2	H3	H4	H5

Notes:
- Item 55B should be the more restrictive horizontal clearance measured from track centerline to restrictive feature.

1. Item 10: Record the lower of the two individual rail clearances. Item 54B: Code the lowest vertical clearance among all of the vertical clearances measured.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the railway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the railway.
3. Restrictive Features would include solid features like walls, structures, or earth slopes which project above the rail bed. If none exist, then code H2 or H5 as 0.0'.

Additional Inspector Notes:

Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For Two Tracks Railroad

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 56B / 55B:	/ NA

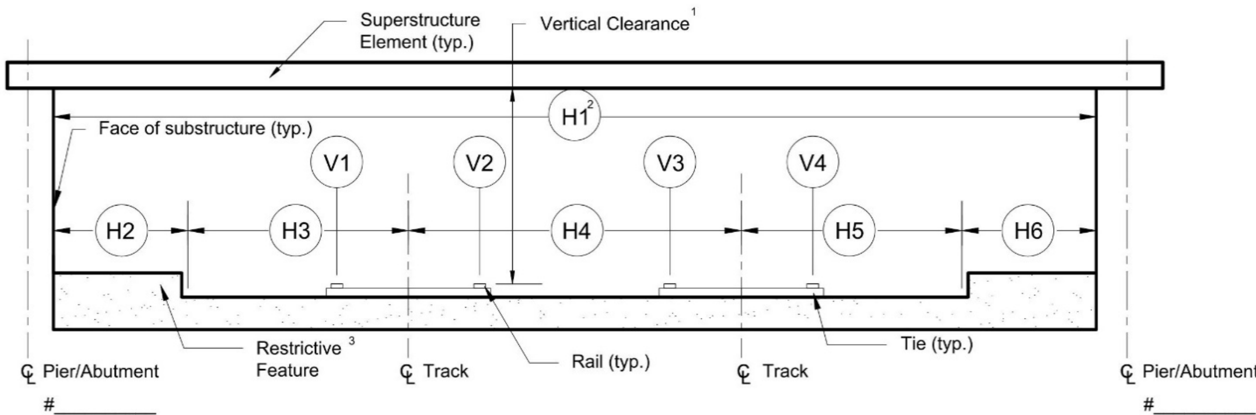
Instructions:

Vertical Clearance Measurements:

1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the Track. Measure starting at the rail near the lowest designated substructure element.
2. For bridges intersecting a divided railway, use a separate sheet for each span.

Horizontal Minimum Clearances:

1. Measure and record horizontal minimum clearances between the limits shown below.
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above			
	V1	V2	V3	V4

Elevation	Horizontal Clearances (XX.X') - at Locations Above					
	H1	H2	H3	H4	H5	H6

Notes:

- Item 55B should be the more restrictive horizontal clearance measured from each outermost track centerline to restrictive feature.

1. Item 10: For the track with the highest clearance, record the lower of the two individual rail clearances. Item 54B: Code the lowest vertical clearance among all of the vertical clearances measured.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the railway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the railway.
3. Restrictive Features would include solid features like walls, structures, or earth slopes which project above the rail bed. If none exist, then code H2 or H6 as 0.0'.

Additional Inspector Notes:

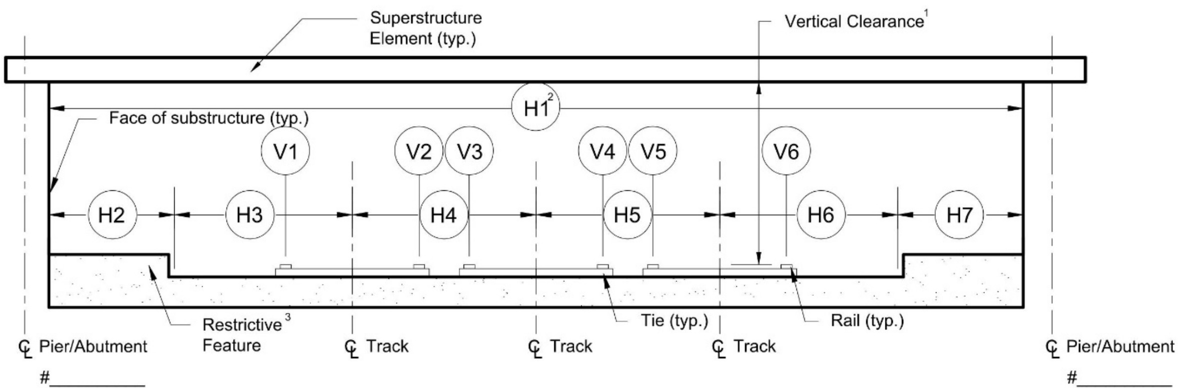
Team Leader	
Inspection Date	
Posted Clearance Height	

BRIDGE CLEARANCES
INVENTORY DATA SHEET
For Three Tracks Railroad

Bridge Number:	
Facility Carried:	
Feature Intersected:	
Span:	
Direction(s) of Travel:	
Item 10:	
Item 47:	
Item 54B:	
Items 56B / 55B:	/ NA

Instructions:
Vertical Clearance Measurements:
1. Measure and record vertical under-clearances to the underside of the bridge facias superstructure element over the Track. Measure starting at the rail near the lowest designated substructure element.
2. For bridges intersecting a divided railway, use a separate sheet for each span.

Horizontal Minimum Clearances:
1. Measure and record horizontal minimum clearances between the limits shown below.
2. Measure total horizontal clearance including reductions due to restrictions as applicable.



Elevation	Vertical Clearances (XX.X') - at Locations Above					
	V1	V2	V3	V4	V5	V6

Elevation	Horizontal Clearances (XX.X') - at Locations Above						
	H1	H2	H3	H4	H5	H6	H7

Notes:
- Item 55B should be the more restrictive horizontal clearance measured from each outermost track centerline to restrictive feature.

1. Item 10: For the track with the highest clearance, record the lower of the two individual rail clearances. Item 54B: Code the lowest vertical clearance among all of the vertical clearances measured.
2. Item 47: The total horizontal clearance is the minimum available clearance between restrictive features parallel to the railway. The total horizontal clearance without restrictions is the measured minimum clearance between substructures parallel to the railway.
3. Restrictive Features would include solid features like walls, structures, or earth slopes which project above the rail bed. If none exist, then code H2 or H7 as 0.0'.

Additional Inspector Notes:

Appendix 3C
Transverse Cracks and Jump Cracks in Concrete Bridge Decks

Defect Discussion

Transverse Cracks & Jump Cracks in Concrete Bridge Decks

Montana Department of Transportation

Bridge Bureau

August 2017

Background

In June of 2016, severe cracking was noted on two relatively new bridge decks, Superior Area Structures –MP 49.397 EB (MDT ID#s: 01358, 01359) and Lozeau-Tarkio Structures –MP 57.472 (MDT ID#s 01367, 01368). The bridges had full deck replacements in 2010 and 2011 respectively. The cracking in both bridges led to full depth holes in the decks. These holes developed relatively rapidly with very little warning compared to typical deck failures that happen on older decks with traditional spalls and delaminations. Additional bridges and bridge decks, many of which are relatively early in their design life, were identified with the same widespread transverse cracking patterns that have the potential to deteriorate and rapidly develop similar deck holes. These decks are being treated with a deck seal to "heal" the cracks and a polymer overlay to cap and protect the surface of the decks.

In April of 2017, Wiss, Janney, Elstner Associates, Inc. (WJE) completed a report on their investigation into these bridge decks. The report can be found at Forensic-Deck-Analysis-Report-2017-04-21. The bridge decks that have been identified with the same transverse cracking patterns are 1 to 9 year old replacement decks over existing superstructures and on complete structure replacements of the same general vintage. The transverse cracks are appearing on both short-span and long-span structures, both steel and prestressed concrete, and includes deck thicknesses ranging from 6½ to 9 inches.

Transverse Cracking

Transverse cracking describes cracks in the bridge deck that are along the transverse dimension of the bridge and occur with regular and repetitive spacing. Generally, the spacing ranges from about 2 to 8 feet between cracks. Transverse cracks are commonly the result of the bridge deck concrete trying to shrink while it cures, dries, and when the temperature decreases. As the concrete shrinks, its length is trying to decrease but is held in place by the connection to the girder. The more the concrete shrinks the more stress builds in the concrete until eventually a weak point will form a crack to relieve the stress and allow the change in length.

Transverse cracks can develop in the first few days after construction and some develop much later after the bridge deck is exposed to traffic. Transverse cracks are typically the full depth of the bridge deck, and most commonly occur directly over transverse reinforcing steel.

Jump Cracks

A jump crack is a semi-longitudinal crack that "jumps" or connects two closely spaced transverse cracks. Jump cracks generally form when two transverse cracks are closely spaced, usually 6 to 24 inches. Jump cracks are usually the full depth of the deck, and may exhibit efflorescence. Jump cracks indicate an advanced stage of deterioration in the deck and are a sign that a hole may soon develop in the bridge deck.

Any delamination or spalling noted in the bridge decks will generally not be associated with the transverse cracking issues. Chaining will not give an indication as to an area that may be a problem, since the cracks are full depth and there is no traditional spalling associated with this issue.

The holes will develop in the areas where the jump cracks create "islands" of concrete. These problem areas occur where the pieces of concrete on either side of the cracks are "working" or moving against each other. This tends to create more cracks in the concrete island and even shears some of the reinforcement because of excessive movement around the cracks. Smaller chunks or "islands" of full depth concrete are then free to fall out, creating full depth deck holes.

One of the best indications of a problem area that is more advanced in its deterioration condition is a change in the efflorescence color on the soffit. If the cracks in and around and "island" of concrete are working and moving, there is usually evidence of excessive of leakage through the cracks and the efflorescence is a grayish color (from the grinding, which creates concrete powder) instead of the normal white in most of the other surrounding cracks.

Inspection

Inspect and document transverse cracks in the deck and any adjoining jump cracks in the concrete deck element transverse pattern cracking defect. Document the typical spacing between the transverse cracks, the typical widths of the transverse cracks, and check to see if the cracks are full depth. Note the size and locations of all jump crack areas, and emphasize areas where heavy and/or grey efflorescence is present, especially if associated with heavy water staining and dense cracking or "islands".

A new defect called Concrete Deck, Transverse Pattern Cracking has been added to SMS. This new defect is attached to the cracking defect for concrete decks, meaning it is always used in conjunction with the concrete deck cracking defect (just like the damage defect must be used in conjunction with another defect). The deck cracking defect can be used without the transverse pattern deck cracking defect if cracking doesn't meet the criteria for transverse pattern cracking, but the transverse pattern cracking defect can never be used without the deck cracking defect.

As always, document conditions with photos. Use the descriptions in the table below to determine the condition state of the defect:

Defect	Concrete Deck, Transverse Pattern Cracking
Condition State	Description
1	No or only short, random "jump" cracks noted.
2	Beginning "jump" cracks. Cracks may be full depth. Minor efflorescence with no gray staining.
3	Narrow jump cracks with concrete islands likely. Most transverse cracks full depth. Efflorescence is present but little to no gray efflorescence.
4	Full depth transverse cracking. Full depth jump cracks, resulting in concrete islands. Possible raveling of closely spaced cracks, especially in "island" areas. Heavy gray colored efflorescence present. Water staining evident from leakage through cracks, especially in island areas. Future deck holes likely or holes repaired by Maintenance are present.

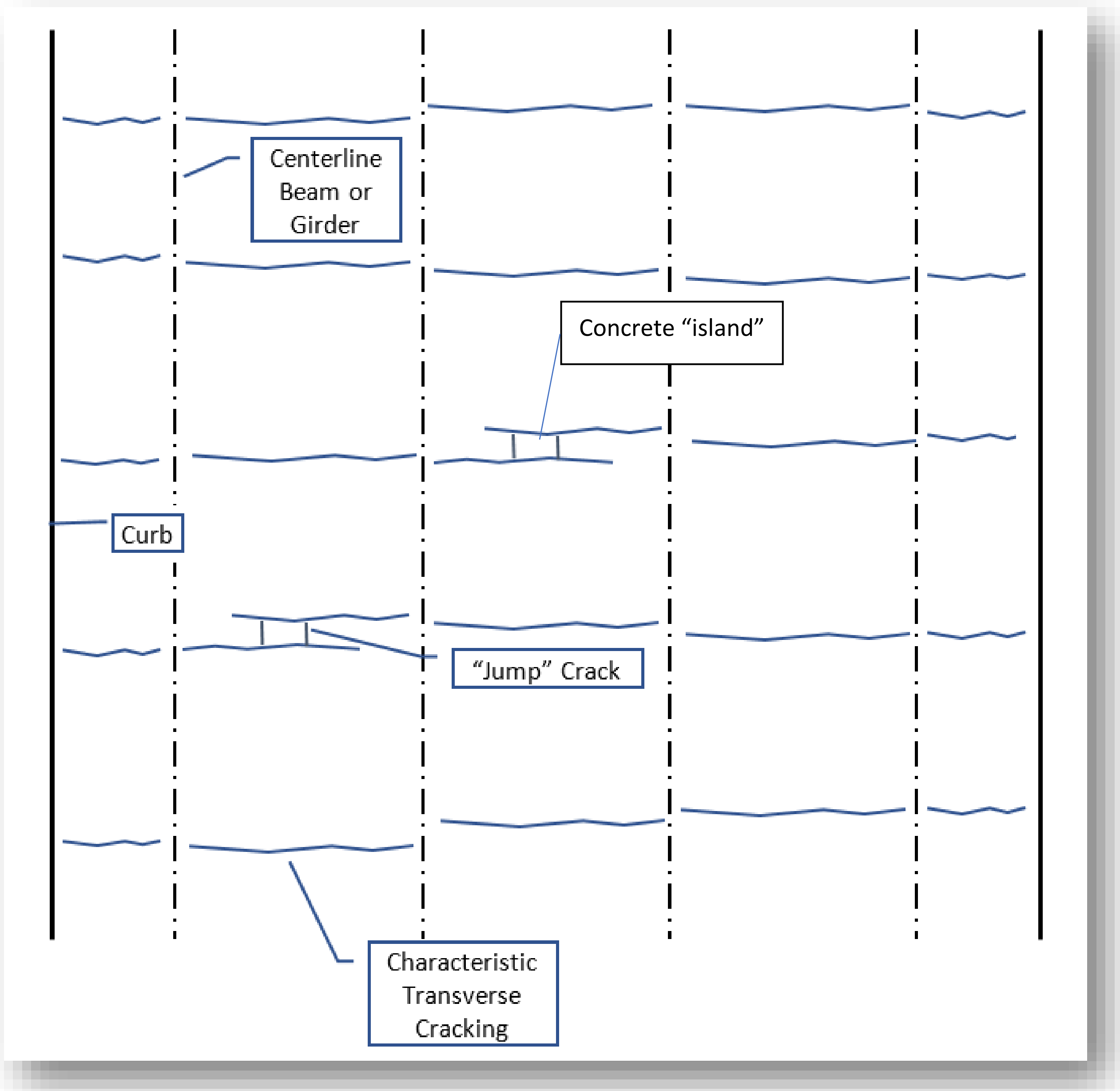


Figure 1. Sketch of Transverse and Jump Cracks

Figure 2. Transverse Cracks in Bridge Deck

Figure 3. Typical Transverse Cracks Seen from Underneath

Figure 4 – Holes in Bridge Deck. Note the longitudinal jump cracks that create the rectangular "island" of concrete. The "island" continued to crack until full depth chunk or "island" fell out, creating the hole.

Figure 5. Same hole as Fig. 4 as seen from Underneath. Note the heavy staining on the soffit and girders from leakage in the cracks around the hole and in nearby transverse cracks. Note, little or no staining in cracks in adjacent girder bay. Note jump cracks with beginning staining at another location not far from the hole.

Figure 6. Example of Heavy staining from water leakage. Note the contrast between the gray efflorescence in the upper 2 transverse cracks (evidence of concrete movement around crack and heavy water leakage) and the white efflorescence in the bottom transverse cracks. Note the longitudinal jump crack with light white efflorescence.

Figure 7. When to not use the transverse pattern cracking defect. Use the deck cracking defect only. Transverse cracking is present but sporadic. Note the wide crack spacing, the lack of staining, and no longitudinal jump cracks. All efflorescence is white.

Figure 8. Example of Condition State 2. Note possible beginning jump cracks

Figure 9. Example of Condition State 3. Note the tight spacing (12” to 18”) of some of the transverse cracks, along with evidence of heavy leakage and some gray efflorescence. Also, small jump cracks evident.

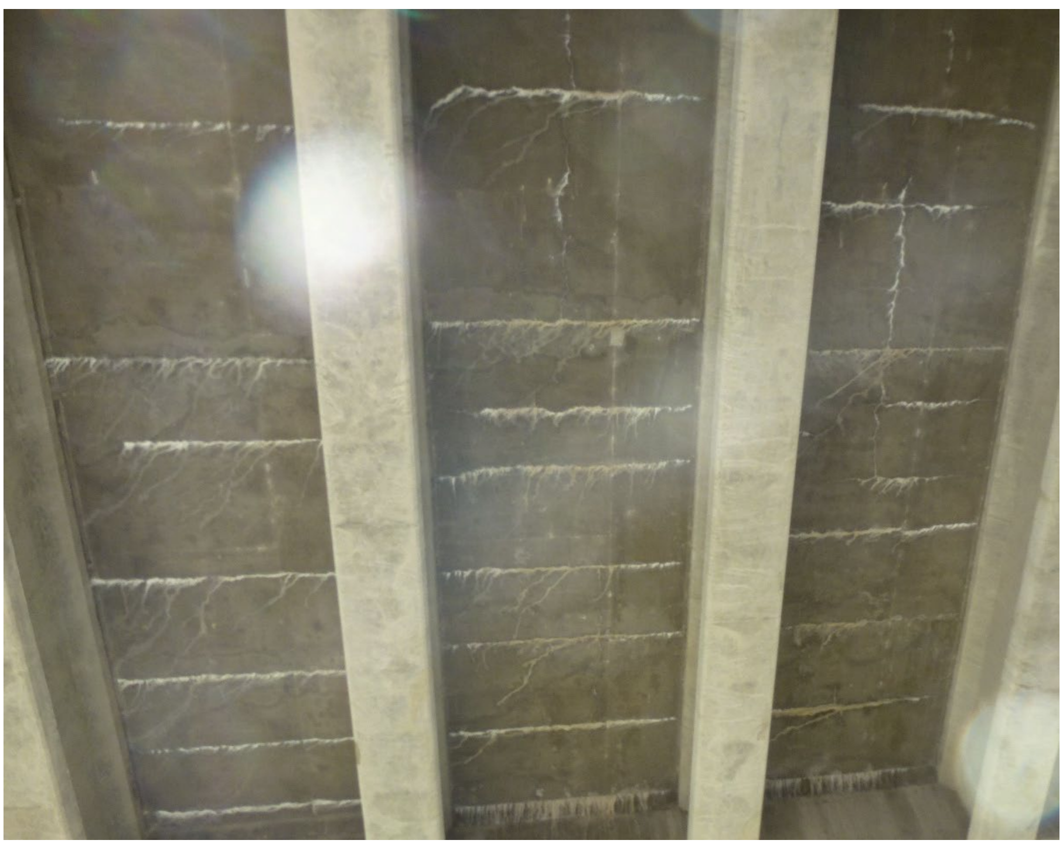


Figure 10. Example of Condition State 3. Tight spacing, jump cracks, some light staining from leakage, and some gray efflorescence.

Figure 11. Example of Condition State 4. Note the tight spacing, multiple jump cracks (some creating the concrete "islands"), very heavy gray staining and efflorescence.

Figure 12. Example of Condition State 4. Tight spacing, jump cracks, “islands”, grey colored efflorescence present, very heavy water staining, repaired hole

Appendix 3D

List of Bridges with Item 113 = “5”

(Over manmade canals with piles in the canal and with unknown foundations)

List of Bridges over Man Made Canals with Unknown Pile Foundations

(Item 113 to be coded "5")

L02090022+07001	BIG HORN CANAL 009	BIG HORN	11M SW ST XAVIER
L02224003+09001	BIGHORN CANAL 018	BIG HORN	3M NE FORT SMITH
L02309001+04001	TWO LEGGIN'S CANAL 015	BIG HORN	3M SW HARDIN
L03026000+09001	IRRIGATION CANAL 015	BLAINE	1M N LOHMAN
L03042002+03001	FT BELKNAP CANAL 008	BLAINE	3M NW CHINOOK
L03051001+05001	IRRIGATION CANAL 012	BLAINE	5M NW CHINOOK
L03051002+00001	FT BELKNAP CANAL 008	BLAINE	5M NW CHINOOK
L03224000+05001	FORT BELKNAP CANAL 026	BLAINE	3M W ZURICH
L11109012+06001	BUFFALO RAPIDS	DAWSON	13M SW GLENDIVE
L11109016+01001	BUFFALO RAPIDS	DAWSON	15M SW GLENDIVE
L11123000+03001	IRRIGATION CANAL 047	DAWSON	12M S GLENDIVE
L18021002+00001	TWO MED IRR CANAL 016	GLACIER	12M SW CUTBANK
L24022006+00001	PABLO CANAL 032	LAKE	2M NW PABLO
L24024003+07001	PABLO CANAL 027	LAKE	5M W PABLO
L24065000+05001	PABLO 3A CANAL 039	LAKE	3M S POLSON
L24352000+02001	PABLO A CANAL 034	LAKE	5M S POLSON
L24623002+03001	PABLO FEEDER CANAL 008	LAKE	2M NW RONAN
L24667000+01001	PABLO FEEDER CANAL 072	LAKE	3M SE POLSON
L24691000+08001	PABLO FEEDER CANAL 024	LAKE	3M NE RONAN
L36051000+05001	DODSON NORTH CANAL 005	PHILLIPS	NW MALTA
L36215003+03001	DODSON SOUTH CANAL 097	PHILLIPS	5M E MALTA
L36235001+07001	DODSON SOUTH CANAL 116	PHILLIPS	6M E MALTA
L36259001+04001	DODSON SOUTH CANAL 117	PHILLIPS	5M E MALTA
L37001003+01001	L Canal	PONDERA	WILLIAMS
L37002003+04001	LAKE FRANCIS CANAL 075	PONDERA	3M SE VALIER
L37003000+03001	C CANAL	PONDERA	3M W VALIER
L37015002+03001	L Canal	PONDERA	WILLIAMS
L37031001+03001	L Canal	PONDERA	4M SE VALIER
L37034002+03001	LAKE FRANCIS CANAL 071	PONDERA	6M SW VALIER
L40108001+04001	BUFFALO RAPIDS	PRAIRIE	3M NE FALLON
L40108003+00001	BUFFALO RAPIDS	PRAIRIE	5M NE FALLON
L40119000+03001	BUFFALO RAPIDS	PRAIRIE	5M NE FALLON
L50166003+06001	SPRING VALLEY CANAL 046	TETON	15M NW FAIRFIELD
L53513028+04001	VANDALIA SOUTH CANAL 089	VALLEY	4M W GLASGOW
M36076000+00101	DODSON SOUTH CANAL 096	PHILLIPS	SW MALTA-9TH ST
M56010000+00701	BBWA CANAL 040	YELLOWSTONE	POLY DRIVE

Appendix 3E
Bridge Rail Protective Coating Quantity Aid

MDT Standard Bridge Rail Protective Coating Quantities

W-Shaped Rails:	SF/LF
- Single W-shaped rail and timber or concrete posts	2.5
- Single W-shaped rail, steel posts; no add'l components (SBBR)	3.5
- Single W-shaped rail, steel posts and 4" diameter hand rail (SBR T4)	5.0
- Single W-shaped rail, steel posts and (2) 4" x 3" backer tubes (T-101)	5.5
- Single W-shaped rail, steel posts and (2) 3.5" diameter backer tubes (SBR T8)	5.5

Square Tubular Rails

- Single 5" x 5" tubular rail and steel posts anchored to curb (SBR T5)	2.5
- Two 4" x 4" tubular rails and steel posts anchored to curb(SBR T6)	4.0

Rectangular Tubular Rails:

- Two steel 6" wide rails and steel posts anchored to curb (W740, W830)	4.0

Picketed Pedestrian rails

- 6" C-shape top/bottom rails, 2" x 2" angle pickets and steel posts (SBR T2/T3)	6.5
- Triple 4" x 4" tubular rails, 1.5" x 3/4" C-shaped pickets and steel posts (SBR T7)	8.0

Note: Multiply the bridge rail NBE original quantity x the proper factor noted above to calculate the square footage for the bridge railing protective coating. Use judgement for bridge railing types not listed above.

Chapter 4 - Agency Defined Elements

DETAILED ELEMENT DESCRIPTIONS

This Chapter contains all of MDT's Agency Defined Elements (ADEs) to track the condition of different types of reinforcement and submerged and miscellaneous elements. The elements are organized by major groupings such as Decks and Slabs, Superstructure, Substructure, Other and Off-Bridge elements. Each element has a detailed element description which is broken down into three subsections:

1. **Description**—Detailed identification and classification of the element, including units of measurement, and guidelines on how to collect the quantity of the element in a consistent manner.
2. **Condition State Definition Table**—Defect descriptions and severity, with guidelines to the inspector for determining defect severity.
3. **Element Commentary**—Additional considerations for the inspector to be aware of during data collection.

For condition coding guidance for the National Bridge Elements (NBEs) and the Bridge Management Elements (BMEs) reference and use the latest version of the AASHTO Manual for Bridge Element Inspection (MBEI). These AASHTO NBE and BME tables were previously provided within this BIRM in Chapters 3 through 6; however, since they are updated regularly by AASHTO and should not be changed by owners, thus they are no longer included within this manual.

4.1 Decks, Slabs, Top Flanges and Related ADEs

4.1.1 Element 39—Prestressed Concrete Slab

Description: All prestressed concrete bridge slabs regardless of the wearing surface or protection systems used.

Classification: ADE **Units of Measurement:** ft^2

Quantity Calculation: Area of the deck from edge to edge, including any median areas and accounting for any flares or ramps present.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Exposed Prestressing (1100)	None.	Present without section loss.	Present with section loss but does not warrant structural eview.	
Cracking (PSC) (1110)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map)cracking.	Wide cracks or heavy pattern (map) cracking.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

The slab evaluation is three-dimensional in nature with the defects observed on the top surface, bottom surface, edges, or all; and being captured using the defined condition states. Slab top or bottom surfaces that are not visible for inspection shall be assessed based on the available visible surface. If both top and bottom surfaces are not visible, the condition shall be assessed based on destructive and nondestructive testing or indicators in the materials covering the surfaces.

The inspector should use judgement when utilizing the condition state defect definitions, especially for prestressed concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation, and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, prestressed concrete cracks less than 0.004 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.004 to 0.009 inches can be considered moderate, and cracks greater than 0.009 inches can be considered wide.

4.1.2 Element 990—Concrete Reinforcing Protective System

Description: All types of metallic reinforcing systems other than carbon steel.

Classification: ADE **Units of Measurement:** ft^2

Quantity Calculation: Should include the entire surface of the protected element.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Effectiveness—Protective System (3600)	Fully effective.	Substantially effective.	Limited effectiveness.	The protective system has failed or is no longer effective.
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This protection system element is intended to capture situations where the concrete element may be expected to deteriorate at a rate that is slower than unprotected situations. This protective system includes metallic systems that do not include standard carbon steel reinforcing. Solid stainless steel, aluminum or other metallic systems are included in this element. Wearing surfaces are addressed under the appropriate wearing surface element and not this element.

4.1.3 Element 991—Corrosion Resistant Reinforcing Protective System

Description: All types of non-metallic reinforcing systems.

Classification: ADE **Units of Measurement:** ft^2

Quantity Calculation: Should include the entire surface of the protected element.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Effectiveness—Protective System (3600)	Fully effective.	Substantially effective.	Limited effectiveness.	The protective system has failed or is no longer effective.
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This protection system element is intended to capture situations where the concrete element may be expected to deteriorate at a rate that is slower than unprotected situations. This protective system includes non-metallic reinforcing systems such as glass, basalt or carbon fiber. Wearing surfaces are addressed under the appropriate wearing surface element and not this element.

4.2 Superstructure ADEs

4.2.1 Element 810—Steel Transverse Girder

Description: All steel girders not including floor beams that are mounted transversely on columns and support longitudinal girders, regardless of protective system.

Classification: ADE **Units of Measurement**: ft

Quantity Calculation: Sum of all the lengths of each rolled, built-up or box girder assembly, measured along the skew.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Condition evaluation for this element includes all visible faces of the girder(s). This element is considered fracture critical.

4.2.2 Element 811—Prestressed Concrete Transverse Girder

Description: All pretensioned or post-tensioned concrete girders that are not concrete caps and are mounted transversely on columns and support longitudinal girders, regardless of protective system.

Classification: ADE **Units of Measurement**: ft

Quantity Calculation: Sum of all lengths of each girder measured along the skew.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Exposed Prestressing (1100)	None.	Present without section loss.	Present with section loss but does not warrant structural review.	
Cracking (PSC) (1110)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, prestressed concrete cracks less than 0.004 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.004 to 0.009 inches can be considered moderate, and cracks greater than 0.009 inches can be considered wide.

4.2.3 Element 812—Other Transverse Girder

Description: All other material girders that are mounted transversely on columns and support longitudinal girders, regardless of protection system.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of all the lengths of each girder.

Condition State Definitions

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

The other material open girder is intended for transverse girders constructed of composite materials, or other materials that cannot be classified using any other defined transverse girder element.

4.2.4 Element 815—Steel Railroad Car Girder

Description: All steel railroad car girders regardless of protective system.

Classification: ADE **Units of Measurement**: ft

Quantity Calculation: Sum of all the lengths of each railroad car girder.

Condition State Definitions

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Condition evaluation for this element includes the car floor (deck) condition as well as the structural components underneath that comprise the total girder construction.

4.2.5 Element 820—Steel Vertical Cross Frame

Description: Steel cross frame elements that are sway frames on through trusses, regardless of protective system.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of all the lengths of each cross frame measured along the skew.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element may be comprised of single or multiple, built up steel sections for each cross frame. There will generally be a cross frame at every panel point as well as portal frames. Sway bracing between the cross frames is not included in the quantity.

4.2.6 Element 821—Steel Curved Girder Diaphragm

Description: All diaphragms on a steel curved girder system regardless of protective system.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of all the lengths of each diaphragm measured perpendicular to the radius of the curved girder or along the skew as required.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element may be a solid rolled section or a built-up space frame section. Condition evaluation for this element includes the web face and the top and bottom faces of the flange for the rolled sections or all faces of the space frame components, including the connection plates.

4.2.7 Element 825—Post Tensioning Anchor

Description: All exposed post tensioning anchor ends in prestressed concrete box and slab sections, timber slabs and post tensioned concrete such as prestressed concrete transverse girders and decks regardless of protective system.

Classification: ADE **Units of Measurement**: Each

Quantity Calculation: The sum of individual anchor ends.

Condition State Definitions

<table>
<tr><th rowspan="3">Defects</th><th colspan="4">Condition States</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th>GOOD</th><th>FAIR</th><th>POOR</th><th>SEVERE</th></tr>
<tr><td>Corrosion
(1000)</td><td>None.</td><td>Freckled rust. Corrosion of the steel has initiated.</td><td>Section loss is evident or pack rust is present but does not warrant structural review.</td><td rowspan="2">The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.</td></tr>
<tr><td>Cracking
(1010)</td><td>None</td><td>Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.</td><td>Identified crack that is not arrested but does not warrant structural review.</td></tr>
<tr><td>Damage
(7000)</td><td>Not applicable.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.</td></tr>
</table>

Element Commentary

None.

4.3 Substructure ADEs

4.3.1 Element 855—Timber Pile Cap/Footing

Description: Timber pile caps/footings that may be placed under one or more piles for element stabilization. To evaluate timber pile caps/footings under the water surface use element 271, Submerged Pile Cap/Footing. For all timber pile caps/footings above the water surface regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the length of the pile cap/footing measured along the skew angle of the pier or bent.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

None.

4.3.2 Element 860—Submerged Steel Column

Description: All steel columns accessible for inspection under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement**: each

Quantity Calculation: Sum of the number of submerged columns that are accessible for inpsection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested by does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
				The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.3 Element 861—Submerged Prestressed Concrete Column

Description: Prestressed concrete columns that accessible for inspection that are under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of submerged columns accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Exposed Prestressing (1100)	None.	Present without section loss.	Present with section loss but does not warrant structural review.	
Cracking (PSC) (1110)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.004 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.004 to 0.009 inches can be considered moderate, and cracks greater than 0.009 inches can be considered wide.

4.3.4 Element 862—Submerged Reinforced Concrete Column

Description: All reinforced concrete columns accessible for inspection that are under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the submerged columns accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide

4.3.5 Element 863—Submerged Timber Column

Description: All timber columns accessible for inspection that are under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Number of columns accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
~~Scour (6000)~~ Use Scour Element 900	~~None.~~	~~Exists within tolerable limits or has been arrested with effective countermeasures.~~	~~Exceeds tolerable limits but is less than the critical limits determined by scour evaluation and does not warrant structural review.~~	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.6 Element 864—Other Submerged Column

Description: All other material columns accessible for inspection that are under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of columns accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) Cracking.	Wide cracks or heavy pattern (map) cracking.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The other material column is intended for columns constructed of composite materials, or other materials that cannot be classified using any other defined column elements.

4.3.7 Element 870—Submerged Reinforced Concrete Pier Wall

Description: Reinforced concrete pier walls accessible for inspection that are under the water surface at the time of inspection regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the lengths of the pier walls measured along the skew angle and accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide.

4.3.8 Element 871—Submerged Timber Pier Wall

Description: Those timber pier walls that include pile, timber sheet material, and filler. For all pier walls accessible for inspection that are under the water surface at the time of inspection, regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the length of the pier walls accessible for inspection measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.9 Element 872—Submerged Masonry Pier Wall

Description: Those pier walls constructed of block or stone. The block or stone may be placed with or without mortar. For all masonry pier walls accessible for inspection that are under the water surface at the time of inspection, regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the wall lengths accessible for inspection measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Efflorescence/Rust Staining (1120) Patched Area (1080)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Mortar Breakdown (Masonry) (1610)	None.	Cracking or voids in less than 10% of joints.	Cracking or voids in 10% or more of the joints.	
Split/Spall (Masonry) (1620)	None.	Block or stone has split or spalled with no shifting.	Block or stone has split or spalled with shifting but does not warrant a structural review.	
Patched Area (Masonry) (1630)	None.	Sound patch.	Unsound patch.	
Masonry Displacement (1640)	None.	Block or stone has shifted slightly out of alignment.	Block or stone has shifted significantly out of alignment or is missing but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.10 Element 873—Other Submerged Pier Wall

Description: Those pier walls constructed of other materials accessible for inspection that are under the water surface at the time of inspection regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the number of the pier walls accessible for inspection measured along the skew.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking	Width greater than 0.05 in. or spacing of less than 1 ft.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

This element should be used for pier walls constructed of other materials not otherwise defined.

4.3.11 Element 880—Submerged Steel Pile

Description: Steel piles that are accessible for inspection, including piles exposed from erosion or scour and piles accessible during an underwater inspection. For all steel piles under the water surface at the time of inspection regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of piles accessible for inspection.

Condition State Definitions

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested by does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.12 Element 881—Submerged Prestressed Concrete Pile

Description: Prestressed concrete piles that are accessible for inspection below the water surface at the time of inspection including piles exposed from erosion or scour. For all submerged prestressed concrete piles regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of piles accessible for inspection below the water surface.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Exposed Prestressing (1100)	None.	Present without section loss.	Present with section loss but does not warrant structural review.	
Cracking (PSC) (1110)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide Cracks or heavy pattern (map) cracking.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.004 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.004 to 0.009 inches can be considered moderate, and cracks greater than 0.009 inches can be considered wide.

4.3.13 Element 882—Submerged Reinforced Concrete Pile

Description: Reinforced concrete piles that are accessible for inspection below the water surface at the time of inspection including piles exposed from erosion or scour. For all reinforced concrete piles regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of piles accessible for inspection under the water surface.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide Cracks or heavy pattern (map) cracking.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide.

4.3.14 Element 883—Submerged Timber Pile

Description: Timber piles that are accessible for inspection under the water surface at the time of inspection, including piles exposed from erosion or scour. For all submerged timber piles regardless of protective system.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of piles under the water surface accessible for inspection.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.15 Element 884—Other Submerged Pile

Description: Other material piles that are accessible for inspection below the water surface at the time of inspection, including piles exposed from scour. For all other material piles below the water surface regardless of protective system.

Classification: NBE **Units of Measurement:** each

Quantity Calculation: Sum of the number of piles accessible for inspection below the water surface.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide Cracks or heavy pattern (map) cracking.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	.
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The other material pile element is intended for piles constructed of composite materials, or other materials that cannot be classified using any other defined pile element.

4.3.16 Element 890—Submerged Reinforced Concrete Pile Cap/Footing

Description: Reinforced concrete pile caps/footings that are accessible below the water surface during the inspection, including pile caps/footings exposed from erosion or scour. The exposure may be intentional or caused by erosion or scour.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the length of footings or pile caps accessible below the water surface along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide.

4.3.17 Element 891—Submerged Timber Pile Cap/Footing

Description: Timber pile caps/footings that may be placed under one or more piles for element stabilization. This element will be used for evaluation of those portions of timber pile caps/footings under the water surface accessible during the inspection. For all timber pile caps/footings regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the length of the pile cap/footing accessible for inspection measured along the skew angle of the pier or bent.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element shall only be included in Underwater Inspections.

4.3.18 Element 910—Reinforced Earth – GRS-IBS Retaining Wall Systems

Description: Reinforced earth constructed retaining wall system used as the structural abutment. The facing for the wall may be concrete block or reinforced concrete precast panels. The caps that support the bearings will be accounted for under the appropriate substructure cap material item.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the length of the wall inclusive of turnbacks as appropriate. For extended turnback sections adjacent to the bridge measure no further than 50 feet along the wall past the centerline bearing of the abutment.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Split/Spall (Masonry) (1620)	None.	Block or stone has split or spalled with no shifting.	Block or stone has split or spalled with shifting but does not warrant a structural review.	
Masonry Displacement (1640)	None.	Block or stone has shifted slightly out of alignment.	Block or stone has shifted significantly out of alignment or is missing but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerablelimits or arrested with no observed structural distress.	Exceeds tolerablelimits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide.

4.3.19 Element 911—Steel Retaining Wall

Description: Steel retaining walls not considered a structural substructure element, including the sheet material retaining the embankment, wingwalls and retaining wall extensions. For all steel retaining walls regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the width of the retaining wall including wingwalls and abutment extensions measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.	Identified crack that is not arrested by does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Wingwalls and retaining wall extensions, shall be considered in the quantity and assessment of the retaining wall element. The retaining wall, any extensions and the wingwalls will be measured at the midpoint of the wall between groundline and the top of the wall.

This element will generally be found as protection for grade beam or pile and cap type structure foundations or as old steel abutments left in place for bank protection

4.3.20 Element 912—Reinforced Concrete Retaining Wall

Description: Reinforced concrete retaining walls not considered a structural substructure element, including the material retaining the embankment, wingwalls and retaining wall extensions. For all reinforced concrete retaining walls regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the width of the retaining wall, wingwalls and retaining wall extensions measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Exposed Rebar (1090)	None.	Present without measurable section loss.	Present with measurable section loss but does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	
Abrasion/Wear (PSC/RC) (1190)	No abrasion or wearing.	Abrasion or wearing has exposed coarse aggregate but the aggregate remains secure in the concrete.	Coarse aggregate is loose or has popped out of the concrete matrix due to abrasion or wear.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Wingwalls and retaining wall extensions, shall be considered in the quantity and assessment of the retaining wall element. The retaining wall, any extensions and the wingwalls will be measured at the midpoint of the wall between groundline and the top of the wall.

This element will generally be found as protection for grade beam or pile and cap type structure foundations or as old reinforced concrete abutments left in place for bank protection.

The inspector should use judgement when utilizing the condition state defect definitions, especially for concrete cracking. The crack defect description definitions describe generalized distress, but the inspector should consider width, spacing, location, orientation and structural or nonstructural nature of the cracking. The inspector should consider exposure and environment when evaluating crack width. In general, reinforced concrete cracks less than 0.012 inches can be considered insignificant and a defect is not warranted. Cracks ranging from 0.012 to 0.05 inches can be considered moderate, and cracks greater than 0.05 inches can be considered wide.

4.3.21 Element 913—Timber Retaining Wall

Description: Timber retaining walls not considered a structural substructure element, including the timber piling, timber plank or sheet material retaining the embankment, wingwalls, and retaining wall extensions. For all timber retaining walls regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the width of the abutment with wingwalls and retaining wall extensions measured along the new angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Wingwalls and retaining wall extensions, shall be considered in the quantity and assessment of the retaining wall element. Timber piling will not be assessed separately, but as part of the entirety of the retaining wall condition. The retaining wall, any extensions and the wingwalls will be measured at the midpoint of the wall between groundline and the top of the wall.

This element will generally be found as protection for grade beam or pile and cap type structure foundations or as old timber abutments left in place for bank protection.

4.3.22 Element 914—Masonry Retaining Wall

Description: Those retaining walls not considered a structural substructure element constructed of block or stone, including wingwalls and retaining wall extensions. The block or stone may be placed with or without mortar. For all masonry retaining walls regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the width of the retaining wall with wingwalls and retaining wall extensions measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Efflorescence/Rust Staining (1120) Patched Area (1080)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Mortar Breakdown (Masonry) (1610)	None.	Cracking or voids in less than 10% of joints.	Cracking or voids in 10% or more of the joints.	
Split/Spall (Masonry) (1620)	None.	Block or stone has split or spalled with no shifting.	Block or stone has split or spalled with shifting but does not warrant a structural review.	
Patched Area (Masonry) (1630)	None.	Sound patch.	Unsound patch.	
Masonry Displacement (1640)	None.	Block or stone has shifted slightly out of alignment.	Block or stone has shifted significantly out of alignment or is missing but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

Wingwalls and retaining wall extensions, shall be considered in the quantity and assessment of the retaining wall element. The retaining wall, any extensions and the wingwalls will be measured at the midpoint of the wall between groundline and the top of the wall.

This element will generally be found as protection for grade beam or pile and cap type structure foundations or as old masonry abutments left in place for bank protection. Do not use this element for mortared stone bank protection.

4.3.23 Element 915—Other Retaining Wall

Description: Other material retaining wall systems not considered a structural substructure element, including the sheet material retaining the embankment, wingwalls and retaining wall extensions. For all other material retaining walls regardless of protective systems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the width of the retaining wall, wingwalls and retaining wall extensions measured along the skew angle.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks that have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element should be used for abutments constructed of materials not otherwise defined.

Wingwalls and retaining wall extensions, shall be considered in the quantity and assessment of the retaining wall element. The retaining wall, any extensions and the wingwalls will be measured at the midpoint of the wall between groundline and the top of the wall.

This element will generally be found as protection for grade beam or pile and cap type structure foundations or as old other material abutments left in place for bank protection.

4.3.24 Element 916—Non-Integral Wingwalls

Description: All wingwalls, regardless of material, that are adjacent to, but not integral with the abutment stems.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Sum of the lengths of all non-integral wingwalls.

Condition State Definitions

Defects	Condition States 1 GOOD	Condition States 2 FAIR	Condition States 3 POOR	Condition States 4 SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

Defects	Condition States			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

All wingwalls, regardless of material, that are adjacent to, but not integral with the abutment stems.

Generally, for wingwalls to be considered to be non-intergral, there must be an open expansion joint between the abutment stem and wingall(s). In the case of timber, wingwalls are considered non-integral if the wingwalls are splayed (not in the same plane as the abutment stem face) and/or do not share common backwall planks for cap planks.

Note that the above table is what is currently in the BrM and consists of timber defects; however, this table may be expanded for the Final 2022 BIRM.

4.4 Other Substructure ADEs

4.4.1 Element 900—Bridge Scour

Description: This element is to track scour distresses which are evident during visual inspections. The primary purpose is to identify bridges that are experiencing scour and to provide some measure of the magnitude of scour. This element may be used as a substructure sub-element and used in support of the scour defect (6000).

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Sum of the number of substructure units affected by scour.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Scour (6000)	None.	Exists within tolerable limits or has been arrested with effective countermeasures.	Exceeds tolerable limits but is less than the critical limits determined by scour evaluation and does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.

Element Commentary

None.

4.4.2 Element 901—Scour Countermeasures

Description: Substructure protection devices or systems installed to mitigate scour problems. This element is not for tracking typical bank protection placed during bridge construction.

Classification: ADE **Units of Measurement**: each

Quantity Calculation: Sum of the number of countermeasure protected elements or protection systems.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Settlement (4000)	None.	Exists within tolerable limits or arrested with no observed structural distress.	Exceeds tolerable limits but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Scour (6000)	None.	Exists within tolerable limits or has been arrested with effective countermeasures.	Exceeds tolerable limits but is less than the critical limits determined by scour evaluation and does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	

Element Commentary

None.

4.5 Off-Bridge ADEs

4.5.1 Element 950—Metal Approach Guardrail

Description: All types and shapes of metal approach railing. Steel, aluminum, metal beam, rolled shapes, etc. will all be considered part of this element. Included in this element are posts of metal, timber, or concrete; blocking; and curb.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Measured length of metal approach rail including the transition section, but exclusive of the end 50’ at each approach rail (this 50’ is covered under Element 960). The element quantity includes only the approach rail between the bridge and the end 50’ section. For approach guardrail that is longer than 150’, only access the first 100’ from the end of the bridge rail.

Condition State Definitions

<table>
<tr><th rowspan="3">Defects</th><th colspan="4">Condition States</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th>GOOD</th><th>FAIR</th><th>POOR</th><th>SEVERE</th></tr>
<tr><td>Corrosion (1000)</td><td>None.</td><td>Freckled rust. Corrosion of the steel has initiated.</td><td>Section loss is evident or pack rust is present but does not warrant structural review.</td><td rowspan="4">The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.</td></tr>
<tr><td>Cracking (1010)</td><td>None.</td><td>Crack that has self-arrested or has been arrested with effective arrest holes, doubling plates, or similar.</td><td>Identified crack that is not arrested but does not warrant structural review.</td></tr>
<tr><td>Connection (1020)</td><td>Connection is in place and functioning as intended.</td><td>Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.</td><td>Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.</td></tr>
<tr><td>Distortion (1900)</td><td>None.</td><td>Distortion not requiring mitigation or mitigated distortion.</td><td>Distortion that requires mitigation that has not been addressed but does not warrant structural review.</td></tr>
<tr><td>Damage (7000)</td><td>Not applicable.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.</td></tr>
</table>

Element Commentary

The approach rail will generally be located on all four corners of a bridge on two lane roads and at least the approach ends of the bridge rail on one or multiple lane, one-way roadways. If the roadway is multiple lanes in each direction separated by a median rail other than metal, just record the metal rail under this element and the different material median rail under the appropriate element. Refer to the other approach rail material elements (concrete, timber, masonry, other) for specific defects for assessing the condition of posts, blocking, and curbs that may be constructed of materials other than metal.

4.5.2 Element 951—Reinforced Concrete Bridge Approach Railing

Description: All types and shapes of reinforced concrete approach railing including transition sections. All elements of the railing must be concrete.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Measured length of metal approach rail including the transition section, but exclusive of the end 50’ at each approach rail (this 50’ is covered under Element 960). The element quantity includes only the approach rail between the bridge and the end 50’ section. For approach guardrail that is longer than 150’, only access the first 100’ from the end of the bridge rail.

Condition State Definitions

<table>
<tr><th rowspan="3">Defects</th><th colspan="4">Condition States</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th>GOOD</th><th>FAIR</th><th>POOR</th><th>SEVERE</th></tr>
<tr><td>Delamination/Spall/ Patched Area (1080)</td><td>None.</td><td>Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched area that is sound.</td><td>Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.</td><td rowspan="4">The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.</td></tr>
<tr><td>Exposed Rebar (1090)</td><td>None.</td><td>Present without measurable section loss.</td><td>Present with measurable section loss but does not warrant structural review.</td></tr>
<tr><td>Efflorescence/Rust Staining (1120)</td><td>None.</td><td>Surface white without build-up or leaching without rust staining.</td><td>Heavy build-up with rust staining.</td></tr>
<tr><td>Cracking (RC and Other) (1130)</td><td>Insignificant cracks or moderate-width cracks that have been sealed.</td><td>Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.</td><td>Wide cracks or heavy pattern (map) cracking.</td></tr>
<tr><td>Damage (7000)</td><td>Not applicable.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.</td></tr>
</table>

Element Commentary

The approach rail will generally be located on all four corners of a bridge on two lane roads and at least the approach ends of the bridge rail on one or multiple lane, one-way roadways. If the roadway is multiple lanes in each direction separated by a median rail other than reinforced concrete, just record the concrete rail under this element and the different material median rail under the appropriate element. Refer to the other approach rail material elements (steel, timber, masonry, other) for specific defects for assessing the condition of posts, blocking, and curbs that may be constructed of materials other than reinforced concrete.

4.5.3 Element 952—Timber Approach Railing

Description: All types and shapes of timber approach railing. Included in this element are posts of timber, blocking and curb.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Measured length of metal approach rail including the transition section, but exclusive of the end 50’ at each approach rail (this 50’ is covered under Element 960). The element quantity includes only the approach rail between the bridge and the end 50’ section. For approach guardrail that is longer than 150’, only access the first 100’ from the end of the bridge rail.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Decay/Section Loss (1140)	None.	Affects less than 10% of the member section.	Affects 10% or more of the member but does not warrant structural review.	
Check/Shake (1150)	Surface penetration less than 5% of the member thickness regardless of location.	Penetrates 5%–50% of the thickness of the member and not in a tension zone.	Penetrates more than 50% of the thickness of the member or more than 5% of the member thickness in a tension zone. Does not warrant structural review.	
Crack (Timber) (1160)	None.	Crack that has been arrested through effective measures.	Identified crack that is not arrested but does not require structural review.	
Split/Delamination (Timber) (1170)	None.	Length less than the member depth or arrested with effective actions taken to mitigate.	Length equal to or greater than the member depth but does not require structural review.	
Abrasion/Wear (Timber) (1180)	None or no measurable section loss.	Section loss less than 10% of the member thickness.	Section loss 10% or more of the member thickness but does not warrant structural review.	

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

The approach rail will generally be located on all four corners of a bridge on two lane roads. Timber rail is generally not found on larger multi lane roadways. Refer to the other bridge rail material elements (metal, concrete, masonry, other) for specific defects for assessing the condition of posts, blocking, and curbs that may be constructed of materials other than timber.

4.5.4 Element 953—Other Approach Railing

Description: All types and shapes of approach railing including transitions except those defined as metal, concrete or timber.

Classification: ADE **Units of Measurement:** ft

Quantity Calculation: Measured length of metal approach rail including the transition section, but exclusive of the end 50' at each approach rail (this 50' is covered under Element 960). The element quantity includes only the approach rail between the bridge and the end 50' section. For approach guardrail that is longer than 150', only access the first 100' from the end of the bridge rail.

Condition State Definitions

	Condition States			
	1	2	3	4
Defects	GOOD	FAIR	POOR	SEVERE
Corrosion (1000)	None.	Freckled rust. Corrosion of the steel has initiated.	Section loss is evident or pack rust is present but does not warrant structural review.	The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.
Cracking (1010)	None.	Crack that has self-arrested or has been arrested with effective arrest hole, doubling plates, or similar.	Identified crack that is not arrested but does not warrant structural review.	
Connection (1020)	Connection is in place and functioning as intended.	Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.	Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant structural review.	
Delamination/Spall/ Patched Area (1080)	None.	Delaminated. Spall 1 in. or less deep or 6 in. or less in diameter. Patched are that is sound.	Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review.	
Efflorescence/Rust Staining (1120)	None.	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining.	
Cracking (RC and Other) (1130)	Insignificant cracks or moderate-width cracks hat have been sealed.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking.	Wide cracks or heavy pattern (map) cracking.	

Defects	Condition States 1 GOOD	2 FAIR	3 POOR	4 SEVERE
Deterioration (Other) (1220)	None.	Initiated breakdown or deterioration.	Significant deterioration or breakdown but does not warrant structural review.	
Distortion (1900)	None.	Distortion not requiring mitigation or mitigated distortion.	Distortion that requires mitigation that has not been addressed but does not warrant structural review.	
Damage (7000)	Not applicable.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.	The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.

Element Commentary

This element should be used for materials not otherwise defined. The approach rail will generally be located on all four corners of a bridge on two lane roads and at least the approach ends of the bridge rail on one or multiple lane, one-way roadways. If the roadway is multiple lanes in each direction separated by a median rail of a defined material, just record the other rail under this element and the different material median rail under the appropriate element. Other material rail used for the protection of pedestrians will only be included if it is attached to a bridge rail element.

4.5.5 Element 960— Approach Guardrail Ends

Description: All types and shapes of approach rail end treatments.

Classification: ADE **Units of Measurement:** each

Quantity Calculation: Number of guardrail end treatments on the approach rail off of the bridge.

Condition State Definitions

<table>
<tr><th rowspan="3">Defects</th><th colspan="4">Condition States</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th>GOOD</th><th>FAIR</th><th>POOR</th><th>SEVERE</th></tr>
<tr><td>Connection (1020)</td><td>Connection is in place and functioning as intended.</td><td>Loose fasteners or pack rust without distortion is present but the connection is in place and functioning as intended.</td><td>Missing bolts, rivets, or fasteners; broken welds; or pack rust with distortion but does not warrant a structural review.</td><td rowspan="2">The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge.</td></tr>
<tr><td>Distortion (1900)</td><td>None.</td><td>Distortion not requiring mitigation or mitigated distortion.</td><td>Distortion that requires mitigation that has not been addressed but does not warrant structural review.</td></tr>
<tr><td>Damage (7000)</td><td>Not applicable.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 2 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 3 under the appropriate material defect entry.</td><td>The element has impact damage. The specific damage caused by the impact has been captured in Condition State 4 under the appropriate material defect entry.</td></tr>
</table>

Element Commentary

Only three defects will be available for this element.

Chapter 7 – Steel, Pin and Hanger, and Fracture Critical Inspections

7.1 Introduction

On December 15, 1967, the Silver Bridge over the Ohio River in West Virginia collapsed due to a fractured eyebar, killing 46 people. The tragedy prompted Congress to enact the Federal-Aid Highway Act of 1968 initiating the National Bridge Inspection Standards (NBIS). By law, the states were now required to inspect all Federal-Aid System bridges on a regular two-year interval.

Ten years later, the Surface Transportation Assistance Act expanded the NBIS to include bridges on all public roads. From this point on, each state was responsible for the inspection of all bridges within its borders including those under county jurisdiction.

The 1983 failure of the Mianus River Bridge in Greenwich, Connecticut was caused by the failure of one pin and hanger assembly in a two-girder span which then caused the other pin and hanger to be overloaded resulting in a hung span falling into the river below. The failure killed three people and severely injured three others. The FHWA immediately required a hands-on inspection of all similar assemblies on fracture critical bridges.

This set the wheels in motion for extensive changes to the national bridge inspection program. The 1988 Revision to the NBIS required each state to:

1. Develop master lists of all bridges having fracture critical members.
2. Establish procedures for the inspection of those members.
3. Determine the frequency of those inspections.

The two bridge failures mentioned above had one similarity; both were almost instantaneous collapses brought on by the failure of fracture critical elements.

Then in 2007, an undersized gusset plate led to the failure of the I-35W deck truss bridge in Minneapolis, Minnesota, bringing the inspection and load rating of gusset plates in truss bridges to the forefront. The undersized gusset plate failed while the bridge was under rehabilitation, partially due to additional weight of construction materials stored on the bridge. Thirteen people died, and over 100 people were injured due to the failure. This collapse also brought a critical review of the national bridge inspection program from the Inspector General and instigated the FHWA 23 metrics that are in use today for reviewing and verifying the adequacy of state bridge management and inspection programs.

The Federal Highway Administration requires that all structures that are fracture critical or have unique features be placed on master lists. The structures on these master lists must receive special inspections. The structures that require these special inspections are identified in the NBIS coding items 92A - Fracture Critical Detail and 92C – Special Inspection Detail. This guide describes the inspection procedures for the structures identified in items 92A and 92C.

To truly understand what we are trying to accomplish with this type of inspection, we must understand the principles involved. AASHTO defines a fracture critical member (FCM) as:

A FCM is a non-redundant steel member in tension or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse.

By this definition, a fracture critical member is a bridge element which performs a function absolutely essential to the stability of the bridge. A FCM is one whose function or load path cannot be redistributed and replaced by any other component of the structure.

The purposes of a fracture critical inspection:

1. Clearly identify a bridge’s fracture critical members.
2. Inspect for flaws in a bridge’s fracture critical members.
3. Document flaw locations and conditions for accurate reporting and swift repair.

The importance of a thorough inspection of fracture critical members cannot be over-emphasized. This section has, therefore, been written to help develop a quality fracture critical inspection program for the State of Montana.

Glossary

Axial Force	A force whose line of action is directed through the centroid of a member's cross-section.
Beam	A structural member subjected to transverse loading. Beam is a general term used to describe such members as girders, stringers, and floor beams.
Bearing	A structural member used to support a beam at its end or at some intermediate point.
Cantilever	A beam supported at one end only, or that portion of a beam which projects beyond a point of support.
Centroidal Axis	The axis of a structural member which passes through its cross-sectional center of gravity.
Compression	The stress resulting from a member or portion of a member being squeezed or shortened
Continuous Beam	A beam supported at intermediate points along its length. It must have at least one support between its exterior supports.
Contraflexure	See "inflection point."
Counter	Diagonal member of a truss panel, which is opposed, by a member in the same panel running in a perpendicular direction. Both members are very slender and, therefore, will accept only a very small compressive load. The counters work in tandem. As a live load crosses the bridge, only that member which carries the shear in that panel as a tension load will function.
Couple	Two forces heading in exactly the opposite direction and spread some distance apart. When acting on a body, a couple will cause it to rotate.

Dead Load	A fixed position gravity load. The permanent load on a structural member. The weight of the structure and any permanent attachments are dead loads.
Equilibrium	The state in which the resultant of all forces acting on a body is zero. For a body to remain at rest, this condition must be satisfied. If a body is in equilibrium, any isolated part of the body must also be in equilibrium.
Floor Beam	A transverse beam connecting main longitudinal components, usually trusses or large girders. A floor beam is used to support smaller longitudinal components (stringers), in effect creating a series of "mini-spans" within the main span.
Free Body Diagram	A sketch of an isolated body and all the external forces acting on it.
Inflection Point	The point in a continuous beam at which the moment due to dead loads is equal to zero. At these locations, the movement of live loads may cause the total stresses to fluctuate between tension and compression.
Line of Action	A line through which a force is directed.
Live Load	Loads acting when a structure is in service, but varying in magnitude and location over time. The main live load is truck traffic, but live load also includes all vehicular traffic as well as lateral loads like wind, ice flows, earthquake, etc.
Moment	The moment about a specific point within a body is the algebraic sum of all individual moments about that point. Each moment is equal to some force acting on the body multiplied by its moment arm to the point.
Moment Arm	The distance perpendicular from the line of action of a force to the point about which the moment is being taken.

Neutral Axis	Locations in the cross section of a member where bending stresses are zero. Usually, it coincides with the centroidal axis.
Principal Stress	The stress applied normal (perpendicular) to the cross section of a member. It refers to the axial stress in a truss member and the tension and compression stresses in bending.
Propagate	Term used to describe the continuation of the ends of a crack. This can only occur when the faces of the crack are being pulled apart by a tensile force.
Simple Beam	A beam supported only at its ends. Bearing is all that is provided by the supports. The ends of the beam are free to rotate.
Stress	The load intensity a material experiences when subjected to a force. It is the load per unit area.
Stress Cycle	The range of stress from a minimum to a maximum that a member experiences during one application of a live load.
Stress Concentration	An increase in stress caused by an irregularity in geometry. There is usually a localized variation in the overall stress in the immediate vicinity of the irregularity. The peak stress at these locations may be several times larger than the stress level in the bulk of the member.
Tension	The stress resulting from a member or a portion of a member being pulled or stretched.
Yield Point	The level of stress at which a material (steel) will begin to deform plastically. Before it reaches this level, the steel will behave elastically, meaning it will sustain a load and bounce back. After surpassing this level, any deformation will be permanent.

7.2 Fatigue, Stress and Redundancy

In most instances, a fracture is not the result of a single load overstressing the element to the point of failure. Generally, it is caused by the repeated application of tensile loads and load reversals, which do not stress the member to anywhere near the yield point. Cracking which occurs under these circumstances is known as fatigue cracking.

A member whose state of stress at rest or under pure dead load is far different than the stress imparted by a live load is very susceptible to fatigue. A good example of this are counters in a truss. The dead load stress in a counter is almost negligible, while under a live load they are asked to carry a very high tensile stress. The large differential in the range of stresses these members experience during a stress cycle make them very vulnerable to fatigue cracking.

It is obvious that fatigue has very little to do with the maximum stress a bridge member will encounter during its lifetime. The real issue here is the range between the lower and upper limits of its stress cycle. The larger the range the more likely fatigue will be an issue.

7.2.1 Fatigue

Fatigue prone details can handle only so many loading cycles are only able to bend so many times before cracking occurs. Cracking of fatigue prone details in non-redundant members normally would not cause a bridge to collapse. However, if cracking occurs in a fracture critical member, the bridge does not have any built-in ability to shift the load to other members, and the bridge may collapse.

Fatigue happens to members in tension and members exposed to cycles of out-of-plane bending. Repetitive tensile and out-of-plane forces can initiate cracks that may grow and cause a fracture to occur. This tension may cause cracks to grow and a fracture to occur. A member in axial tension is stressed the same throughout the cross section for the total length between connections. Hangers, suspension cables, and some truss members normally are stressed in axial tension. Direct tension members, even though they may have no welding associated with them, are the most critical because they are usually used in situations where limited redundancy exists, and defects can initiate and grow to possibly critical flaw size without being detected. Eyebars and hangers that have been repaired by field welding are highly susceptible to fatigue cracking.

Any sudden change in the geometry of a structural member's cross-section can lead to a stress concentration (cover plate ends, coped webs/flanges at connections, gouges, etc.). These changes in geometry are referred to as stress risers. Bolt holes, rivet holes and many commonly-used fabrication details are also stress risers and are subject to fatigue. The bridge inspector must be able to identify stress risers and spot flaws before they reach the critical flaw size. Most cracks found in the field are in the vicinity of a geometric stress riser.

Many of the problems being discovered in in- service bridges are associated with weld terminations or weld defects, which are inherent to the welding process. Welding of structures generally started in the 1950's, so it is very likely that fatigue prone flaws are present in steel structures from this period due to the infancy of the welding process and weld inspection procedures in-place back then. Welds made in the field are especially susceptible to fatigue cracking. Even tack welds could initiate cracking under certain conditions. Though not harmful by themselves, they will cause cracking in areas of high-tension stress or stress reversal (fatigue).

A FCM can be endangered by corrosion, which can lead to loss of section, pack rust, and shortened fatigue life. Proper maintenance and painting can reduce this problem. Rust can build up between plates and add additional stress to members

Steel details are categorized by their ability to resist cracking due to fatigue. As such, steel details are placed into Fatigue Categories that range from A to E'. Fatigue Category A is the most resistant to fatigue cracking, whereas Fatigue Category E' is the least resistant to fatigue cracking. Fatigue Categories are discussed below. While there are numerous steel fatigue references available, the following two references are recommended for bridge inspection:

- Lehigh University's "Inspecting Steel Bridges for Fatigue Damage", commonly referred to as the Fisher Manual (https://preserve.lib.lehigh.edu/islandora/object/preserve%3Abp-3114250).
- The most recent edition of the American Institute of Steel Construction's Steel Construction Manual, commonly referred to as the AISC Manual.

Both references clearly present the different fatigue categories found on steel bridges through the use of illustrations and descriptions. Both references also instruct the inspector as to where cracking may occur along various steel details. Of the two, the Fisher Manual is a more-thorough reference for bridge inspectors. Refer to these manuals for fatigue-prone information and to identify and categorize fatigue prone details found on Montana's bridges.

7.2.2 Stress

An overview of the stresses a bridge member experiences will help in locating zones of tension stress. A load applied to any structural member will cause a force or moment, which is resisted by the entire cross-sectional area of the member. This distributing of the force or moment over the cross-sectional area is known as a stress distribution.

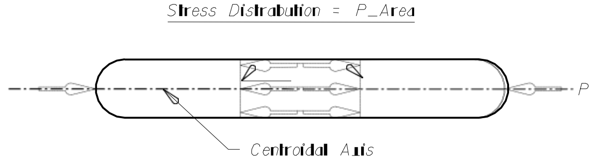
Axial Stress

A force whose line of action acts through a member's centroidal axis causes axial stresses. There are two types of axial forces:

Tension: the force which, when applied, tends to pull the member apart, and

Compression: the force which, when applied, tends to squeeze or contract the member.

Axial forces are resisted by a stress distribution of equal intensity over the entire cross section of the member.

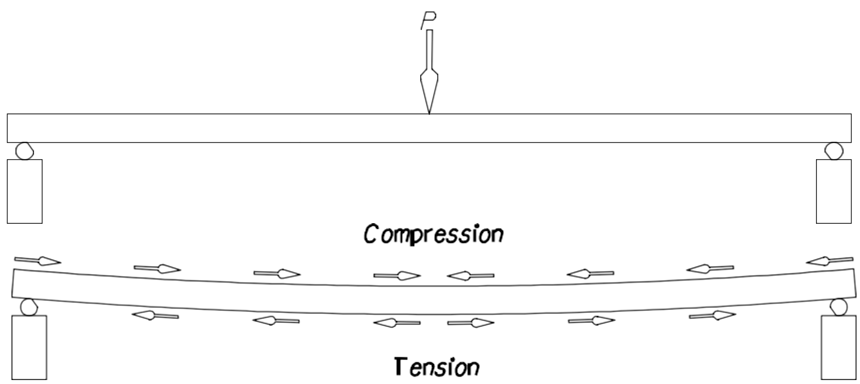


Bending and Shear Stresses

As opposed to axial stresses, which are caused by forces applied along the length of the member, bending deals with stresses due to forces acting transversely to the member. Here we are dealing with beams. A beam is a slender member (relative to its length) that is subjected to a transverse gravity load.

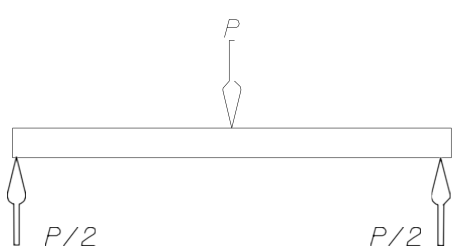
Members in bending have variable stresses throughout. On a simple beam, the maximum tension is in the bottom flange at midspan. An equally important location on a continuous span is the top flange over the support. High stress may also be concentrated at locations along a member where the cross section changes or where there is a discontinuity.

Consider the simple beam, shown supporting a weight "P" at midspan. This loading configuration causes the beam to deflect downward. As a result, the bottom of the beam is being stretched or pulled and is in tension. The top is being squeezed or contracted and is in compression. Therefore, what we have when we analyze bending is a combination of the two axial stresses: tension and compression.



In order for the beam to be in equilibrium, the sum of all forces must equal zero; therefore, the sum of the forces at the end bearings (reactions) must equal the load "P". In this example, we will neglect the weight of the beam itself.

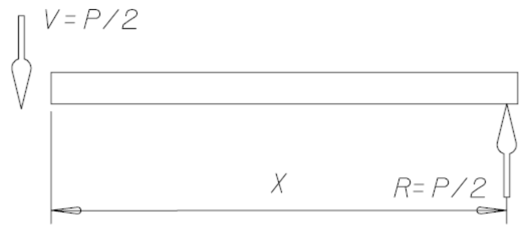
Since the load is applied directly at the center of the span, the reactions will act equally in resisting it. Therefore, each reaction (R) must equal P/2.



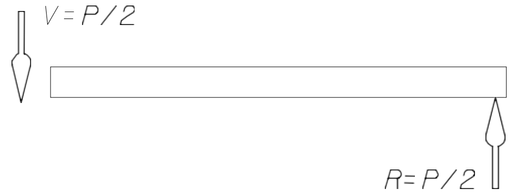
FREE BODY DIAGRAM OF BEAM

As stated, the beam under consideration is in equilibrium. This being the case, any portion of the beam must also be in equilibrium. We, therefore, can draw a free body diagram of any part of the beam we choose.

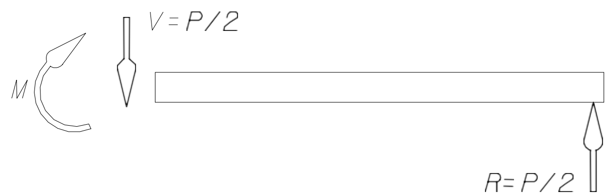
Take a segment of the beam a distance “x” from the right reaction.



As stated earlier, the reaction is equal to P/2. Because we know that this portion is in equilibrium, there must be a force just to the left of the cut equal in magnitude and opposite in direction to the reaction, P/2. This is called the shear force at this section and is designated “V”.



The sum of the vertical forces now equal zero; however, they have formed a couple which tends to rotate the member counterclockwise. For the segment to remain in equilibrium, this tendency must be resisted. This is done by an internal moment designated “M”. The final free body diagram of the segment is shown below.

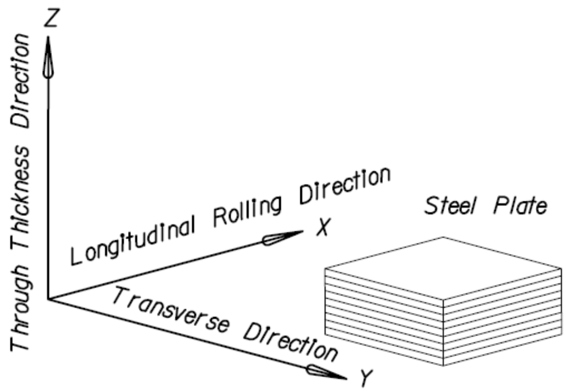


Laminations and Lamellar Tearing

Laminations, which generally occur during fabrication, are extensive and continuous imperfections lying parallel to the plate surface. Generally, they are aligned with the direction of principal stress and are seldom critical. However, they have been known to cause structural failures.

A lamination can result in an imperfection, which might lead to a stress concentration transverse to the applied stress and become critical. This is why all tension and stress reversal regions of a fracture critical member must be looked at, not just the fatigue-prone details.

Like laminations, lamellar tearing is a separation in the through-thickness direction of a plate.



LAMELLAR TEARING AND LAMINATION

While lamination occurs during the fabrication or rolling process, lamellar tearing is the result of welding attachments to the plate. It is caused by weld metal shrinkage in highly restrained joints. A weld connecting a transverse stiffener to a girder web is an example of such a location. As the weld metal cools, it will contract and try to pull the web with it. If the web is highly restrained such, as near the flange, it won’t be able to flex. Large stresses will result, and the web may separate along imperfections between the grains.

Beams

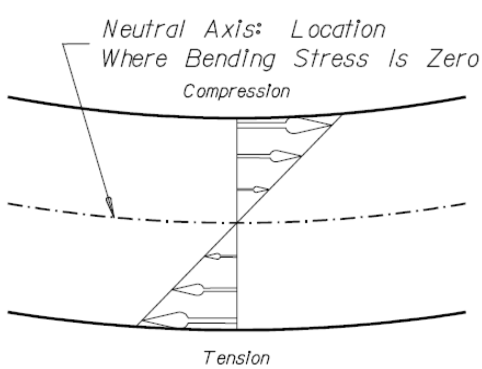
We have now established the stresses that occur in a beam.

Shear Stresses

Vertical forces that tend to displace vertically one part of a member relative to the adjacent part cause shear stresses. (Though this vertical displacement is impossible in real life, analysis and experimentation have shown the physical evidence of shear is cracks that appear at approximately a 45-degree angle with the horizontal.)

Bending Stresses

Tension and compression stresses, which vary linearly along the vertical face of the section. (When permanent deformation takes place, at the onset of yielding--refer to yield point in the glossary--this linear behavior no longer applies.)



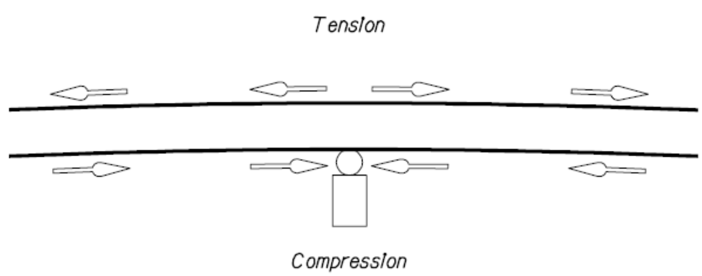
Stress Distribution Varies Linearly From Maximum Compression at the Top to Maximum Tension at the Bottom

BENDING STRESS DISTRIBUTION

For the purposes of fracture critical inspection, we will consider the neutral axis to be located halfway between the top and bottom flange. This is not necessarily the case, but will be close enough for our purposes.

Until now we have dealt with a simply supported beam. The moment has caused the portion of the beam below the neutral axis to be in tension. We refer to this situation as positive bending, or a positive moment region.

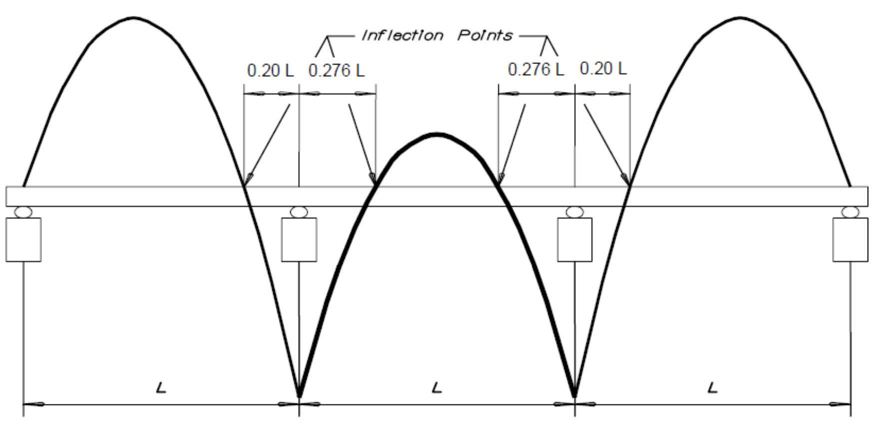
Now consider a continuously supported beam. As was the case for the simple beam, it will deflect downward near midspan. However, as the beam approaches a support, the amount of deflection will decrease until at the support it becomes zero. The situation here is reversed from the simple beam. Relative to the adjacent spans, the portion over the support is deflecting upward; hence, the top of the beam is in tension. We refer to this as negative bending, or a negative moment region.



NEGATIVE MOMENT

As the moment goes from negative at the support to positive at midspan, there must be some point between the two where the moment is zero. This point is called the inflection point, or the point of contra flexure. Because the live load moments at each section are constantly changing as a truck travels across the bridge, the inflection point is determined using only dead load moments.

An example of a graph, called a moment diagram, of the dead load moments at each section along the length of a three-span continuous beam.



MOMENT DIAGRAM - DEAD LOAD

The dead load moments in the region of the inflection point are relatively small and can be overcome by a large live load as it moves across the bridge. In this area, a negative dead load moment may be changed to a net positive moment by the addition of the live load moment. Or a positive dead load moment changed to negative. The overall effect is that a portion of the beam goes from being in a tension zone to compression and back again.

This portion of the beam is said to be in stress reversal for obvious reasons. This cyclic occurrence leads to fatigue in the member. It can cause cracking and eventual failure even though the stresses involved may never approach the yield point. Fatigue can also be a problem in areas that have stress ranges which are always in tension, but where the stress range and number of cycles is significant.

When inspecting beams, there are some important things to consider. In all instances, while inspecting steel I-beams, the flanges will carry the bending stresses as tension or compression. One flange will, therefore, be designated the tension flange, and the other the compression flange.

Almost exclusively the web will carry the shear stresses. In fracture critical inspections, shear stresses are not our primary concern. However, if a crack does develop in the web, its ability to carry shear stresses will be reduced, possibly increasing the serious nature of the situation. This is especially important in the top (tension) portion of the web over or near the support, where shear stresses are high.

Trusses

A truss may be thought of as a special I-beam with most of its web cut away. The functions of the flanges in the beam are the same as the function of the top and bottom chord in a truss. The function of the I-beam's web is the same as that of the diagonals and verticals.

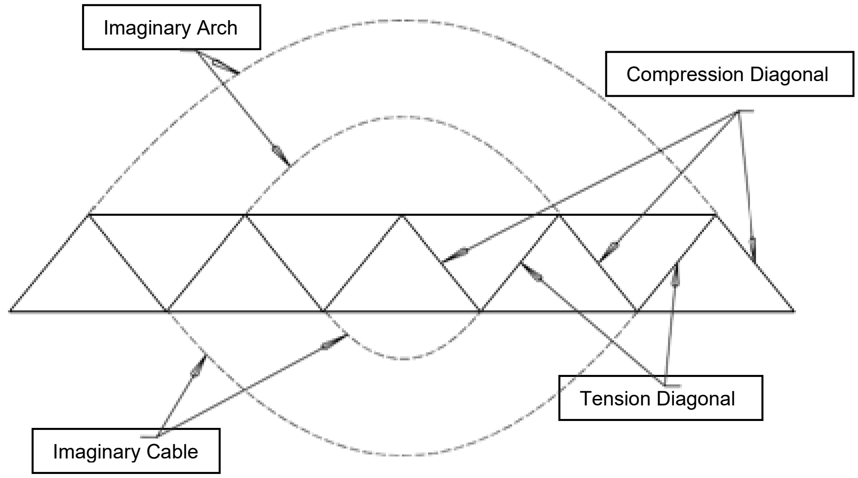
A truss is designed such that the overall bending stresses are carried as axial forces in individual members: the top and bottom chords. Likewise, the shear stresses are carried as axial forces in the diagonals and verticals.

Let's carry the correlation one step further. In the case of a beam, given a specific load and span length, we can decrease the bending stresses in the flanges by increasing the depth of the beam. In the same way, by increasing the depth of a truss, we can reduce the forces in the top and bottom chords.

A very small percentage, around four percent of truss bridges in Montana are continuous; therefore, in this manual we will concentrate on simple span trusses. Continuous trusses will be singled out and analyzed individually.

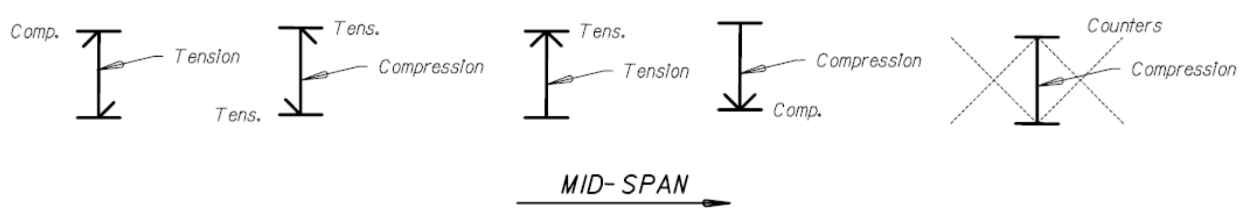
As was the case for the flanges in a simple beam, the top chord in a simply supported truss will be a compression member and the bottom chord a tension member. The distribution of shear forces is another matter. How each member of a truss panel will carry the forces in that panel depends upon the geometry of the truss. The following are some rules of thumb, which will help in determining how the diagonals and verticals react to loads applied to the truss.

Two exactly opposing structure types can help in this discussion: an arch and a suspended cable. In an arch bridge, the arch itself is always in compression. On the other hand, a suspended cable is always in tension. Using these two concepts will allow us to determine which diagonals are in compression and which are in tension.



DIAGONAL STRESS

After the stress in each diagonal is determined, stress in the verticals can be determined.



VERTICAL STRESS

1. Those diagonals, which incline upward toward the center of the span, may be thought of as the ends of an arch and are, therefore, compression members.
2. Those diagonals, which incline downward toward the center of the span, may be thought of as the ends of a suspended cable and are, therefore, in tension.

Because tension members are the focal point of a fracture critical inspection program, the bottom chord of a simple span truss must be checked thoroughly. Any diagonals and verticals, which were also determined to be tension members, must be examined as well. Also, any connection or splice plates for fracture critical members require fracture critical inspection.

7.2.3 Redundancy

Structures have properties that can compensate for failure. Failure from stress or fatigue can be compensated by the structure redistributing the load via load paths to alternate locations.

Redundancy is the ability of other members to help carry the load, providing duplication of replacement of some function, when a member becomes weak or fails. A bridge, which is considered fracture critical, is said to be non-redundant. Where bridges are concerned, the term redundancy can be divided into three distinct areas: load path, structural, and internal.

Load Path Redundancy

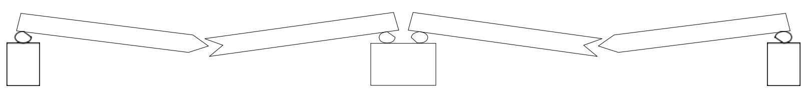
Load path redundancy considers the number of supporting members (e.g., stringers) that transfer the deck loads to the substructure. Each supporting member would be considered a separate load path.

An easy way to picture this is to look at the number of bearings at each bent or pier. The deck loads are delivered through the supporting members to the substructure at these locations. The number of bearings a bridge has at each bent can determine the number of load paths a structure has.

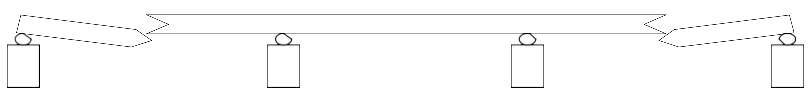
A structure is considered non-redundant if it has two or less load paths. A truss bridge, using only two trusses, has two bearings at each pier. Having only two load paths, it must be considered non-redundant or fracture critical. Conversely, multi-girder bridges with three or more girders and, therefore, three or more load paths, are redundant.

Structural Redundancy

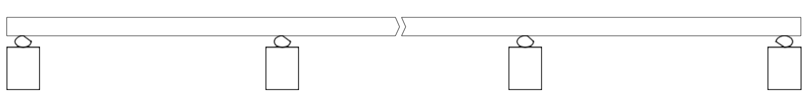
Structural redundancy refers to the number of substructure units and the way in which those units are used to support the superstructure. To be considered structurally redundant, a bridge must have a minimum of three continuous spans, and then all spans except for the end spans are redundant. A structure constructed of a simple span or a series of simple spans is considered structurally non-redundant.



Structurally Non-Redundant (Two Simple Spans)



Spans 1 and 3 – Structurally Non-Redundant (Three Span Continuous)



Span 2 – Structurally Redundant (Three Span Continuous)

Internal Redundancy

Internal redundancy relates to a particular structural member and the redundancy created by the independence of its individual components. A good example of an internally redundant bridge member is a riveted plate girder. This type of girder is constructed of double angles (which provide the flanges) riveted to a web plate. A crack beginning in one leg of one of the angles may eventually separate the entire angle, but it is not likely to travel into the web plate.

On the other hand, a welded plate girder cannot be considered internally redundant. The weld fuses the different components together so they become a single section. Cracks appearing in one portion may propagate into adjacent elements through the weld itself. In fact, far from hindering crack propagation, flaws in the weld in many instances are the cause of cracking found in welded plategirders.

Some examples of internally redundant and non-redundant members are given below.

Internally Redundant	Internally Non-Redundant
Riveted or bolted plate girder	Welded plate girder
Cables constructed of several strands	Single strand cables
Multiple eyebars in a truss member	Single eyebar in a truss member
Rolled sections	

If a crack or flaw develops in a structural member, the only stresses, which will cause it to propagate, are tension stresses. For the ends of a crack to spread, the faces of the crack must be pulled apart. This can only occur in a tension zone and only when the crack is at an angle or across the direction of the applied tensile stress. Therefore, when inspecting fracture critical members, the compression areas of those members may be neglected.

7.3 Fracture Critical Inspection Planning and Preparation

A steel bridge inspection begins before the bridge inspection crew arrives at the bridge. The crew should study the bridge's history and inspection file carefully while still in the office and develop a fracture critical inspection plan. It is important for each inspector to understand which members are fracture critical and where the fracture critical zones are located. A copy of the plans with fracture critical areas marked on them and the bridge-specific fracture critical drawings will be taken into the field for the inspection. These bridge-specific fracture critical drawings have been prepared by Bridge Management, are available in the SMS and include any previous defect/damage notes, repair notes, as well as fatigue-prone details along the members. The Bridge Bureau also has shop and construction drawings showing the fracture critical members for almost all State-owned bridges and quite a few county-owned bridges and will supply them to the districts as necessary. In most cases it is desirable to perform the fracture critical inspection in conjunction with the element level bi-annual inspection.

A Fracture Critical Inspection Plan will be created prior to field work commencing. See the Fracture Critical Inspection Plan Template in Appendix 7A for Items that are included in the Fracture Critical Plan. Note that the Fracture Critical Inspection Plan Template and methodology / content are currently being updated internally by MDT.

7.3.1 Inspections

Fracture critical inspections will commence following the procedures prescribed in the Fracture Critical Inspection Plan referred to above. While the hands-on access requirement is the same for all fracture critical members, the bridge elements vary greatly from bridge to bridge and can range from welded steel box girders to forged truss eyebars. Note that not all elements on a fracture critical bridge are fracture critical. Refer to each bridge's Fracture Critical Plan and Section 3.3 for Fracture Critical inspection and documentation requirements for various types of superstructures with FCMs.

7.3.2 Inspection Reports

By definition, fracture critical bridge failures may result in partial or total collapse of the bridge. Thus, it is important that the inspection of a fracture critical bridge be documented thoroughly and accurately. This effort will include a narrative description of all fracture critical members as shown in the fracture critical inspection plan with problem areas noted.

The importance of these inspections cannot be overstated. We are looking for flaws in members which are vital to the integrity of the bridge. Along with stating the existing condition, the inspection report will provide an ongoing record of the condition of the bridge and verification of the thoroughness of the inspection activities. Occasionally there will be serious flaws that cannot be seen by the inspector. If a fracture occurs, the report can be used to verify that a proper inspection was made.

Refer to Appendix 7A and Section 3.3 for Fracture Critical documentation requirements for various types of superstructures with FCMs.

7.3.3 What To Do If a Flaw or Crack Is Found

It would be very difficult to defend a situation where a bridge failed after the defect had been identified. It is therefore very important that the inspector communicates any serious findings in accordance with the current Critical Findings Guidance found in Chapter Section 2.14.7 of this manual. Other problems such as a flaw in a web may be reported when the inspector returns to the office. It is better for the inspector to err on the side of safety. If there is a question about the significance of a finding, the District Bridge Inspection Manager should be contacted as soon as possible. In the defect notes, document any time MDT is notified of a crack, flaw or potential critical finding (i.e. “MDT was notified on 4/22/22 about the crack in the truss bottom chord via phone from the field.”) and upload any associated emails to the SMS Multimedia Tab.

When problems are identified, it is a good idea to go back and look at similar details throughout the bridge. Often inspectors have found cracks at other locations that had already been inspected after finding the first. This demonstrates that it helps to know exactly where to look and what to look for on the other details. After a flaw or crack has been identified, it may be helpful to perform additional evaluation with NDT such as dye penetrate, magnetic particle, ultrasonic or radiographic testing.

7.4 Steel Bridge Inspection

There are five main types of fracture critical members / systems in Montana:

- Trusses
- Two-girder systems
- Bridges using transverse girders (including all floor beams)
- Pin & Hangers
- Steel Pier / Bent Caps

Note that MDT has a separate contract to ultrasonically test the pins in pin & hanger type bridges. The scope and terms of those inspections are specified in those specialty contracts.

7.4.1 Truss Bridges

Only the tension members of a truss are singled out for fracture critical inspection; however Montana requires all truss members to be inspected hands-on, per Appendix 7A. As is the case with any axial tension member, the critical locations are the connections at either end. While the entire member must be looked at, the inspector should be especially careful at the ends.

There are two types of trusses used in this state: riveted and pinned.

- Riveted / Bolted Truss - A truss constructed of structural sections riveted or bolted together using plates or lacing to connect the sections. Gusset plates and rivets / bolts are usually used at all connections.

- Pinned Truss - Compression members are built-up members similar to those of a riveted truss. Tension members are eyebars or rods. Pins are used at the connections.

Riveted / Bolted Trusses

As connection points for these mechanically fastened trusses, gusset plates will be checked very closely as they are considered a fracture critical member. Fastener holes are locations of stress concentration in the gusset plate. The critical portions of the gusset plate are the exterior lines of fasteners at right angles to the applied stress (perpendicular to the centroidal axis of the member). The reason for this is that cracks will propagate at right angles to the tensile stress. The entire set of gusset plates at each connection point will be evaluated. If geometry of the connection precludes a full visual inspection and the inspector can find no problems in these critical areas, he/she can be fairly confident of the rest of the connection.

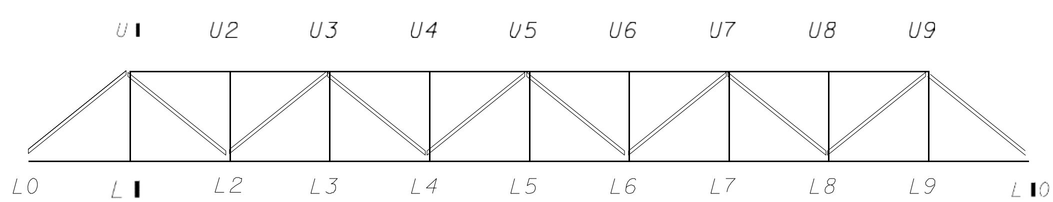
Pinned Trusses

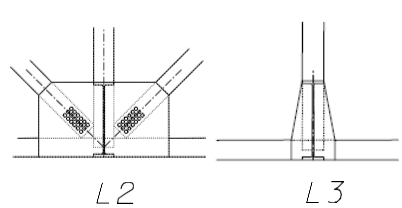
Again, as was the case for the riveted / bolted truss, the connections are crucial. In pinned trusses, the members either have pin holes or are looped at the ends and held together with pins - see Parker Truss Connection Detail below.

The method used to form the ends of eyebars on these old bridges is called forge welding. It involved heating the metal to a plastic state and hammering it into shape. On the lighter bridges, one piece of steel (generally a circular rod) was used. The bar was heated, bent around a pin, and formed back on itself. On larger bridges, the ends of the eyebars (generally rectangular bars) were cast in a mold separately and then forge welded to the bar itself. A thorough visual inspection will be considered adequate at these locations.

NDT testing will very likely detect some sort of flaw at all connections using forge welding. Therefore, unless the flaw can be seen, it will not be considered critical.

Warren Truss





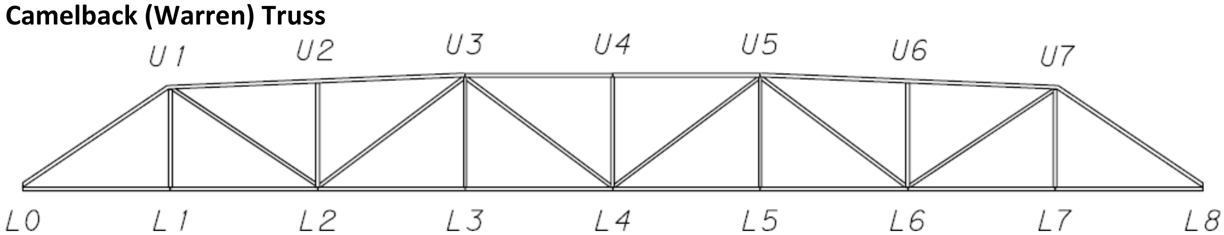
CONNECTION DETAIL

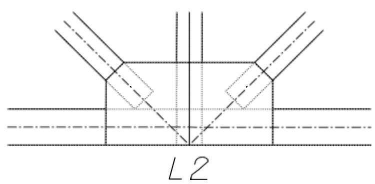
The diagonals in a warren truss will carry both compressive and tensile forces. Verticals that frame into the bottom chord by themselves (no diagonals frame into the bottom gusset plates) are tension members. The verticals which frame into the top chord by themselves serve only as bracing for the top chord and, therefore, may be considered compressive members only.

The first line of rivets (or bolts) transverse to the applied stress and closest to the center of each member are the most critical; however, all rivets (bolts) should be inspected closely, where accessible.

Diagonals U1-L2, U3-L4, L6-U7, and L8-U9 are tension members for this particular truss. These members and their connections along with the bottom chord and the tension verticals will require fracture critical inspection.

Camelback (Warren) Truss



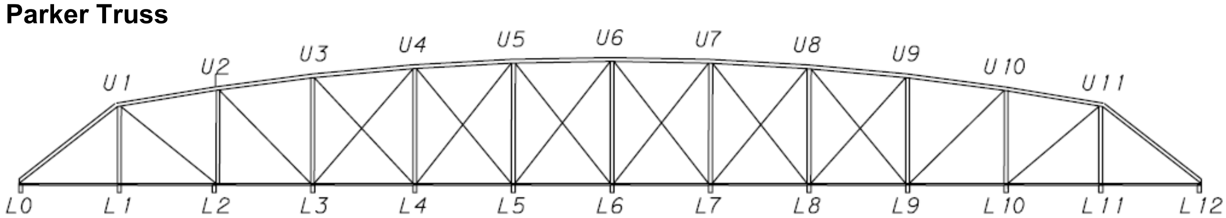


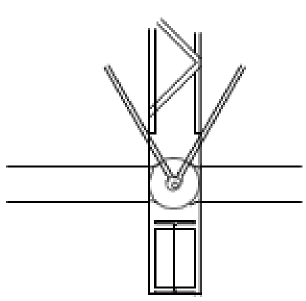
CONNECTION DETAIL

Sometimes referred to as a camelback because of its top chord having exactly five slopes, the truss pictured is actually a Warren.

The inspection requirements for the Warren truss will apply here, too. The tension diagonals are U1-L2, U3- L4, L4-U5, and L6-U7. These, the bottom chord, and the gusset connections and the tension verticals will require the fracture critical inspection.

Parker Truss



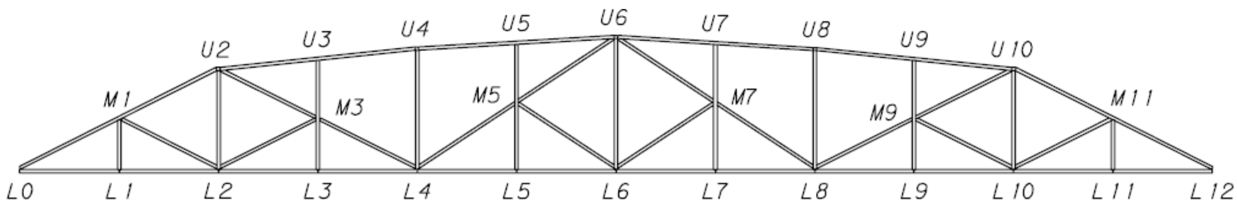


CONNECTION DETAIL

The verticals in this truss are all compression members. The diagonals are all tension members. This is one case in which the arch and suspender analogy will not apply because here we are dealing with counters. The diagonals in the middle six panels are all counters and, as such, are unable to accept any significant compressive load. The shear loads in each of these six panels are carried by one of the counters as a tensile load. When a truck crosses the bridge, one counter will carry the entire load until it begins to go into compression, at which point it becomes ineffective and the other counter takes over.

The connections in this truss are pinned. The bars, which are used as tension members have been forge welded. The lighter counters consist of a rod which has been bent around a pin and bent back on itself. The larger counters and the lower chord are bars whose ends have been cast separately. These have then been forge welded onto the bar itself. All of these connections must be visually inspected very thoroughly.

Pennsylvania Truss (Subdivided Parker)



Sometimes for large span bridges, a truss will be subdivided to reduce member sizes and to shorten the span length between floor beams. The newly added members are referred to as sub-diagonals and sub-verticals. They may also be referred to as sub-struts (if they are compression members) or sub-ties (if they are tension members).

The main interior diagonals for the truss pictures will behave as given in the rules of thumb. That is, U2-L4 and L8-U10 are tension members. L4-U6 and U6-L8 are compression members. After determining the diagonal stresses, the vertical members will obey the tension and compression rules. The sub-verticals M1-L1, M3-L3, M5-L5, etc., will be tension members because they frame into the lower chord without the presence of diagonals. The sub-verticals U3-M3, U5-M5, U7-M7, and U9-M9 are braces for the top chord and are considered compression members. The main verticals U2-L2, U4-L4, U6-L6, etc., are compression members.

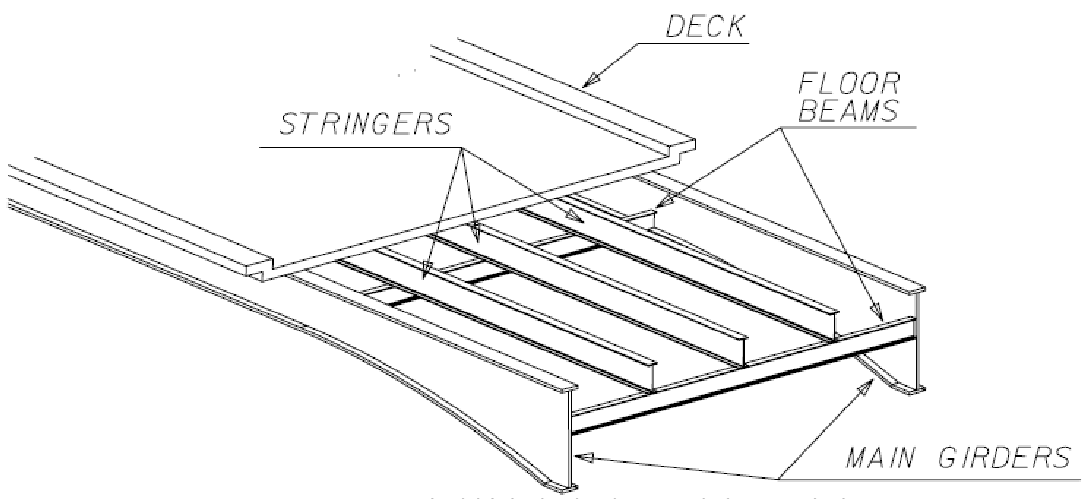
The only members of this truss where the rules of thumb do not apply are the sub-diagonals. They are all compression members no matter what direction they are inclined. Their main function is to prevent the main diagonals from being bent laterally due to the tensile loads being applied by the sub-verticals.

This truss may look complicated, but it really isn't. The members requiring a fracture critical inspection are the lower sub-verticals; the main diagonals inclined downward, U2-L4 and L8- U10, and the bottom chord.

7.4.2 Two-Girder Systems

The fracture critical members on a two-girder system are the two main girders. The fracture critical components are those parts of the girder within tension zones or areas of stress reversal, if it's continuous.

The inspection of two-girder systems will generally follow the guidelines set forth in the article on beams. The inspector will need to determine the tension and stress reversal zones before beginning the inspection. In tension zones, only that half of the girder in tension needs the full fracture critical inspection. In areas of stress reversal, the full depth of the girder must be given this type of inspection.

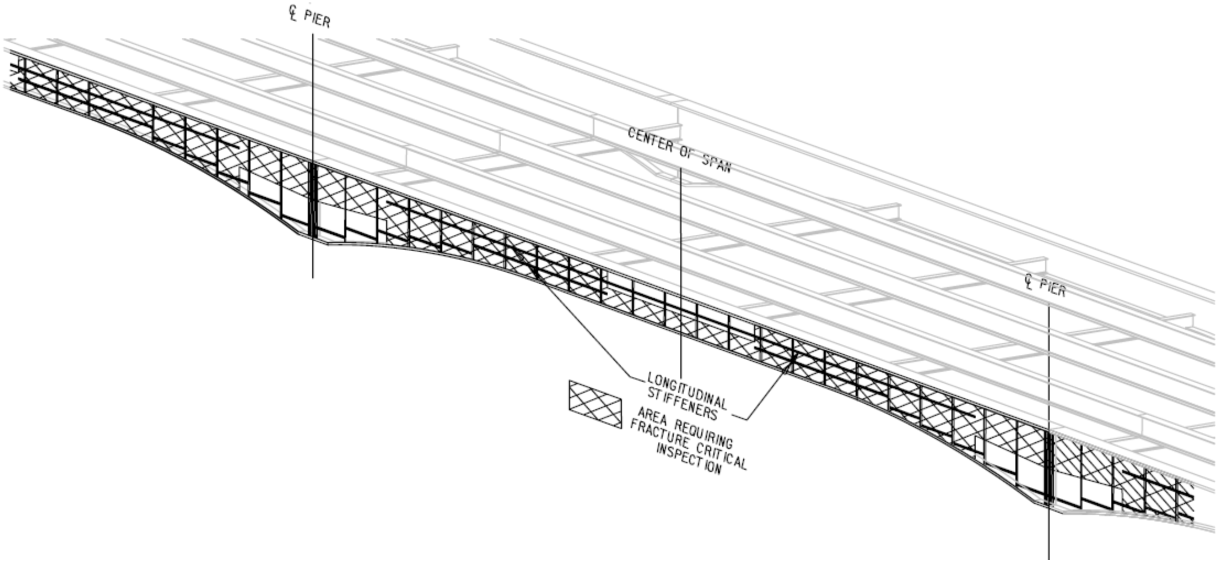


CROSS SECTION OF A TWO-GIRDER SYSTEM

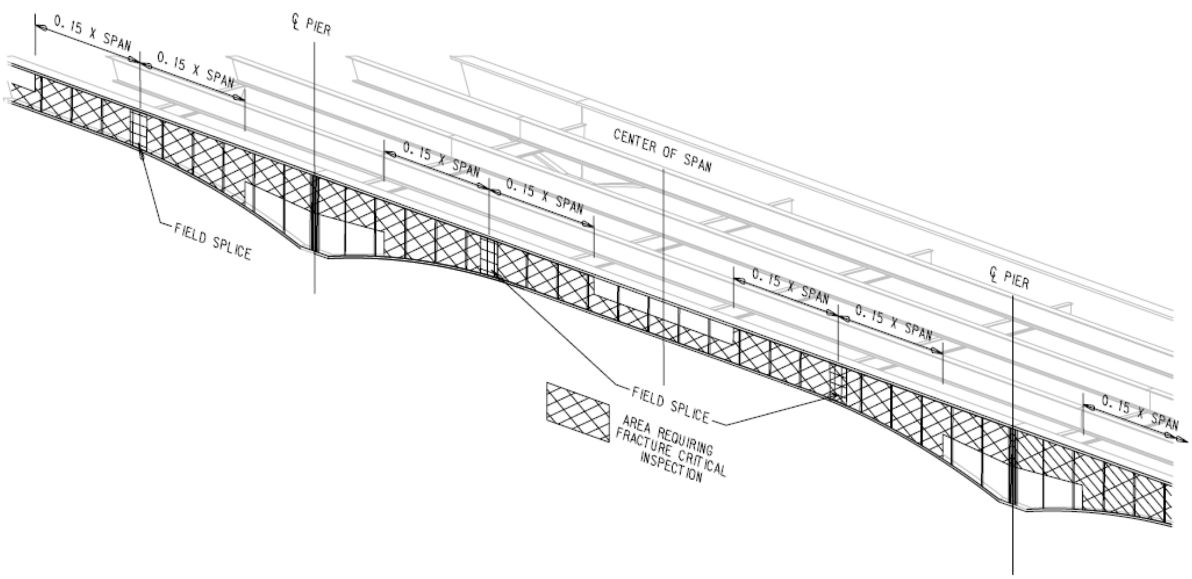
Locating Zones of Stress Reversal in Continuous Girders

In those cases where longitudinal stiffeners have been used, their placement near both the top and bottom flanges is an area of stress reversal as shown in the below diagram.

Without the presence of longitudinal stiffeners, inflection points are located between 20% and 30% of the span length from either side of each intermediate bent. In most cases, a field splice has been placed at these locations. In these instances, the zones of stress reversal will be taken as the area equal to 0.15 times the span length on both sides of these splices.

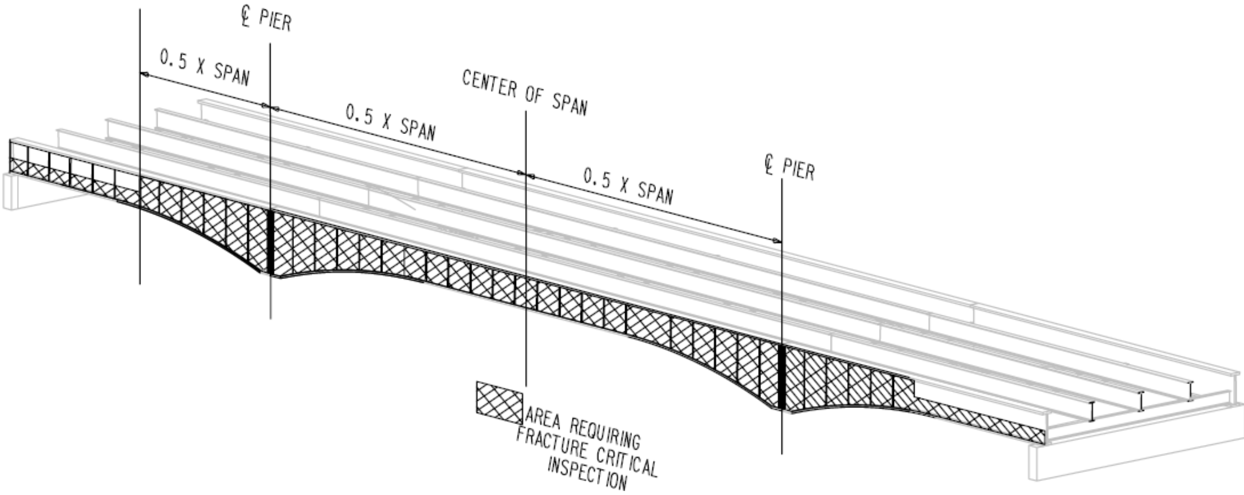


MAIN GIRDER INSPECTION W ITH LONGITUDINAL STIFFENERS



MAIN GIRDER INSPECTION WITH FIELD SPLICES

If field splices or longitudinal stiffeners have not been used, the inspector will perform a full- depth inspection at each intermediate to a point 0.50 times the span length from the bent. This will be done on both sides of the bent.



MAIN GIRDER INSPECTION WITHOUT FIELD SPLICES OR LONGITUDINAL STIFFENERS

Gusset Plates

Gusset plates are used in many instances to attach lateral bracing to the web of the girder. Unlike the case with riveted trusses, the plates themselves are not fracture critical. However, the lateral bracing will vibrate as a vehicle crosses the bridge. This vibration can cause cracking in the girder's web at the gusset plate attachment. If this happens to be in a tension zone, the tensile stresses may cause the crack to propagate.

Transverse Stiffeners

In the case of a welded plate girder, any weld perpendicular to the direction of applied stress is critical and must be inspected thoroughly. The reason is that any flaw in this kind of weld is a point of stress concentration transverse to the direction of the principal stress.

The weld attaching a transverse stiffener, by definition, qualifies as a category "C" fatigue detail. However, this weld is more critical when welded to a tension flange.

In riveted girders, the same rules apply as those used for gusset plates in riveted trusses. Rivet holes are points of stress concentration. The line of rivets is at a right angle to the direction of principal stress and are considered fatigue category "D".

Longitudinal Stiffener

Longitudinal stiffeners are critical only when used on a welded girder. Their function is to reinforce the web in the area of the compression flange and, as such, they are not significant unless used in a zone of stress reversal as mentioned above.

Because the welds connecting longitudinal stiffeners are parallel to the direction of principal stress, they are not in and of themselves critical. However, discontinuities or flaws in the weld may cause stress concentrations that can be perpendicular to the applied stress. Such a flaw may propagate under cyclic loading.

Floor Beam to Girder Connection Near an Interior Support

Whether inspecting a welded plate girder or riveted girder, these locations need special attention. In these regions, the movement of both flanges, the top flange by the slab and the bottom by the bearing of the main girder, is restricted. As a truck deflects the floor beam, its bottom flange is pushed toward the girder while the top flange is pulled away. This prying action causes out-of-plane bending in the girder web. Because the flanges of the girder are restrained, the bending in the web results in stresses which will exceed the yield point.

Repeated loading can, in time, cause cracking in the web of the girder. Because this occurs near support, the tension zone is the upper half of the girder. It is this portion of the web that must be checked out thoroughly.

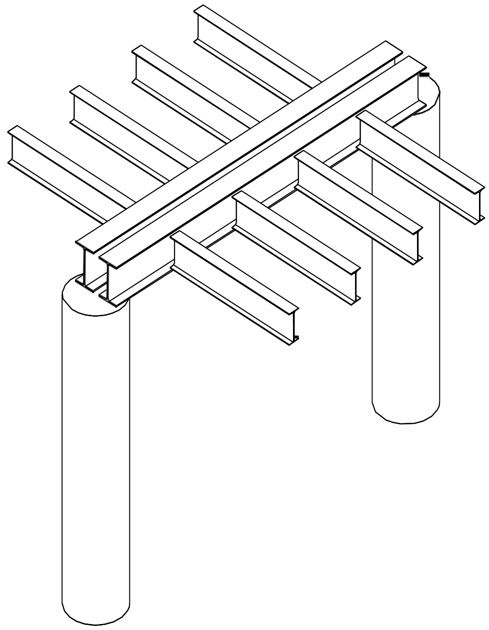
Welded Cover Plates

An abrupt change in the flange cross section is a stress riser which will cause a stress concentration in the fillet weld at the end of a cover plate. Whether or not the weld is brought around the end of a cover plate is of little consequence. The end of a cover plate has a low fatigue strength and is susceptible to cracking with or without a transverse end weld. The problem occurs mainly when the end of the cover plate is left in a region of positive moment (tension in the bottom flange).

7.4.3 Transverse Girder or Cross Beam and Steel Bent Caps

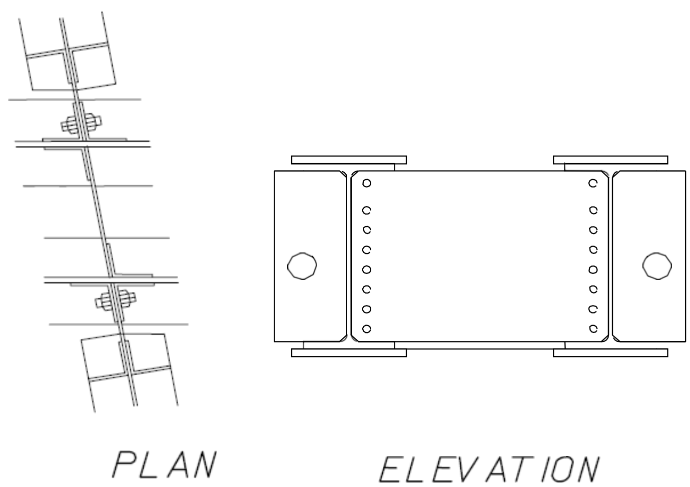
Transverse girders are used at overpasses where a long span length is needed, but clearance requirements will not allow the use of a bent cap plus the depth of the longitudinal beams. When two sections are used, it gives some measure of redundancy. However, should one section fail, the other cannot be expected to carry both spans. Therefore, whether a single member is used or not, the transverse girder must be considered fracture critical.

A good rule of thumb to tell the difference between a transverse girder and a steel cap is that the transverse girder transfers forces to the substructure from the bearings on the bottom of the girder. A steel cap has the bearings that transfer longitudinal girder loads on the top of the transverse member and is therefore considered a substructure member. Either way, both are considered fracture critical members by definition.



TRANSVERSE GIRDER

As a simply supported beam, the bottom half of the entire girder should be inspected closely. Special attention should be given to the stringer connections. The prying action mentioned in the discussion on the floor beam connection in a two-girder system can occur here too if a connection plate is used with rivets or bolts. If the connection is pinned, as shown below, this pin will eliminate this problem. Also, the ends of welded cover plates are critical details and should be treated as such while inspecting transverse girders.

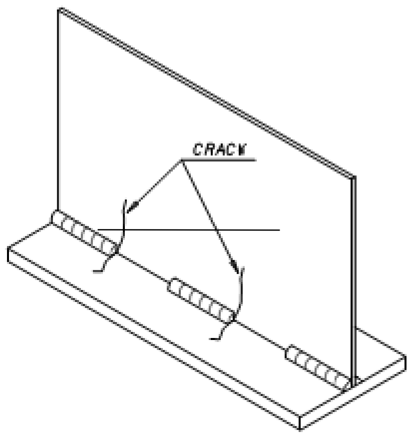


BEAM CONNECTION DETAIL

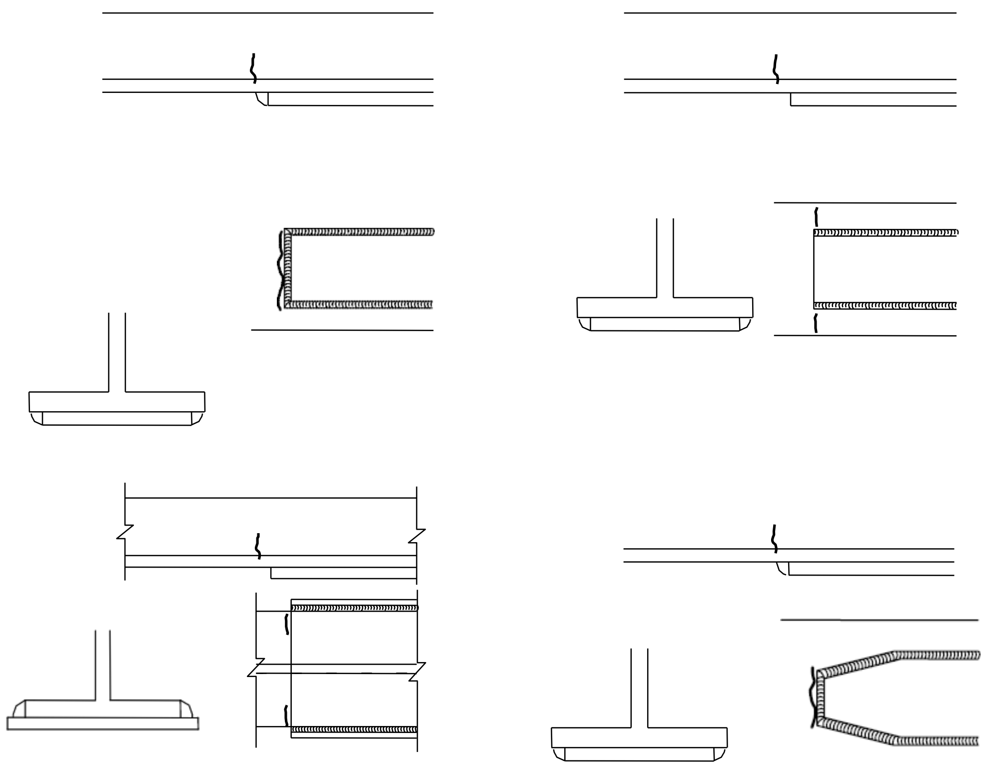
During the inspection of the structure, the inspector should be concerned with details and problem areas that influence the health and strength of the bridge. Some of these details and areas are summarized below.

Examples of Details That Should be Checked Closely Are:

1. Intermittent welds between the web and tension flange.

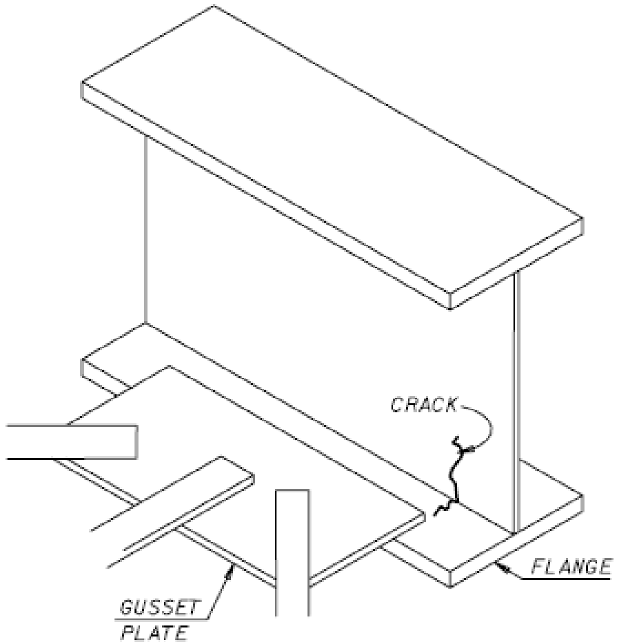


2. Areas of sudden change of cross-section. Examples, near the ends of cover plates.

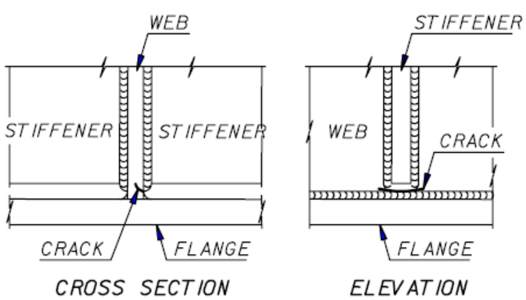


3. Location of stress risers such as nicks, scars, flaws, and holes that have plug welds, irregular weld profile, and areas where the base metal has been undercut during welding.

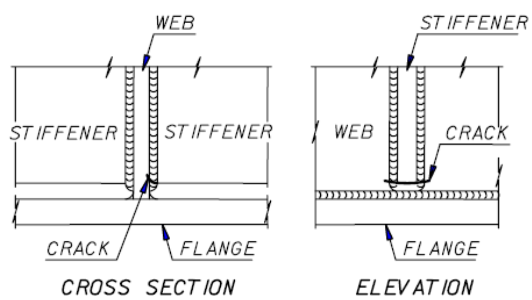
4. Locations where stiff bracing members of horizontal connection plates are attached to thin webs and girder flanges.



5. Gusset plates, improperly coped members re-entering corners, and the gap between web stiffeners and flanges.

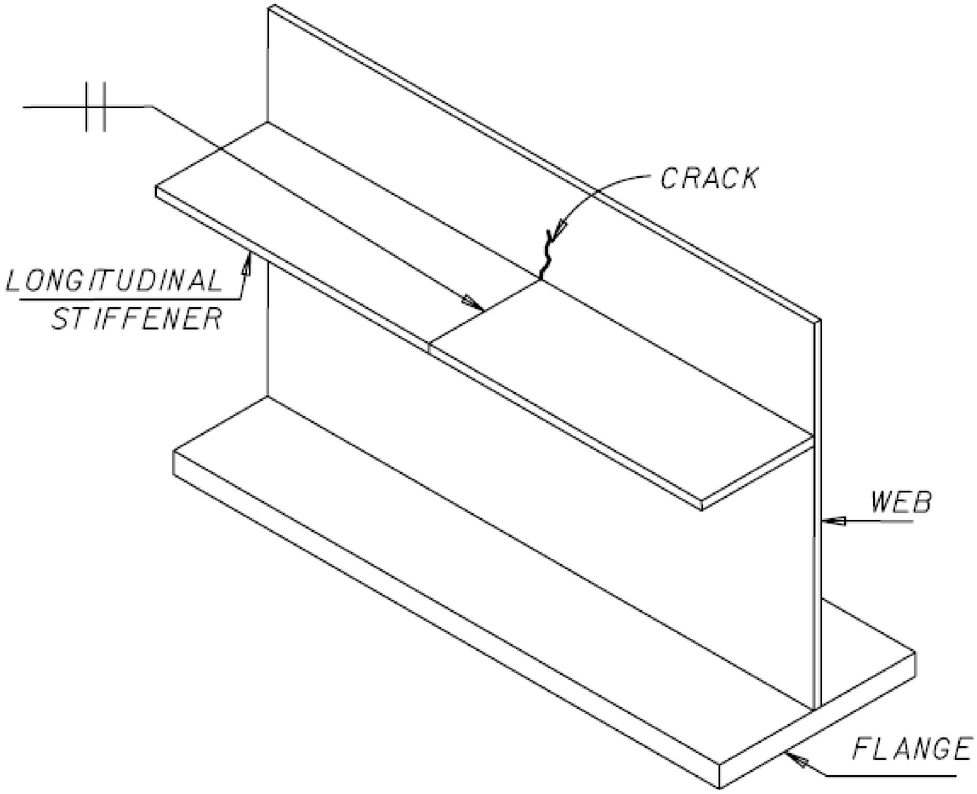


Schematic of crack at end of stiffener welds.

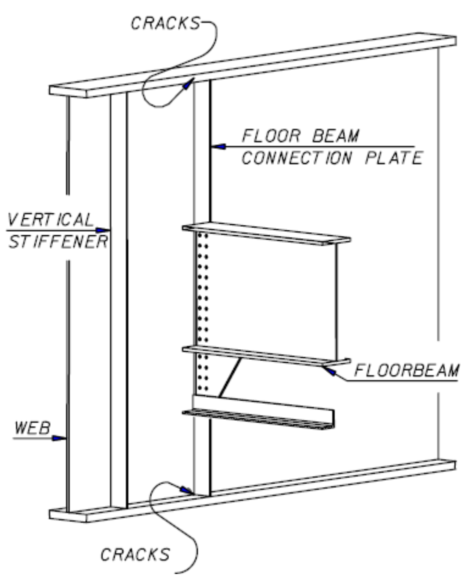


Schematic of crack at end of stiffener into weld (and web).

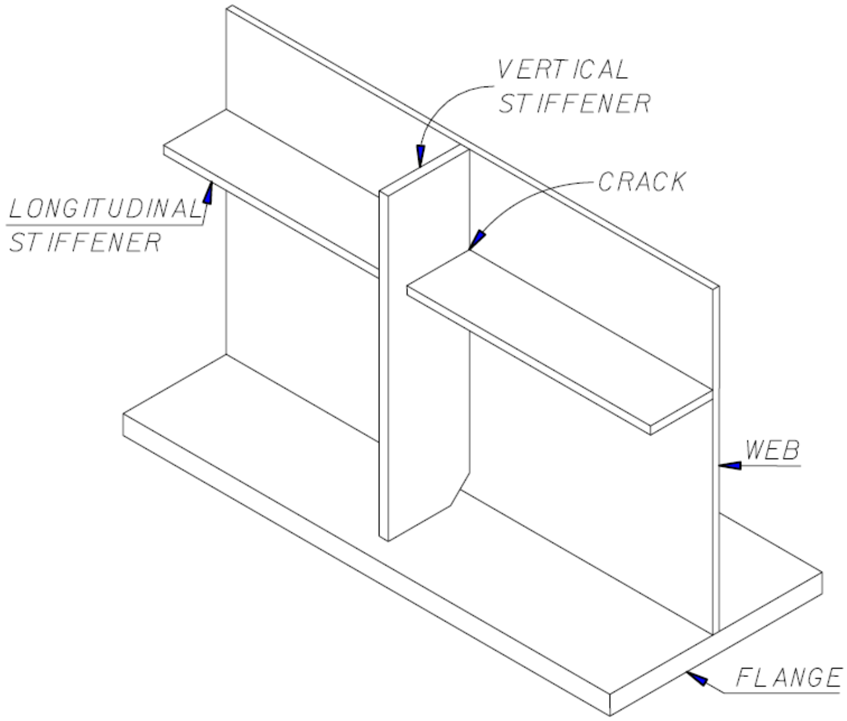
6. Stiffeners that have been connected together with butt welds.



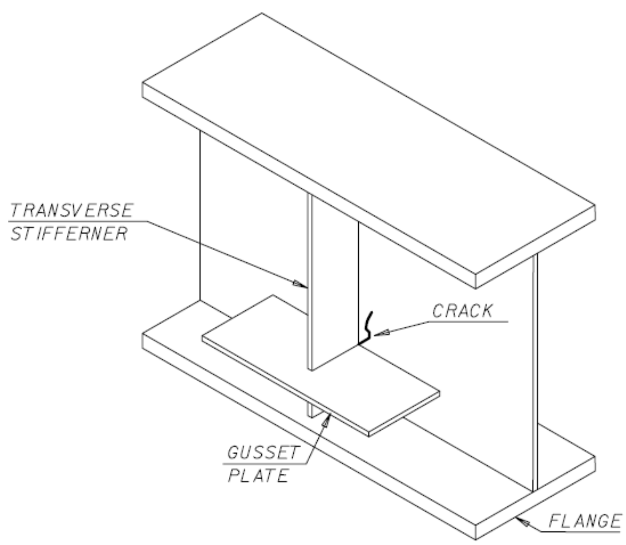
7. The web adjacent to a floor beam connection plate.



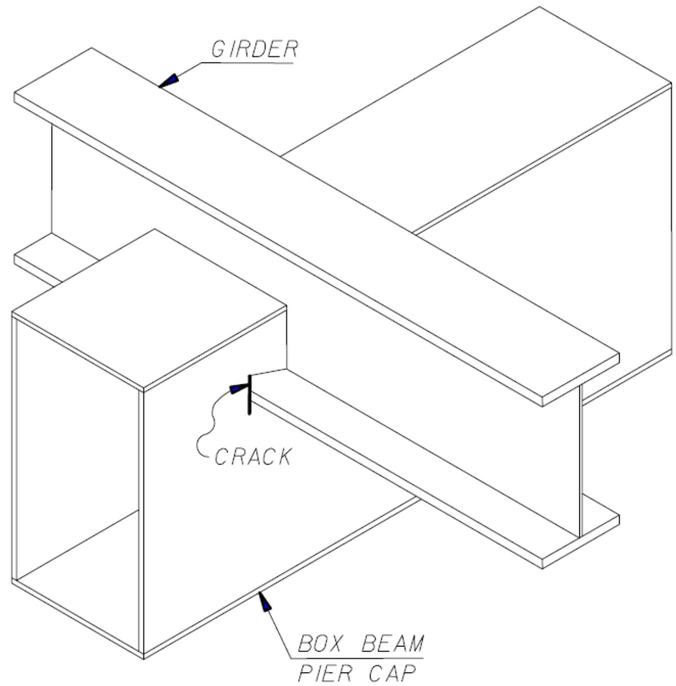
8. Longitudinal and vertical stiffener intersections and intersecting welds.



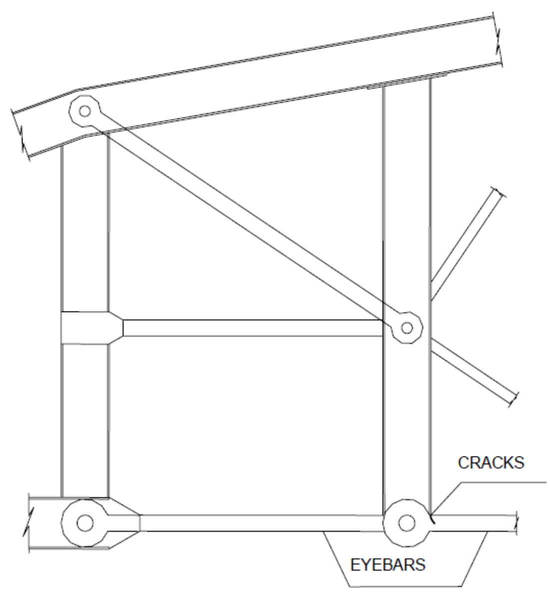
9. Location of welds at gusset plate-transverse stiffener-web or flange intersections.



10. Flanges that pass through a web, such as a girder flange passing through a box girder pier cap.



11. Eyebars.



Areas Where Corrosion is likely to give problems are:

- Under deck joints.
- In the areas around scuppers and drainpipes.
- On flat surfaces where debris accumulates.
- At overlapping steel plates.

- At corners of steel angles and channels.

Other Special Details That Should be Given Attention During FCM Inspection Are:

- Tack welds on bolted or riveted connections.
- Unfilled holes or holes filled with weld metal.
- Field welds in tension zones.
- Suspicious attachments made in tension zones, such as utility attachments.
- Fabricator stamps on girders.

7.4.4 (Transverse Girder) and Pin & Hanger Inspection Procedures

In June 1983, a failed hanger pin initiated the collapse of one span on the Mianus River Bridge on the Connecticut Turnpike. The incident resulted in the deaths of three motorists. Following the collapse, there was an immediate increase in interest in the inspection and condition assessment of bridge hanger pins.

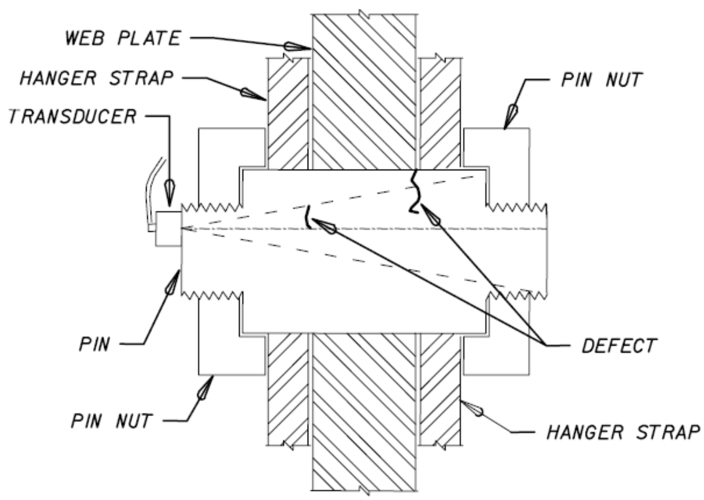


Figure 1: Pin and Hanger Assembly

Hanger pins are structural elements connecting the suspended span of a bridge to the fixed cantilever arm of the same bridge, a diagram of a pin and hanger assembly is shown in Figure 1: Pin and Hanger Assembly. The primary function of a pin and hanger connection is to allow for longitudinal thermal expansion and contraction in the bridge superstructure. These connections are designed to support the transfer of shear forces from the suspended span into the anchor span. As long as the connection is operating properly, neither shear forces from the anchor span nor moments from either span can be transmitted across the connection. In general, loads from the suspended span are transmitted into the anchor span as follows: The loads travel from the suspended girder web reinforcement plate to the lower hanger pin and into the hanger plates (labeled strap in the diagram). From the hanger plates, the load is then transferred into the upper hanger pin and finally into the anchor girder web reinforcement plate. This load path creates two shear planes in each pin – one at each of the intersections of the web reinforcement plate and hanger plate. If a pin were to fail along both shear planes, the portion of the bridge section suspended by that pin would be unsupported.

Pin and hanger connections are typically located directly beneath bridge expansion joints. Consequently, they are frequently exposed to water, de-icer and debris that fall through failed joints. The presence of moisture in the confined interfaces between the hanger plates, web and around the pins can lead to pack rust and corrosion of both of these elements and of the pin, at the critical shear planes. This corrosion can have two detrimental effects on the pin. First, the cross-section of the pin can decrease due to corrosive section loss. This corrosion produces pitting that may act as a crack-initiating site. Second, corrosion can effectively lock the pin within the connection so that no rotation about the pin occurs. This can lead to large torsional stresses, within a reduced section in the pin. The torsional stresses, combined with the shear stresses, provide a likely location for the development and propagation of cracks and the eventual failure of the connection. Therefore, the most likely location for a crack to be initiated is at the hanger to the web interface. This area of interest is closely examined using the Ultrasonic method.

Pin and hangers are not fracture critical unless they are used in conjunction with an already fracture critical member (e.g., main girder in a two-girder system or a truss). However, they are often used in multi-beam bridges. There have been instances where the failure of one assembly has led to a domino-effect failure of successive assemblies. For this reason, in Montana, they have been given a high priority for a fracture critical type inspection whether used in a fracture critical bridge or not. All bridges using pin and hangers will be included in this program.

A pin and hanger assembly is used to suspend a span from a cantilevered arm. The main reason for using this type of design is that it allows for economy in selecting structural members. It also lets us move the expansion joint out away from the bent. This keeps the joint from leaking on an abutment or pier. The problem is that, if the joint was going to leak on the abutment or pier, it would now leak on a pin and hanger assembly.

The thermal expansion and contraction that takes place in this type of bridge is accounted for in these assemblies. The hanger rotating around the pins allows for this movement. Water, and especially water in the presence of salt, will set up a corrosive action between the pin and hangers. This corrosion can build up until the hangers' ability to rotate becomes completely frozen. The inability for these details to move as the bridge expands or contracts will cause stresses in both the pin and hangers. Stresses could precipitate cracking and eventual failure.

Corrosion is important, but the bearing of stresses that these details experience can also cause problems that, in most instances, will be hidden from view. For this reason, the pin and hanger assembly should always be inspected using ultrasound during a Pin and Hanger Inspection.

Visual inspection is used only as a method to gather obvious information. Pin and hanger assembly, due to access limitations, visual inspections will not detect a defect that is not open to the surface or is covered with paint, rust or organics. The pins primary area of interest is the body of the pin, and is inaccessible due to the hanger assembly configuration. Another inspection option is to measure the position and certain gaps and offsets between various pin and hanger components and note any unusual or inconsistent measurements. They can also be compared from cycle to cycle. See Chapter 3 for measurement forms that can be used for suspect pin and hangers.

Ultrasonic inspection is one of the most reliable methods used to inspect pins, and has become the primary method of performing a detailed inspection of an in service hanger pin. Ultrasonic Testing offers a reliable method by which pins may be inspected in the field without the removal of the pin being required. The portability of the equipment, reliability, and cost to complete an inspection makes Ultrasonic Testing the logical method for inspection. One exception to this would be that some pin and hanger assemblies have pin caps held in place via a through bolt which also restrains the pin from shifting and the hanger plates from spreading. The pin cap covers the end of the pin, so that neither visual nor ultrasonic inspection of the pin end can occur, unless the cap is removed. This should only be done after a separate temporary restraining clamp or system is in place to prevent the hangers from spreading and falling off the pins.

Ultrasonic standards are fabricated using precise tolerances with induced defects of a known dimension. Calibrations are performed to ascertain reliability and sensitivity of the system used to inspect the pin.

7.4.5 Inspection

Visual Inspection Procedures

Visually inspect Pin & Hanger assembly for the following:

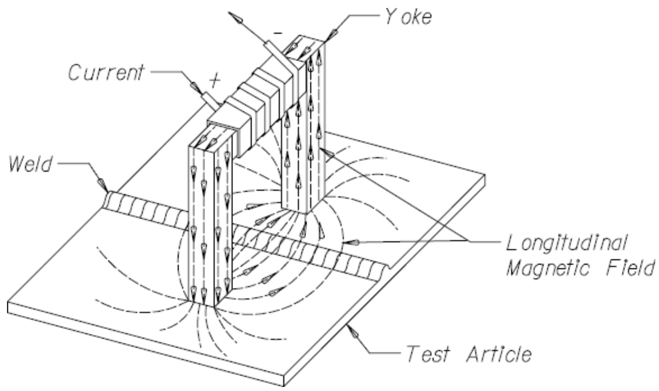
- Loose or missing nuts
- Pack-rust behind the hanger
- Proper movement of the hanger
- Deformations of the hanger assembly
- Cracks
- Nicks or gouges

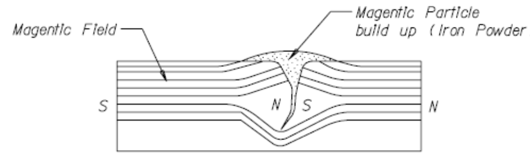
Ultrasonic Inspection Procedures

Note that ultrasonic testing of pin and hanger assemblies is performed through a separate contract with its own special scope requirements.

7.5 Magnetic Particle Procedure Yoke Method

Magnetic Particle Testing (MT) is a nondestructive testing (NDT) method of revealing surface and slightly subsurface discontinuities in materials that can be magnetized. The testing method is based on the principal that magnetic flux in a magnetized object is locally distorted by the presence of a discontinuity. This distortion causes some of the magnetic field to exit and reenter the test object at the discontinuity. This phenomenon is called *magnetic flux leakage.* Flux leakage is capable of attracting finely divided particles of magnetic materials, which in turn form an outline, or indication of the discontinuity.





Montana Department of Transportation (MDT) personnel performing MT on state-owned structures or equipment will be qualified in accordance with this procedure prior to performing any inspections or interpretations of discontinuities.

7.5.1 Inspector Requirements

Inspectors will be required to complete a training course that will qualify them to inspect structures and assemblies by the Yoke method.

Inspectors will complete a method specific MT with a passing score of 80% weighted between a general, specific and hands on practical test.

Level One (I)

Level I Inspector will complete eight (8) hours of classroom training and four (4) hours hands-on equipment specific training. Twenty (20) hours field training will be conducted with a current American Society of Nondestructive Testing (ASNT) Level II inspector.

MDT Level I individual will be qualified to properly perform specific calibrations, specific NDT, and specific evaluations for acceptance or rejection determinations according to written instructions. Level I inspectors may inspect materials but only qualified Level II or III inspectors will be allowed to interpret results and record results.

Level Two (II)

Level II Inspector will complete four (4) hours of classroom training and four (4) hours hands-on equipment specific training. Twenty (20) hours field training will be conducted with a current ASNT Level II inspector.

MDT Level II individual will be qualified to set up and calibrate equipment and to interpret and evaluate results with respect to applicable codes, standards and specifications. The NDT level II should be thoroughly familiar with the scope and limitations of the methods for which qualified and should exercise responsibility for on-the-job training and guidance of trainees and NDT level I personnel. The NDT level II should be able to organize and report the results of NDT tests.

Level Three (III)

Level III Inspector certification is administered by ASNT.

MDT Level III individual should be capable of developing, qualifying and approving procedures, establish and approving techniques, interpreting codes, standards, specifications and procedures; and designating the particular NDT methods, techniques and procedures to be used. The MDT Level III should be responsible for the NDT operations for which qualified and assigned and should be capable of interpreting and evaluating results in terms of existing codes, standards and specifications. The MDT Level III individual should have sufficient practical background in applicable materials, fabrication and product technology to establish techniques and to assist in establishing acceptance criteria when none are otherwise available. The MDT Level III should have general familiarity with other appropriate NDT Methods, as demonstrated by an ASNT Level III Basic examination or other means. The MDT Level III, in the methods in which certified, should be capable of training and examining MDT Level I and II personnel for certification in those methods.

7.5.2 Material Testing

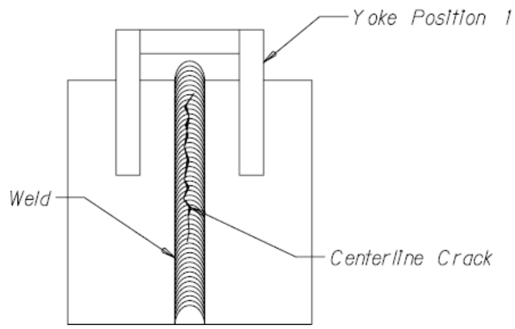
The test or (inspection) consists of six basic operations.

1. Calibration
2. Pre-cleaning
3. Establishing a suitable magnetic flux in the test object (Induced Field)
4. Apply magnetic particles
5. Examine the test object and interpret inspection results
6. Record and report the results.

Inspectors will be limited to the use of 110VAC portable test equipment and B300 AC Yoke. Equipment is to be calibrated using the ten (10) pound calibration block after eight (8) hours of continuous use or the beginning of each shift.

1. **Calibration**
   Yoke calibration will vary based on the yoke model and manufacturer. Follow manufacture-specific procedures for yoke calibration.
2. **Pre-cleaning**
   Remove all loose and flaking paint, rust, organics, water or anything that might interfere with the inspection process. Approved processes for removal are power wire brush, hand brushing or flapper disc sanding pad. MT inspection may be performed with a light covering of paint however; approved method would be to thoroughly clean the area as prescribed. Clean three (3) inches around the area to be inspected in all directions. Relevant indications that extend into the unclean area will be suitably cleaned. Care should be taken not to remove base material during cleaning.
3. **Inducing a Magnetizing Field**
   Magnetic Fields induced into the inspection area will be of the (Continuous Method) by energizing the Yoke and inspecting while AC current is on.
4. **Applying Magnetic Particles**
   Magnetic particles will be applied using the dusting bulbs or bottles. A light coating of particles applied will form flux lines and be attracted by defects in the inspection areas. Inspection will be conducted with the unaided eye. Lighting conditions may be enhanced with a flashlight or inductive light on the yoke.

5. Examining the Test Object and Interpreting Results

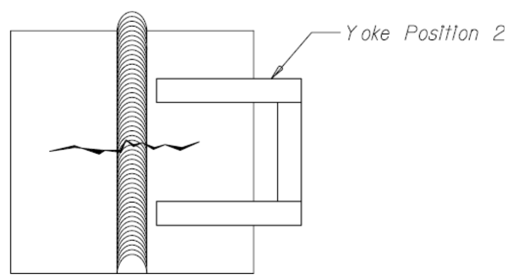


Note:
Yoke legs are transverse of the area of interest.

Position 1 – Cracks will appear perpendicular to the leg orientation

The yoke will be positioned such that suspected defect and the yoke legs are perpendicular to each other.

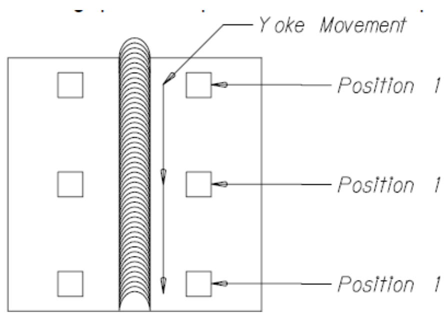
The yoke will be positioned such that the suspected defect and the yoke legs are perpendicular to each other. Rotate the yoke 90 degrees and inspect with the yoke in this position. This will reveal indications transverse of position 1.



Note:

Rotate yoke 90 degrees from position 1.

Yoke legs positioned parallel with the weld to produce crack indication.

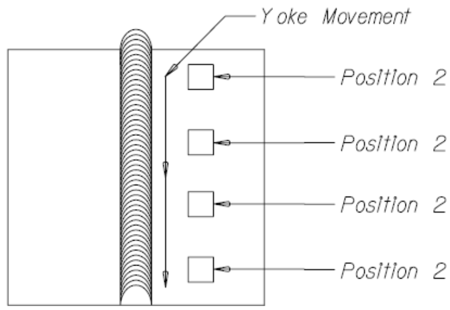


Note:

Maximum leg spacing 6 inches overlap. Spacing 5 inches overlap inspection 1 inch.

The yoke must be moved over the inspection area with an overlap of the legs by one (1) inch from

Position 1.



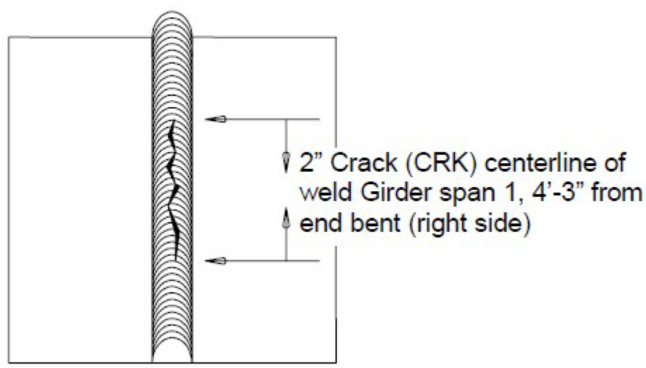
Note:

Maximum leg spacing 6 inches overlap. Spacing 5 inches overlap inspection 1 inch.

Rotate the yoke 90 degrees. Position 2 movement will overlap 1 inch.

6. Record and Report Indications

Relevant indications that are revealed and hold powder will be recorded on Magnetic Particle Inspection Report form. Drawings or photos to be attached on a separate page(s). Record length and orientation. Mark the indication on the inspection piece at the ends of the crack, do not mark over the defect (crack). Mark the length of the indication on the test piece.



Typical Defect Marking

MONTANA DEPARTMENT OF TRANSPORTATION
BRIDGE BUREAU
MAGNETIC PARTICLE INSPECTION REPORT

Bridge Number:	Bridge Name:	
Bridge Location:		
Inspector:	ASNT Level:	Company:
Specification: In accordance with ANSI/AWSD1.5 -1996 Bridge Welding_Code [ ]		
Specification: In accordance with ANSI/AWSD1.5 -1996 Bridge Welding Code [ ]		

EQUIPMENT DATA					
Unit Mfg:	Model #	Serial #	Cal Date:		
Yoke:[ ]		Leg spacing: "			
METHOD					
Dry [ ]	Wet [ ]	AC [ ]	DC [ ]	Residual [ ]	Con t [ ]
PARTICLE					
Mfg:	Type:	Color:	Batch #		

Girder	Span	Pier	Indication #	Type	Left Side	Right Side	Accept	Reject

Additional space to orient the indications may be attached on a separate sheet

Comments:

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of:

ANSI/AASHTO/AWS			
Inspector/	Signature	Level	Date:
Review/	Signature	Level	Date:

Chapter 7 Appendix

Appendix 7A
Climbing Bridge Inspection Guidance

General scope guidance/expectations for the Climbing Inspections

- Inspection reports will be sent to the MDT contract manager for QC review within 75 days of the inspection.
- Upload the Inspection Procedure to the "Inspection Procedures" folder in the bridge's SMS Multimedia Tab.
- Avoid duplicating information, data and photos in the inspection reports and summaries that is already contained in SMS, except for the NBI values and other content guidance recommended in the templates provided.
- Inspection report will be in accordance with the table of contents template provided.
  - Include both NBI Bridge ID # and the MDT Asset # on the cover sheet or first page of any documents uploaded to SMS.
- Format the FC Inspection Procedure in accordance with the template provided in the following pages.
- If applicable, the Inspector will determine if an Underwater inspection is required per Chapter 9 and update the appropriate attributes in SMS. Include comments about any change in channel inspection in the summary.
- Probe and Wade channel inspections will be performed with Routine and FC Inspections when applicable. See Chapter 9 for Probe and Wade Inspection requirements.
- Review and update all Inspector-responsibility attributes in SMS.
- Where applicable, consider most recent Underwater Inspection report in the evaluation of the NBI rating for Item 60 (Substructure) and Item 61 (Channel). Any significant channel defects noted in the most recent Underwater Inspection will be discussed, as well as an additional / worsened channel defects at the time of the Climbing Inspection.

Updated Climbing Bridge Inspection Guidance will be included in the final version of this manual.

Climbing Bridge Inspection Full Report Guidance

1 INTRODUCTION

2 INSPECTION FINDINGS

Subdivide the bridge into appropriate elements. Compare organization to previous climbing inspection report, if one exists. This will change from bridge to bridge, but the intent is that a specific bridge will have similarly formatted reports from one inspection cycle to the next.

2.1 Deck

2.2 Superstructure

2.3 Substructure

2.4 Etc.

3 CONCLUSION

Reports will include the following information in the Conclusion section:

- NBI ratings for Deck (58), Super (59), Substructure (60), Channel (61)
    - Substructure (60) will be an aggregate of the above water and below water condition; so where applicable, the Inspector will consider the most recent underwater inspection report available when evaluating the rating.
- NBI (41) Structure Open, Posted, or Closed to Traffic and a comment on if bridge is properly posted according to load rating values in SMS.
- A recommendation to review the load rating of the bridge, where applicable.
- Underwater inspection recommendation if applicable (Only if MDT(061) is currently blank).
    - If the condition of the bridge was based on the above water condition only then a recommendation for an underwater inspection will also be included.
- Note if the Fracture Critical Inspection Procedure was updated or state that no changes to the FC procedure were needed.
- Repair/maintenance recommendations

APPENDICES

APPENDIX A – Fracture Critical Member Diagram

Include defects and a Floor Beam Inspection and Reporting Form for each floor beam.

APPENDIX B – Photos (Avoid repeating any photos uploaded to SMS)

APPENDIX C – Appendix C and additional appendices will likely be specific to individual bridges. Review previous routine inspection report and stay consistent where applicable. If this information is included in a previous inspection under "Appendix D", stay with that naming convention.

MDT Structure ID	
NBI Structure ID	
Inspection Frequency	
(6A) Feature Intersected	
(7) Facility Carried	
(9) Location	
Latitude	
Longitude	
Inspection Procedures Update Info	
Procedures Edited Date	
Procedures Edited By	

Fracture Critical Inspection Plan – Template

Note that this Plan – Template is currently being updated internally by MDT.

1. FRACTURE CRITICAL (FC) INSPECTION PROCEDURE

Example:

I. *Review the following documents in SMS(BrM) and discuss any questions with MDT:*
   a. *FC inspection Procedure*
   b. *Previous inspection report*
   c. *Most recent underwater inspection report if applicable*
   d. *Any other Special inspections or Repair items occurring since the most recentfracture critical inspection.*

II. *Team leader holds a pre-inspection meeting to review procedure with team*

III. *Notify MDT contact of anticipated inspection schedule*

IV. *Once team arrives onsite, team leader reviews safety risks and precautions with teambefore beginning inspection work.*

V. *Traffic control set up*

VI. *Team members perform inspection roles as directed by team leader and according to FC inspection sequence:*

VII. *Once inspection of all elements is complete, Onsite QC review performed.*

VIII. *Immediately notify MDT contact of any critical findings*

2. ON-SITE SAFETY RISKS AND PRECAUTIONS

Examples:

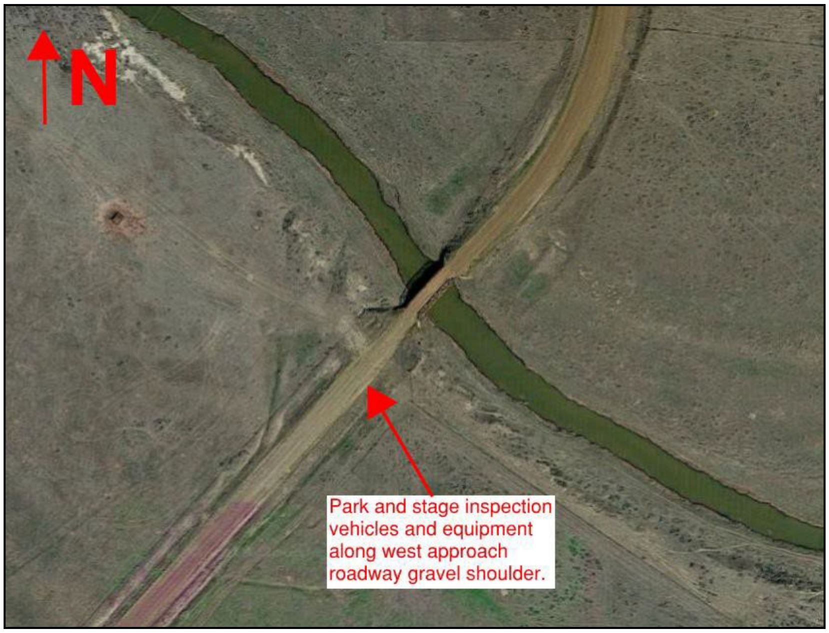
- *Loose riprap at Abutment 2 is a falling hazard*
- *Poor vertical sight distance on approach to the North*
- *High voltage lines present onsite*
- *Small roadway shoulder provides poor parking and staging areas*
- *Wildlife (Osprey nest, or other?)*

3. TRAFFIC CONTROL MEASURES NEEDED

4. EQUIPMENT NEEDED FOR ARM'S LENGTH INSPECTION OF FC MEMBERS

5. MANPOWER NEEDED FOR ARM'S LENGTH INSPECTION FOR FC MEMBERS

6. STAGING AREAS AND ACCESS LOCATIONS



In addition to a written description, an aerial photo (i.e. Google Earth screenshot) is preferredExample:

The gravel shoulder along the west approach roadway was used to park inspection vehicles and stage inspection equipment. Sight lines were good from both directions; however, caution shouldstill be used. Advanced warning signage was placed approximately 100 yards from bridge in both directions.

7. NOTIFICATION REQUIRED FOR LOCAL AGENCIES

Examples:
No notification required for local agencies
Fresno Reservoir Spillway – contact BLM and Sherriff
Indian Reservations – detail applicable requirements (i.e. business license, work permits,timelines)

8. PREVIOUS REPAIRS, RETROFITS, CRITICAL FINDINGS, AND FC RISK FACTORS

Risk Factor	**Comment** *(required if risk factor is applicable)*
Fatigue and fracture prone details	
Problematic materials	
Poor welding techniques	
Potential out-of-plane distortion details	
Previous cracking or repairs *Indicate source of prior cracking*	
Cold service temperatures	
Superstructure condition of 4 or less	
Subject to overloads or impact damage	
Load Posted	
Older service life	
Debris	
High ADTT (i.e., ADTT > 5,000)	

Example – if not captured above in the above table, include any issues noted during previous inspections as potential issues that should be closely inspected during subsequent inspection.

Additional factors identified as potential issues during previous inspections that should beclosely inspected during subsequent inspections:

9. GENERAL INSPECTION PROCEDURE COMMENTS

Examples:

- *Describe any NDT testing techniques that are required (i.e. dye penetrant, magneticparticle, etc)*
- *Notes about bridge orientation/numbering (i.e. truss panel points are labeled West toEast, L0 – L3 – L0')*
- *Excessive bird dropping hinder adequate inspection of critical members. Contact MDTand recommend to removal/cleaning prior to inspection*
- *Utility pipe requires aid to climb around*
- *4 floor beams and panel points are easily inspected from ground*
- *All floor beams require aid 6 times per floor beam*
- *Significant section loss to stringer ends. Start on stringer ends.*

10. FRACTURE CRITICAL MEMBER INSPECTION SEQUENCE

General sequence is acceptable, but it's encouraged to include a more detailed sequencedescription if warranted by level of complexity.

Example (general sequence):

The *following tasks should be performed as part of the bridge inspection:*

- *Mobilize to site and set-up signage at each end of the bridge to warn oncomingmotorists.*
- *Hands-on inspection of all primary members in the plane of the primary truss lines, and secondary bracing member connections.*
- *Cursory inspection of secondary bracing members, with hands-on inspection of any noted deficiencies.*
- *Hands-on inspection of floor beams, floor beam-to-stringer connections,*

and stringerends supported by substructure units. Cursory inspection of all other floor system elements.

- *Inspection notes and photographs of any noted deficiencies*
- *Required photos of approaches, portal view, elevation view, underside of superstructureand any posting signs with bridge in background.*
- *Element level inspection and NBI inspection of approach spans and substructure elements*

During the inspection, the bridge should be inspected for:

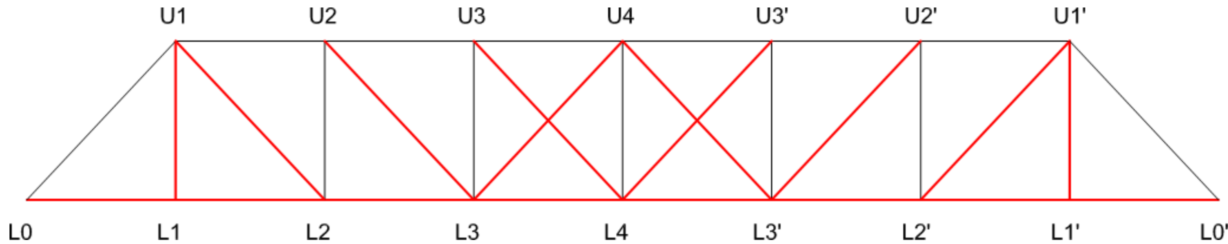
- *Steel deficiencies including corrosion, section loss, cracking of welds or base metal,bolting or welding issues, and load induced distortion or damage*
- *Concrete deficiencies including delamination, spalls, patched areas, exposed rebar,cracking, abrasion, wear, and load induced distortion or damage*
- *Timber deficiencies including checking, splitting, decay or section loss, distortions, cracks,shakes, and abrasions*
- *Substructure deficiencies including wingwall tipping, settlement, and scour*
- *Bearing deficiencies including corrosion, connection issues, movement, alignment, loss ofbearing area, and damage*

11. SKETCH OF BRIDGE WITH FRACTURE CRITICAL MEMBERS (FCM) IDENTIFIED IN RED

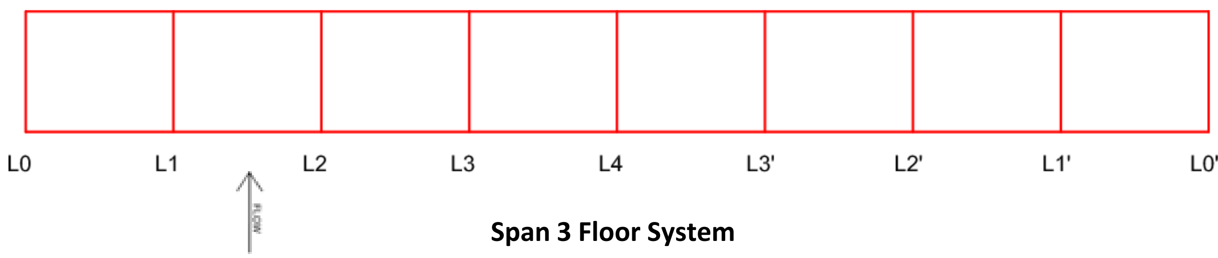
Show both truss elevation and floor system plan views. Two different examples shown below,either format is acceptable. Key things – make sure spans are labeled, indicate stream flow direction on floor system plan, only color present should be red to indicate fracture critical members. Please include a screenshot of the diagrams in the Inspection Procedures word document (rather than a separate document).

The following diagram shows all Fracture Critical Members (FCMs) in red. FCMs will beinspected at arm’s length per FHWA Requirements:

Example #1:

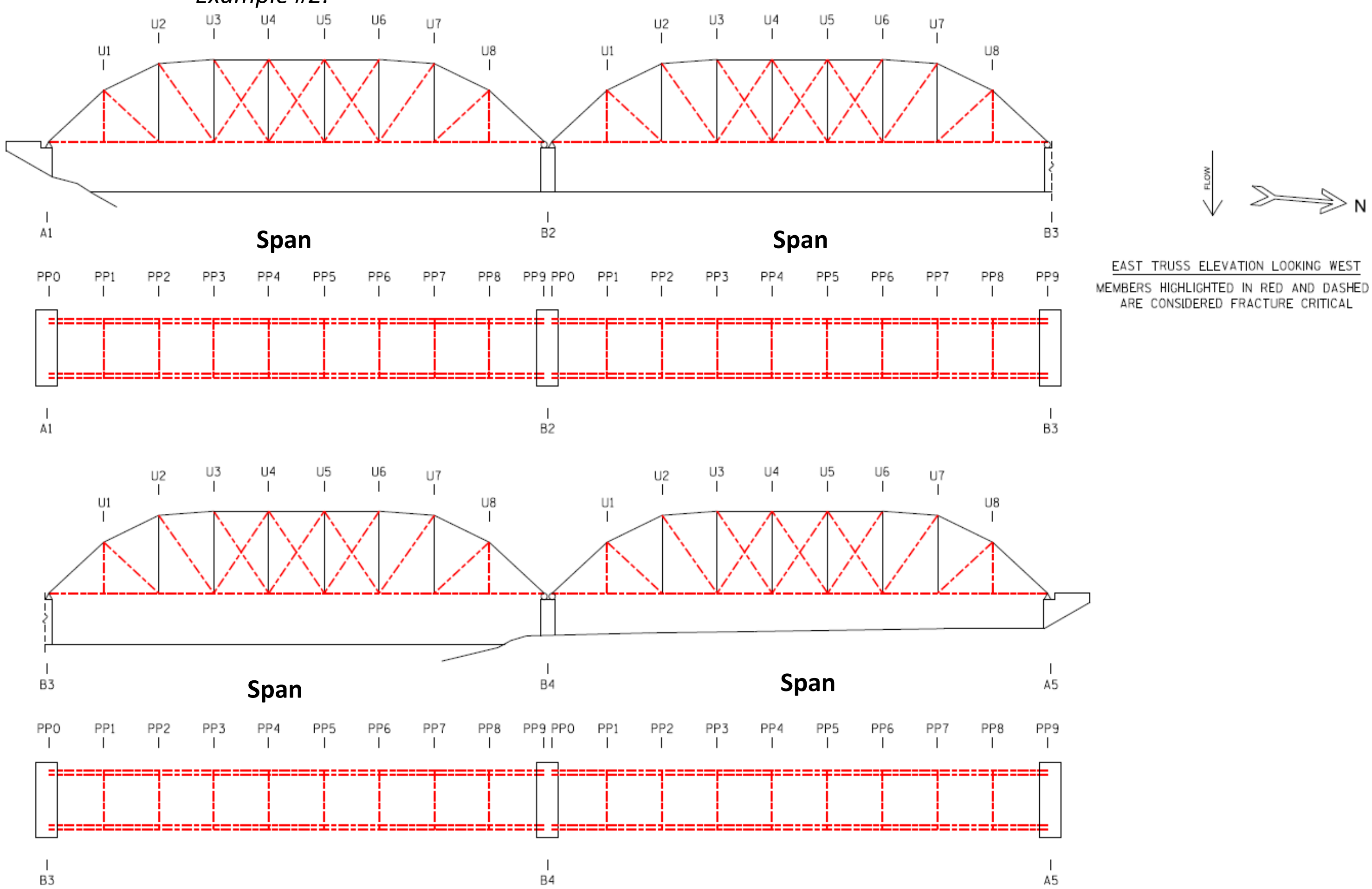


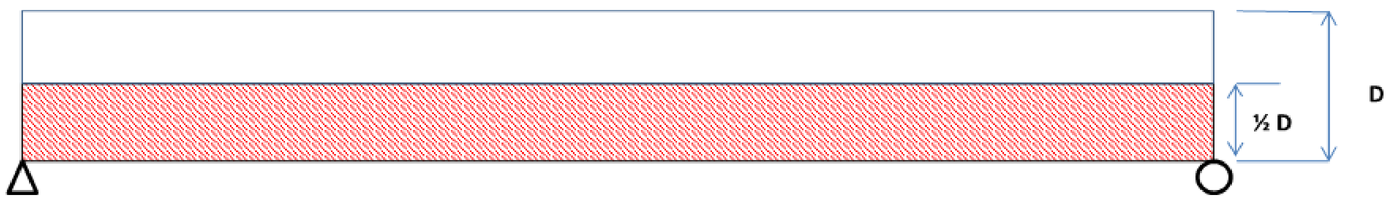
Span 3 Truss Elevation



Span 3 Floor System

Example #2:





Consider the fracture critical portion of the floor beam as the lower half of the beam depth, the portion below the neutral axis that is in tension. Note any defects and label the defect accordingly. Make sure and note that a defect isNear Face (NF), Far Face (FF) or Both Faces (BF). All notations will be recorded looking ahead on line. Use this drawing for trusses or two girders system bridges with solid rolled or built-up section floor beams.

Typical Floor Beam Comments:

Span	Panel Point	Inspection Comment	Photos
i.e. 1	*i.e. L0*	*i.e. Broken tie plate on North Truss*	*i.e. see SMS Element 152*

Span	Panel Point	Inspection Comment	Photos

Chapter 9 - Underwater Bridge Inspection

9.1 Background and Inspection Determination

This Chapter is unchanged from the 2018 BIRM, but will be updated for the Final 2022 BIRM. Note that the methods and procedures are changing.

9.1.1 Background

On Sunday, April 5, 1987 the center and east center span of the 542-foot-long bridge on the New York State thruway over Schoharie Creek in Montgomery County, New York, collapsed during a near record flood. About an hour and a half later the west center span fell into the water and the western-most span slid off the abutment. One semitrailer and four automobiles fell into the river after the first span collapsed, resulting in ten fatalities.

The investigation of the tragedy indicated that there was a cumulative effect of local scour around pier three over the last ten years. The bridge was designed with shallow spread footings and riprap to protect the piers.

Following the collapse of the Schoharie Creek Bridge, the Federal Register in Part 650-Bridges, Structures, and Hydraulics, added the following:

"The individual in charge of the organizational unit that has been delegated the responsibilities for bridge inspection, reporting and inventory shall determine and designate on the individual inspection and inventory records and maintain a master list of … those bridges with underwater members which cannot be visually evaluated during periods of low flow or examined by feel for condition, integrity and safe load capacity due to excessive water depth or turbidity. These members shall be described, the inspection frequency stated, not to exceed five years, and the inspection procedure specified."

This statement is the basis for Montana's underwater inspection program. All states are required to have criteria and a master list of structures requiring underwater inspections.

In addition, the December, 2014 review of the Montana bridge inspection program found MDT to deficient under Metric 15. A review of MDT's bridge files found that "for all bridges over water, not all waterway information is collected and maintained (filed)". The waterway information in question was stream cross-sections. Due to this finding, MDT created a plan of action to correct this deficiency. The guidance below is intended to clarify MDT's policy on underwater inspection requirements, and correct the deficiency under Metric 15.

9.1.2 Underwater Inspection Purpose

The purpose of an underwater inspection of a bridge is twofold:

1. To assess the condition of those substructure units under water
2. To determine the bridge's susceptibility to scour

9.1.3 Underwater Inspection Determination

A bridge with substructure elements in water that is more than two feet deep year-round requires an underwater inspection.

Bridges whose substructure units at some time are dry or in very shallow water (making a full inspection possible without the use of special equipment) do not require an underwater inspection unless NBI item 113, Scour Critical Status, is coded as a 3. This includes single-span bridges where the abutments are not in the water.

If NBI item 113 is coded as a 3, regardless of whether the substructure units are dry or in very shallow water at the time of the inspection, cross-sections are required. This means that all bridges with NBI item 113 coded as 3 require an underwater inspection.

If element 900, Scour, has been added to the bridge, an underwater inspection is required.

If any undermining of the abutments is present, regardless of whether they are in the water when the inspection is done, an underwater inspection is required.

Once it has been determined that a bridge requires an underwater inspection, it will be placed in one of two categories:

1. Type 1 Underwater Inspection
2. Type 2 Underwater Inspection

The first determination an inspector must make is whether the bridge requires underwater inspection. See the guidelines above to determine whether a bridge requires underwater inspection. If a bridge does not meet the requirements above for an underwater inspection, the inspector may still do underwater inspections on the bridge if they are deemed necessary.

Keep in mind the time of year you are looking at the bridge, and what it may look like during a different time of the year.

Example: you're looking at a bridge in March trying to determine whether it requires an underwater inspection. The substructure units are in 3 to 4 feet of clear water, and for that reason you feel it requires a Type 1 Underwater Inspection. Consider the possibility that in October or November, a lower water level will allow complete visual access to all portions of the bridge. If – in your judgment – this is the case, the bridge does not require an underwater inspection. The regular inspection, however, MUST be conducted when the water is low and all of the substructure units can be visually inspected.

Next, the inspector needs to determine what kind of underwater inspection is required. On bridges where the substructure units remain under water year-round, the inspector must determine whether at some time it will be possible to adequately inspect all underwater portions using waders or a boat. If the answer is no, the inspector will notify the Bridge Management Section. Bridge Management Section personnel will review the recommendation, and change the underwater inspection requirements as needed.

9.1.3.1 Type 1 Underwater Inspection

Bridges that require an underwater inspection and can be inspected by personnel using special equipment (waders, boat, fathometer, probe), qualify for Type 1 Underwater Inspections.

The inspector must be able to fully evaluate the condition of the substructure unit using waders or working from a boat. To accomplish this, the water must be clear enough to allow a thorough visual examination of all substructure units. The inspector must be able to perform any cleaning which may be necessary to access all portions of the substructure unit.

If the water is not clear enough for a full visual inspection, it must be shallow enough to allow inspectors to feel the condition of all substructure units and determine the possibility of undermining.

These bridges will be given a 48 month inspection interval. Adjustments to the frequency of these inspections will be made if it is decided that the bridge requires more intensive monitoring.

9.1.3.1.1 Performing Type 1 Underwater Inspections

In the case of a pile cap or spread footing, the inspector will indicate to what extent, if any, the footings are exposed or undermined. The inspector will also record the condition of the underwater substructure elements and note the depth of any localized scour.

In the case of driven piles or drilled shafts, the inspector will determine the condition of the underwater substructure elements, and note the depth of any localized scour at the piles or shafts.

Type 1 Underwater Inspection – Streamflow Condition

The Type 1 Underwater Inspection form in SMS will be filled out to indicate the condition of the items listed in the form. Fields to fill out include inventory items such as the number of piers, pier width, and pier nose shape; and inspection items such as the angle of attack, whether flow is impinging on the abutment or wingwall, etc.

Type 1 Underwater Inspection – Element Condition

The condition of elements that are underwater, such as piles and footings, will be noted and entered into the inspection form. Only those elements underwater need to be inspected during an underwater inspection.

Type 1 Underwater Inspection – Cross-Sections

Inspectors will take cross-section measurements of the streambed along the upstream face of the bridge during all Type 1 Underwater Inspections. These cross-sections may be taken using survey equipment or using a survey rod or sonar device to determine the depth of the water at each point and measuring the vertical distance from the reference point to the water level. The reference point for all cross-sections is the paving notch at centerline at abutment 1. See figure 9.1.3.1.1-1 for a sketch showing the cross-section reference point. Cross-section measurements will be entered into the appropriate form in the Bridge Management System.

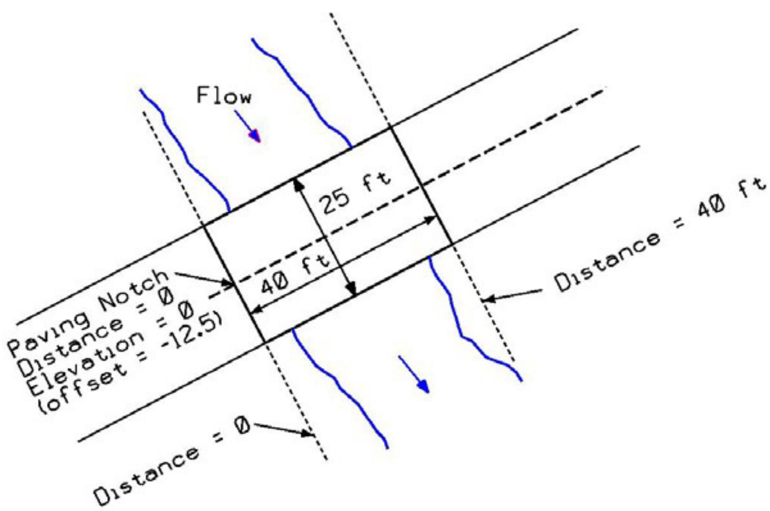


Figure 9.1.3.1.1-1

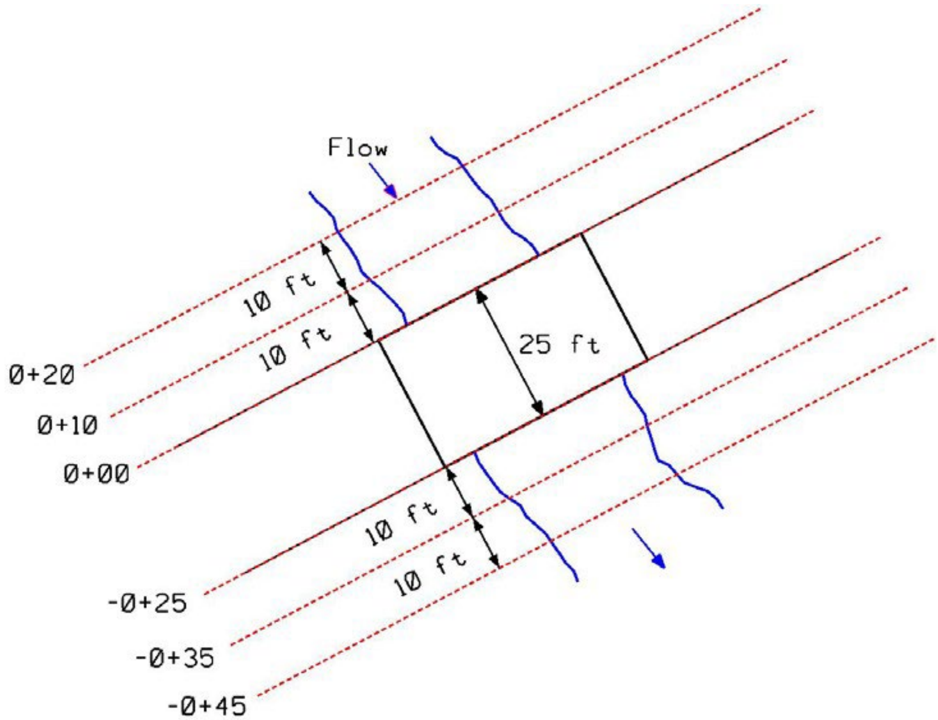


Figure 9.1.3.1.1-2

Cross-sections may also be taken farther upstream or downstream of the upstream face of the bridge as needed. These cross-sections will be entered with an offset measured from the upstream face of the bridge. The distance from the upstream face of the bridge will be entered as an offset. A offset distance upstream will be entered as a positive number, and the distance downstream will be entered as a negative number. See figure 9.1.3.1.1-2 for more information.

9.1.3.2 Type 2 Underwater Inspection

Bridges that require an underwater inspection, but cannot be inspected using Type 1 Underwater Inspection methods require inspection by a diver. Diving inspections are performed by consultants under a contract managed by the Bridge Management Section in Helena. Diving inspections include stream cross-sections taken by the consultant and entered into SMS using the procedures for cross-sections as described above for Type 1 Underwater Inspection - Cross- Sections.

Type 2 Underwater Inspections are given a 60 month inspection interval.

Streams are dynamic, and always changing their position, shape and other morphological characteristics with variation in discharge and the passage of time. When a channel at or near a bridge is modified, this local change frequently causes modification of the channel characteristics both upstream and downstream. Conversely, channel modifications above or below the bridge can affect channel characteristics within the bridge crossing. Understanding stream processes and the stream scour and stability factors will assist the inspector coding items as related to the element level inspection, NBIS inspection and the MDT Scour Appraisal.

Stability

Rivers and streams are dynamic and always changing the position, shape, and other characteristics with discharge and the passage of time. When a channel at or near a bridge is modified, this local change frequently case modification of channel characteristics both upstream and downstream.

Stream stability is dependent on several factors. Each factor relates to stream stability.

Stream Size

Flow depth tends to increase with increasing stream size. The potential for scour increases with increasing depth. Lateral erosion potential also increases with increasing stream size.

Flow Habit

Ephemeral	Flows in direct response to rainfall (including intermittent streams)
Perennial, but Flashy	Flows all or most of the year, but responds to precipitation by rapid changes in stage and discharge
Perennial	Flows all or most of the year

Bed Material

Streams can be classified by the dominant size of the sediment on their beds. There is no direct relation between bed material size and incidence of scour problems. Deep scour holes are generally more probable in fine bed material. All bed material can erode; it is a function of time.

Valley Setting

Streams in mountainous areas have high relief have low hydraulic problems at bridge crossings due to coarse bed material, narrow floodplains, and non-alluvial type conditions. In contrast streams in regions of lower relief are usually alluvial and have more problems due to more active channels.

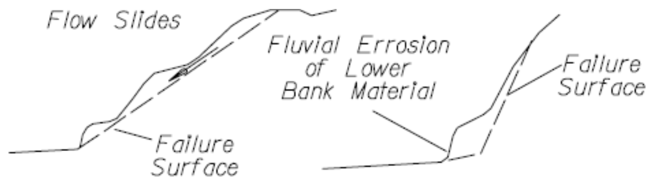
Floodplains

Floodplains width affects the length of the highway crossing, composed of the approach embankments and the bridge. For longer highway crossings there are usually more bridge components exposed to the flow.

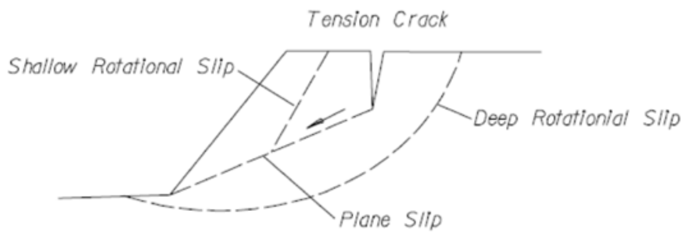
Channel Boundaries

Channel Boundaries may be alluvial, semi-alluvial, or non-alluvial. Alluvial channels may be defined as channels that are formed in materials that have been and can be transported by water. Non- alluvial channels may be defined as channels in bedrock or in very large material (cobbles or boulders).

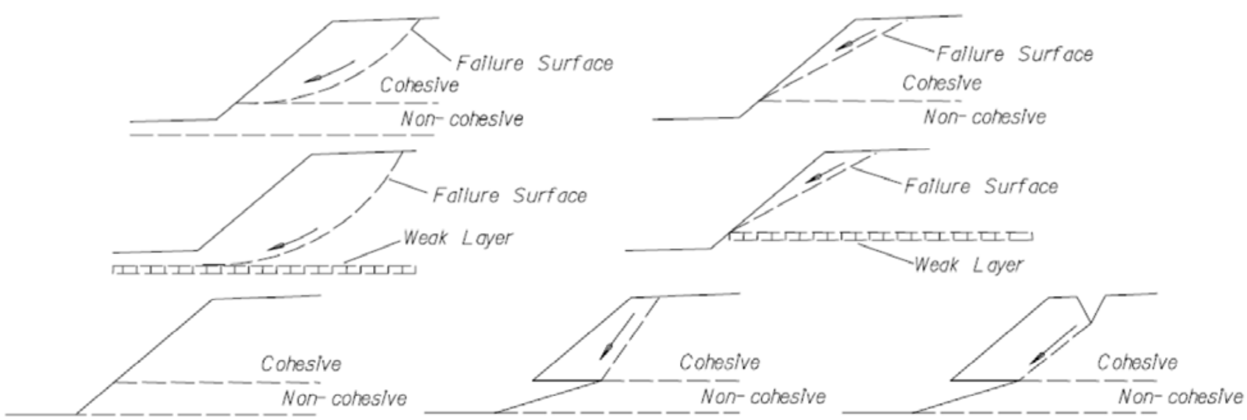
Bank appearance is good indicator of stability. Tree cover or vegetative cover on the channel banks or over-bank (riparian vegetation) can provide stability against lateral channel erosion. Typical bank failure can be categorized as non-cohesive, cohesive and composite failure.



Non-cohesive



Cohesive



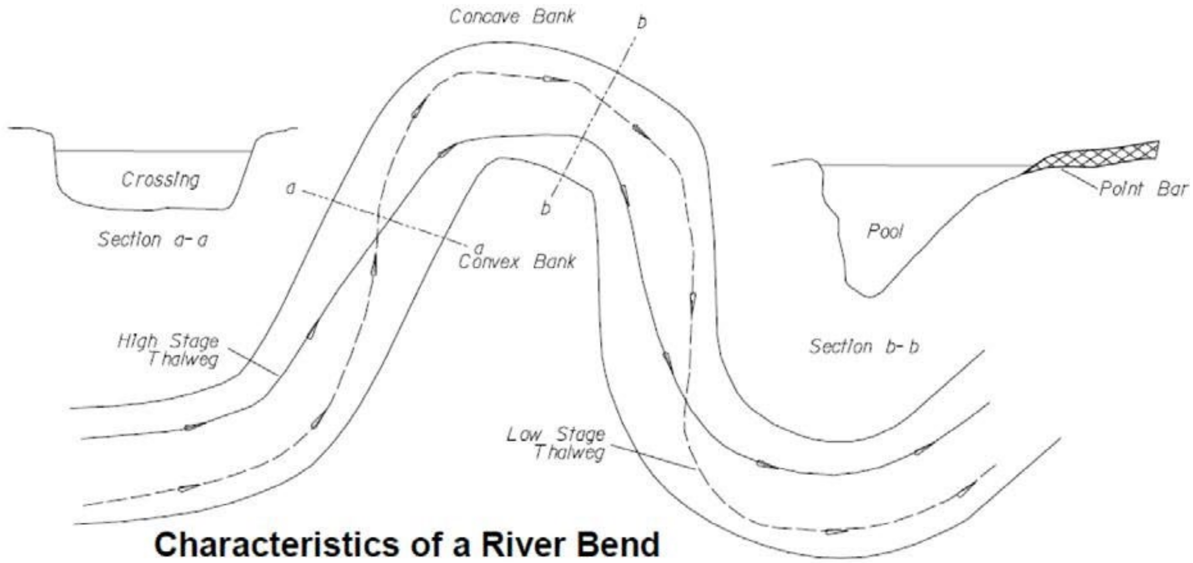
Composite

Meandering Streams

A meandering channel consists of pools and crossings. The thalweg, (deepest point in the cross section where the main current is flowing) water is flowing from pool to pool through the crossings in an S-shaped alignment.

The degree of meandering is described by sinuosity, defined as the ratio of the thalweg distance to the valley distance. Straight channels have a sinuosity of one.

For a meandering stream, erosion generally attacks the outside of the meander bend. Deposition occurs on the point bar on the inside of the bend.



Characteristics of a River Bend

Scour

In general scour involves the removal of material from the bed and banks across all or most of the width of a channel. General scour can result from a contraction of the flow, a change in downstream control of the water surface elevation, or the location of the bridge in relation to a bend. The most common form of general scour at a bridge is caused by the approach embankments to the bridge encroaching onto the flood plain or into the main channel with resulting contraction of the flow. General scour at a bridge can also be caused by a decrease in flow area or an increase in velocity. The decrease in flow area may be naturally occurring or may be caused by the structure. If the structure is located on or close to a bend, the concentration of the flow on the outer part of the channel can erode the bed. The contraction of flow at the bridge can be caused by a decrease in flow area of the stream channel by the abutments projecting into the channel, or the piers taking up a large portion of the flow area.

Aggradation and Degradation

Aggradation is deposition of material in the streambed. This deposition of material over time will raise the streambed. Degradation is the lowering or scouring of the bed of the stream over relatively long distances. Long-term degradation is generally estimated by comparing successive cross section plots or the change in thalweg profiles over time.

Contraction Scour

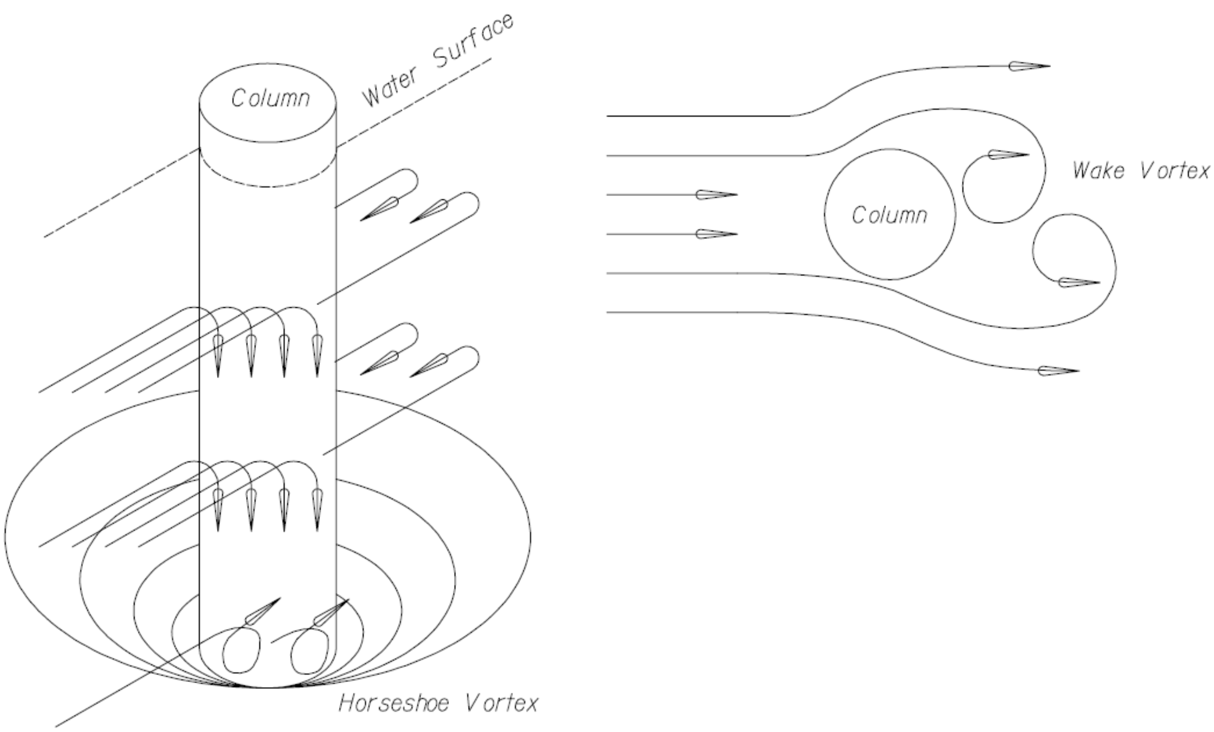
The flow will remain constant in the reach of river upstream and downstream of a bridge. Therefore, if the area of the bridge opening is smaller than the area of the channel, the velocity of the water through the bridge must be greater than the velocity upstream. Since the speed of the water increases as it travels through the bridge opening, its ability to scour the streambed also increases. For this reason the potential for scour is magnified at any bridge which constricts a channel.

The amount of scour that can take place depends a great deal on the size and type of streambed material. If a bridge is founded on bedrock, for example, the fact that it constricts the channel will have very little effect on its stability. Conversely if the streambed is a silt, constricting the channel may cause a very significant increase in the possibility of a failure due to scour. Between the two extremes are bed materials with varying degrees of scour susceptibility. It is very important, therefore, that the inspector note the makeup of the streambed in the vicinity of the bridge.

Local Scour

Obstructions to the flow such as a bridge pier will create a turbulence that can also cause scour. Local scour is dependent on the depth and velocity of flow, size of the bed material, the approach flow's angle of attack, the width of the pier and shape of the pier nose.

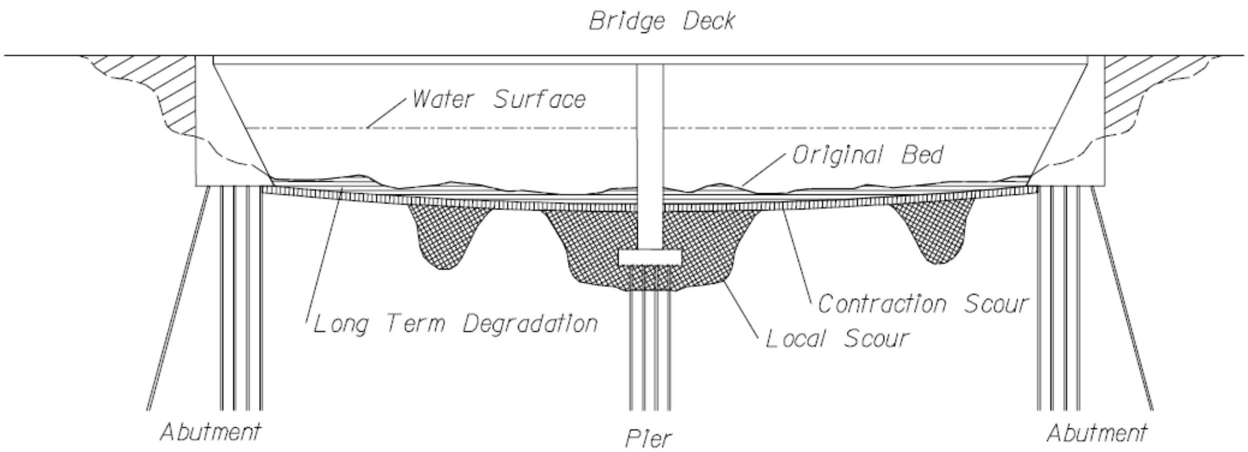
The extent to which this occurs relies largely on how streamlined the pier is. The pier, which splits the water with the least amount of disruption to the flow, will cause the least amount of turbulence. Therefore, the width of the pier as well as the shape of its nose will have a direct bearing on the amount of local scour.



9.2 Stream Stability and Scour

Total Scour

Total scour is generally the sum of the aggradation or degradation, contraction and local scour.



The underwater inspection involves assessing the condition of the bridge elements under water. In this regard an underwater inspection is no different than a normal above water inspection. The inspector must be able to thoroughly evaluate and rate the structural condition of the element in question.

An underwater inspection also involves determining the extent of scour present and the potential for future problems. For this the inspector must not only assess the condition of the bridge but the streambed as well. The inspector must determine the interaction between the bridge and stream. Measure how much the stream is affecting the bridge or the bridge affecting the stream.

The inspector will complete the underwater assessment, which incorporates both a structure condition appraisal and a scour evaluation. This evaluation includes:

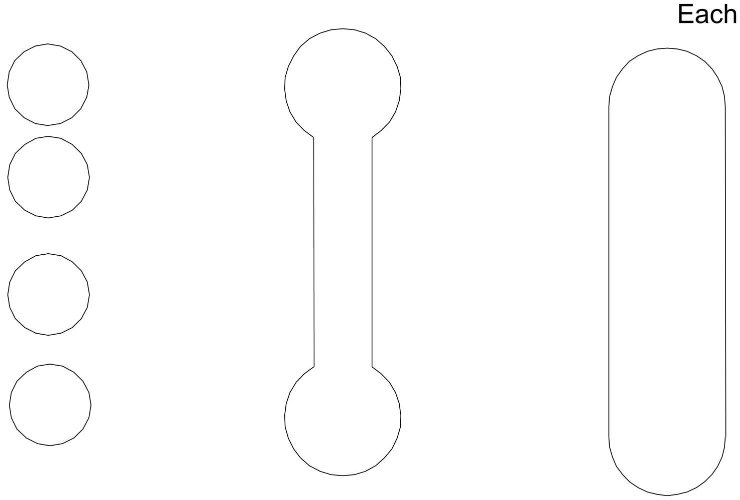
Element Level Inspection Through 899	Elements 200 through 299, 800
	Defect 4000 Settlement Element 900 Scour, 901 Countermeasures
NBIS Coding Items	Item 60 Substructure Item 61 Channel and Channel Protection Item 71 Waterway Adequacy
MDT Scour Appraisal	MDT's Twelve evaluation questions to assist in evaluation of NBIS Item 113 Scour Critical Bridges

Scour Appraisal

There are twelve evaluation questions for the scour appraisal and ranking of the bridge for scour susceptibility.

1. Number of Piers

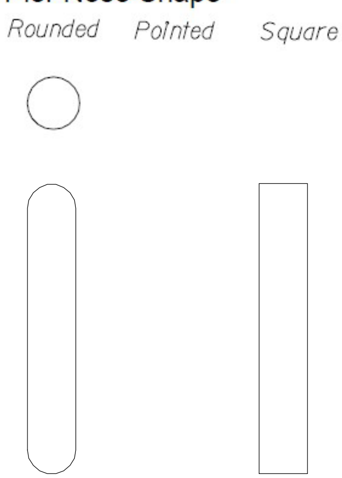
Count the number of piers in the active channel. Each pier is one point.



Pier Group | Columns With Web Wall | Pier Wall

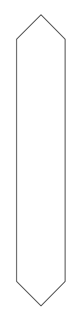
Examples of Piers - Count as one pier

2. Pier Nose Shape

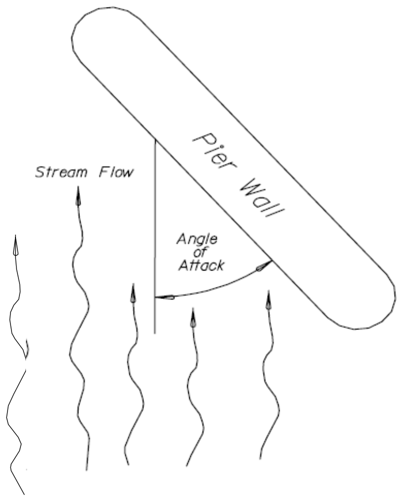


Record the pier nose shape.

Shape	Value
Rounded	0
Pointed	1
Square	2



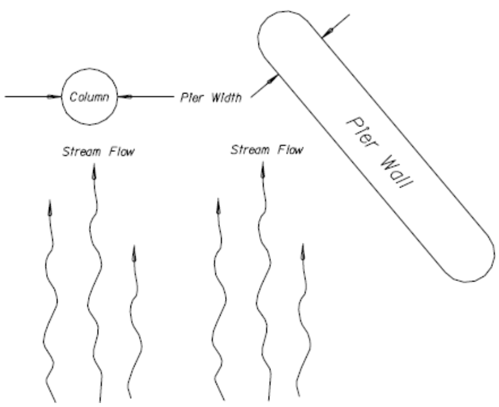
3. Angle of Attack



The acute angle between the pier and the direction of stream flow.

Angle of Attack	Value
0° to 10°	0
11° to 20°	1
21° to 30°	2
31° to 40°	3
> 40°	4

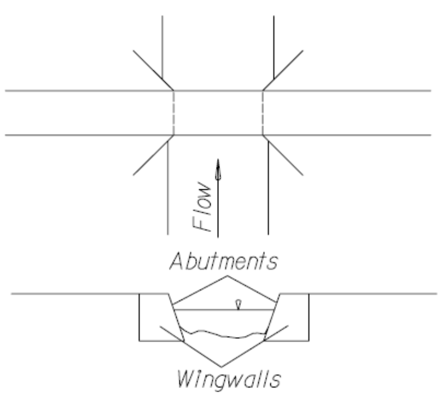
4. Pier Width



Measurement of the pier in the direction of flow.

Width	Value
< 3’	0
3’ to 4’	1
4’< to 7’	2
7’< to 9’	3

5. Flow impinging on abutment or wingwall

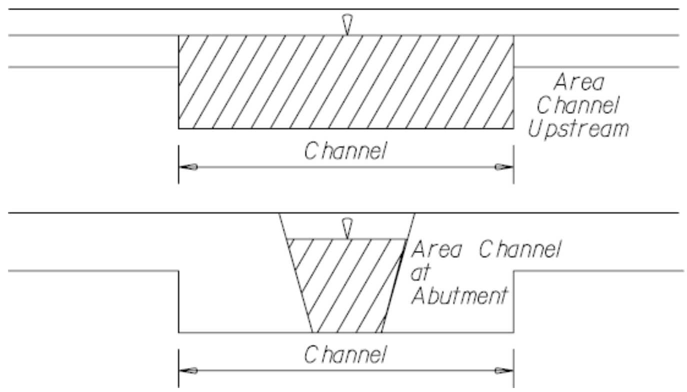


Stream flow hitting the abutment.

Impinging	Value
Yes	2
No	0

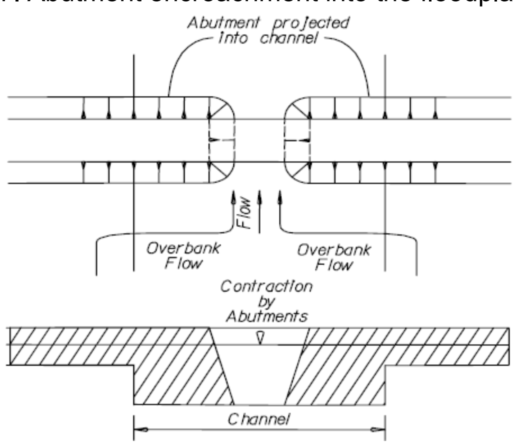
6. Amount of Channel Constriction = Area at Bridge Opening / Area of Upstream Channel

Estimate the area of the opening at the structure and divide by estimated nominal channel size upstream.



Area Percentage	Value
>90%	0
75% to 90%	1
50 to < 75%	2
< 50%	3

7. Abutment encroachment into the floodplain



Does the bridge encroach into the stream floodplain?

Floodplain	Value
Yes	1
No	0

8. Constriction due to channel vegetation

Is there a large amount of vegetation growing in or encroaching into the stream channel restricting flow?

Constriction	Value
None	0
Low	1
Medium	2
High	3

9. Potential for Debris/Ice Accumulation

Material in the stream that will allow the accumulation of ice or debris causing scour or undermining of the bridge substructure

Buildup Potential	Value
None	0
Low	1
Medium	2
High	3

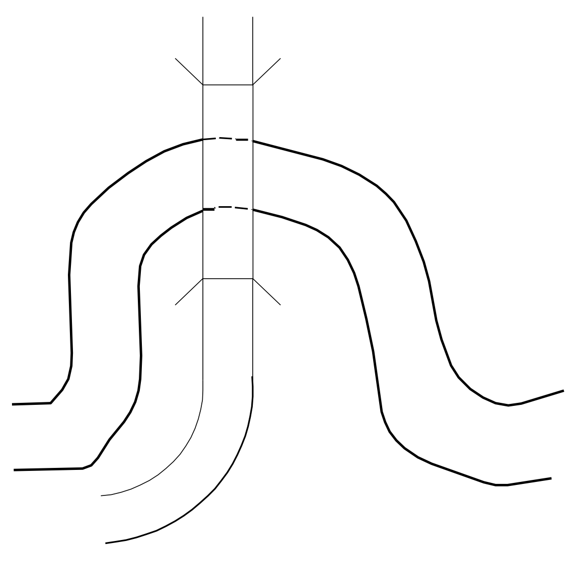
10. Bed Material

Makeup of the stream channel material

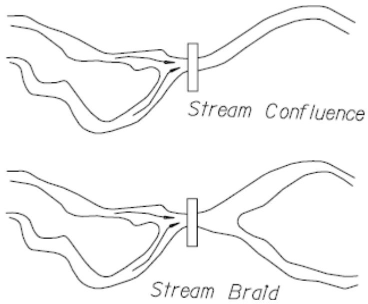
Material Type	Value
Bedrock	0
Boulder/Cobble	1
Gravel	2
Sand	3
Silt/Clay	4

Is the bridge located at a stream bend?
Is the bridge located at a sharp bend on a meandering stream?

Stream Bend	Value
Yes	1
No	0



11 Is there an upstream confluence nearby?
Is the bridge located at near a confluence of two streams or braids?



Stream Confluence	Value
Yes	1
No	0

Cross Sections

Soundings shall be made along the circumference of all substructure components. Stream cross-sections shall be made within the limits established by the table below.

BRIDGE LENGTH (Up and Downstream)	LIMITS OF STREAM CROSS SECTIONS
< 100 feet	Length of bridge *
>= 100 feet	100 feet *

*If the inspector feels conditions at the site warrant the need for more cross sections, these limits should be extended.

The number of cross sections required will be left to the discretion of the inspector. There should be enough to adequately show the depth and extent of scour in the vicinity of the bridge. The soundings shall be taken continuously on a recording depth sounder, or at ten (10) foot intervals if spot sounding is used. In the latter case additional soundings shall be made as necessary to identify significant features or abrupt changes in the channel bottom.

After the initial soundings at the structure are made, Category I bridges will require only a single cross section at the upstream edge of the structure. If no change in the cross section is observed, no additional cross sections will be required.

The water surface and the datum used in taking the soundings shall be referenced to some point on the bridge. Generally this will be the top of deck or curb at a specific point, or the top of a pier. Piers and abutments shall be located on cross sections within bridge limits.

Contours

Where cross sections indicate the existence of scour problems a contour map shall be developed to establish the size, depth and location of each scour hole. The orientation and location of piers and abutments should be shown as well. If a footing is found to be exposed or undermined, the volume of the void should be dimensioned within an accuracy of half (1/2) foot in each direction.

Photos

As is the case with any inspection, photographs should be used to document the findings. These photos should include:

- Inadequate waterway area
- Ice jams or flows
- Debris
- Channel and structure alignment
- Condition of the rip rap